

1 **COVID-19 and Anatomy: Stimulus and Initial Response**

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7 **Conflict of interest statement:** The authors have no conflicts of interest to declare

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9

1 **Abstract**

2 The outbreak of COVID-19, resulting from widespread transmission of the SARS-CoV-2 virus,  
3 represents one of the foremost current challenges to societies across the globe, with few areas  
4 of life remaining untouched. Here, we detail the immediate impact that COVID-19 has had on  
5 the teaching and practice of anatomy, providing specific examples of the varied responses  
6 from several UK, Irish and German universities and medical schools. Alongside significant  
7 issues for, and suspension of, body donation programmes, the widespread closure of  
8 university campuses has led to challenges in delivering anatomy education via online  
9 methods, a particular problem for a practical, experience-based subject such as anatomy. We  
10 discuss the short-term consequences of COVID-19 for body donation programmes and  
11 anatomical education, and highlight issues and challenges that will need to be addressed in  
12 the medium- to long-term in order to restore anatomy education and practice throughout the  
13 world.

14

15 **Keywords:** COVID-19; coronavirus; anatomy; education; body donation

16

## 1 **Introduction**

2 The emergence of infectious diseases with the potential to spread rapidly amongst the human  
3 population, such as severe acute respiratory syndrome (SARS) and Zika virus, presents a  
4 major threat to global public health (Wolfe et al., 2007; Ventura et al., 2016). However, the  
5 recent arrival of a severe respiratory disease, first reported in Wuhan city (Hubei province)  
6 China in December 2019 (Wu et al., 2020, Zhu et al., 2020), has generated an unprecedented  
7 global response. COVID-19 is caused by a novel and highly pathogenic coronavirus (SARS-  
8 CoV-2), that is easily and rapidly transmitted through respiratory droplets (Wu et al., 2020,  
9 Zhu et al., 2020).

10

11 The highly contagious nature of COVID-19, and the potentially life-threatening nature of  
12 symptoms for an affected individual, has led to widespread, global attempts to control person-  
13 to-person contact and disease spread within and between populations (Wilder-Smith et al.,  
14 2020). One major consequence of the ensuing political decisions has been a closure of most  
15 university campuses, and with them medical schools and anatomy units/departments.

16

17 In the following review of actions taken after the COVID-19 outbreak, information was collated  
18 from the following 10 universities:

19 Ireland: National University of Ireland Galway (NUIG), Royal College of Surgeons in  
20 Ireland (RCSI)

21 Scotland: Universities of Aberdeen, Dundee, Edinburgh and Glasgow

22 England: University of Cambridge, Imperial College London, University of Oxford

23 Germany (Bavaria): Ludwig Maximilian University of München (LMU).

1

2 Although there is no *a priori* rationale for claiming these universities are representative of all  
3 affected European universities, the similarities of their response to the COVID-19 pandemic  
4 suggest that in this respect at least, they might be. The challenges that have arisen, and/or  
5 are likely to arise, over the coming months and years are outlined, and the immediate  
6 decisions taken, the rationale for them and their effects are described on an institution-by-  
7 institution basis. In the final section, possible longer-term effects and challenges are also  
8 discussed.

9

## 10 **Closure of university campuses, medical schools, and anatomy units/departments in** 11 **response to COVID-19**

12 *Aberdeen:* The Principal of the University announced University-wide lockdown on 13 March,  
13 to be in place by 20 March. This affected teaching sessions for c.800 undergraduate students  
14 on medical, dental, physician associate and science programmes. Fortunately, the majority of  
15 practical teaching was able to be completed prior to lockdown, except for Year 3 Medicine  
16 students who would have returned after the Easter vacation. The practical element of two,  
17 ongoing blended anatomy postgraduate courses was also suspended. At the same time,  
18 several surgical skills courses catering for c.100 delegates had to be cancelled. Postgraduate  
19 (PhD) student work on cadaveric material also ceased. All anatomy staff commenced working  
20 from home by 20 March, and the anatomy building closed to all but essential staff, which  
21 comprised two licensed teachers and two technicians. The extensive collection of prosected  
22 cadaveric material and freezer content was monitored weekly. As the building is shared by the  
23 University and the National Health Service (NHS), it was immediately opened for essential  
24 training which was coordinated by staff in the Clinical Skills Centre. To date, no requests have  
25 been forthcoming for assistance with mortuary facilities. The Anatomy team donated all basic

1 Personal Protective Equipment (PPE) to the NHS. Currently, the University Senate has agreed  
2 a fortnight's delay to the start of the first semester in September.

3

4 *Cambridge:* An announcement was made by the Vice-Chancellor on 18 March that by the  
5 end of 20 March the University's normal operations would cease. The teaching term for all  
6 three years of preclinical medical students had already ended on 13 March, with completion  
7 of an anatomy practical exam for over 300 second year medical students on that day. Most  
8 students returned home on or soon after 13 March, although students who could not do so,  
9 including international students and those with immunosuppressed family members, were  
10 supported in University/College accommodation where some remain in residence. Clinical  
11 teaching for Years 4 & 5 students ceased after 13 March, and final year (Year 6) clinical exams  
12 were cancelled. Several external courses in surgery and ultrasound in regional anaesthesia  
13 were also cancelled, affecting c.100 delegates. The department was not asked to provide  
14 mortuary facilities. A donation of PPE was made to the local hospital following a university-  
15 wide appeal.

16

17 *Dundee:* It was announced on 15 March by the Interim Principal that all face-to-face teaching  
18 would be suspended from 16 March, with an immediate move to online teaching. The  
19 university then closed down for all but essential activities on 18 March. Three weeks of  
20 anatomy teaching remained for most students, who comprised c.900 undergraduate and  
21 postgraduate students in anatomical sciences, forensic anthropology, medicine, dentistry, oral  
22 health sciences, and medical and forensic art. Medical students are taught for a longer period,  
23 with classes for Year 3 students continuing well into May. However, there was no more  
24 dissection in that period, with only some anatomy revision sessions remaining. MSc students  
25 carrying out practical projects on Thiel embalmed bodies either completed data collection  
26 swiftly before university closure, or moved to literature projects instead. PhD students using

1 Thiel specimens had to suspend data collection for the foreseeable future. All external  
2 activities, including surgical skills courses, research projects, service work with medical device  
3 companies, and any other events utilising Thiel bodies were suspended. While most staff  
4 members commenced working from home on 19 March, technical staff continued to enter the  
5 building for essential maintenance, and both technical and administrative staff were permitted  
6 to go into work to prepare bodies for cremation. The local Dundee COVID-19 response teams  
7 requested provision of the following: i) access to dissecting rooms for body storage if the local  
8 mortuaries were stretched beyond capacity; ii) assistance from technical staff to ease  
9 anticipated pressure on pathologists and technicians at the local police mortuary, where  
10 Anatomy staff had already undergone induction, as well as the mortuary at the local teaching  
11 hospital; iii) loan of the Anatomy van, which has the capacity to transport six bodies at a time;  
12 and iv) provision of any excess PPE as part of a Dundee-wide initiative.

13

14 *Edinburgh:* All on-campus teaching at the University of Edinburgh was formally suspended  
15 following an announcement from the Principal on 13 March with a move to online teaching  
16 and examinations. From 16 March, all face-to-face anatomy teaching ceased, affecting  
17 c.1,000 medical students from Years 1, 2, 4 & 5, as well as c.100 Biomedical Science students  
18 and 5 postgraduate Master's students. The online Anatomical Sciences postgraduate  
19 programme remained unaffected, but with some students requiring extension of deadlines due  
20 to changing personal and professional circumstances. All anatomy exams for Year 1 & 2  
21 Medicine students were cancelled, as were practical spotter exams for Biomedical Science  
22 undergraduates and MSc Human Anatomy postgraduates. In addition, several postgraduate  
23 and continuing professional development (CPD) courses had to be cancelled, both at the  
24 University and at the Royal College of Surgeons of Edinburgh. Final year Medicine students  
25 were permitted to graduate early in April 2020, to allow them to join the NHS workforce dealing  
26 with the COVID-19 pandemic. All Anatomy staff, including academic, technical, museum and  
27 research staff, commenced working from home following a meeting on 16 March, except for

1 two senior Anatomy Technicians and the Professor of Anatomy, who retained access to care  
2 for donor remains. A request was received from the University of Edinburgh and NHS  
3 colleagues in Pathology for technical/mortuary assistance with COVID-19 research post-  
4 mortems, albeit taking place outside of Anatomy facilities.

5

6 *Glasgow:* The University of Glasgow announced on 14 March that all face-to-face teaching  
7 would be suspended from 16 March, and that arrangements had to be put in place to deliver  
8 online teaching. In advance of this, considerations had already been made regarding  
9 cancellations of continuing professional development (CPD) courses. This coincided with the  
10 announcement on 13 March that the educational activities of the Royal College of Physicians  
11 and Surgeons of Glasgow (RCPSG) would be suspended until the summer. These included  
12 courses hosted in the Clinical Anatomy Skill Centre, a joint initiative between the College of  
13 Medical Veterinary and Life Sciences of the University of Glasgow and the RCPSG. Only a  
14 week of teaching remained for the Life Sciences courses, which comprised c.380 students in  
15 Year 2 and c.80 students in Years 3 & 4. A longer period of teaching was outstanding for the  
16 following groups: over 600 medical students in Years 1 & 2; a smaller number in the pre-  
17 medical Glasgow Access Programme; c.160 dental students in Years 1 & 2 who receive  
18 anatomy teaching in our facility; and c.120 nursing students in Years 1 & 2. However, the bulk  
19 of gross anatomy teaching and dissection activities had already been completed for these  
20 students. In addition, an international Undergraduate group of 12 students taking a Functional  
21 Anatomy course had two weeks of teaching remaining, and a postgraduate student cohort,  
22 comprising 14 Master's students and 2 undertaking a postgraduate certificate that  
23 incorporates Anatomy teaching, still required a substantial amount of teaching. These two  
24 groups were most affected by dissection room closure. From the week beginning 23 March,  
25 all staff commenced working from home, as the building in which the Anatomy Facility is  
26 housed was closed and only accessible for essential maintenance and key workers in case of  
27 emergency.

1

2 *Imperial College London:* Imperial College London closed for face-to-face formal teaching on  
3 20 March and all staff, apart from key workers, were instructed to work from home. This  
4 coincided with the last day of the Spring Term for the Faculty of Medicine and anatomy  
5 teaching for preclinical medical undergraduates had already finished, as timetabled. On 17  
6 March, a formative online anatomy spotter examination had already been sat by c.360 first  
7 year medical students. On 18 and 20 March, 280 medical students in Year 6 sat their final  
8 examinations online. A Year 2 Objective Structured Practical Examination for c.360 students  
9 planned for 19-20 March was cancelled, with all students permitted to progress to Year 3  
10 without sitting the examination. There is no timetabled anatomy teaching for Years 1 & 2 in  
11 the Summer Term, and the Year 1 summative anatomy spotter examination will take place  
12 online. The small amount of anatomy normally delivered to students in their clinical years is  
13 being delivered online for the remainder of the academic year. Imperial College delivers the  
14 Core Surgical Anatomy course to c.90 first year core surgical trainees (CT1) and Surgical  
15 Skills Courses for Specialist Surgical Trainees in the London Postgraduate School of Surgery.  
16 The practical elements of these courses have been cancelled until further notice and as much  
17 teaching as possible will be delivered online, while bearing in mind the practical limitations of  
18 online teaching of surgical skills and the likely reassigning of trainees to non-surgical frontline  
19 duties. All other postgraduate anatomy courses have also been cancelled. Anatomy facilities  
20 were offered to the NHS but were deemed unsuitable for its current needs. The Human  
21 Anatomy Unit donated PPE for use by the NHS.

22

23 *Münich (LMU):* The State of Bavaria closed all state-run university buildings to students and  
24 the general public on 17 March. Employees who had returned within 14 days prior to that date  
25 from a region of the world recognised as a high-risk area by the Robert-Koch-Institute Berlin,  
26 were immediately home quarantined for 14 days. All employees were asked to work from

1 home if possible. On 20 March, the Bavarian government issued a general public contact  
2 restriction for all citizens, resulting in further reduction of employee personal contacts within  
3 the university sector. From 24 March, all pregnant LMU employees were sent home for the  
4 duration of the crisis. Clinical departments prepared for treatment of COVID-19 patients and  
5 other emergency cases. Staff members on the preclinical medical faculty continued working  
6 and were tasked with preparing for a summer term of online teaching. All university  
7 employees, especially medically-trained personnel, were registered for emergency service in  
8 the public health care sector, potentially depleting the number of anatomy staff able to continue  
9 to undertake anatomy education activities.

10

11 *NUI Galway:* On 12 March, the Irish Government announced a range of stringent measures  
12 to help combat the spread of COVID-19, which included the closure of all schools and colleges  
13 in the country. Consistent with public health protocols and priorities, campuses were only  
14 accessible by those doing work related to, or supporting the public health service in COVID-  
15 19-specific work. Only key technical staff were permitted access to maintain facilities. There  
16 were only 3 weeks left in the NUI Galway term, ending on 4 April in 2020. The lockdown mainly  
17 affected medical students taking Gastrointestinal System and Renal System modules,  
18 normally delivered as an integrated systems-based module with lectures from Anatomy,  
19 Physiology, Biochemistry and clinical disciplines. Only 60% of the Gastrointestinal System  
20 practical sessions were able to be completed, and the Renal system practical did not run.  
21 There were similar cancellations of practical classes for undergraduate science students  
22 taking Gastrointestinal System and Head and Neck modules. Teaching for biomedical device  
23 companies and the MSc/PG Dip in multidisciplinary Radiology were also suspended.

24

25 *Oxford:* In accordance with the UK Government directive, face-to-face teaching was  
26 suspended on 13 March, which primarily affected students in Years 1-3 of the undergraduate

1 medicine course. Year 1 did not receive their usual practical classes in the final term, which  
2 normally focuses on the lower gastrointestinal tract and genitourinary system. Year 3 students  
3 were scheduled to undertake the intensive Principles of Clinical Anatomy course in June,  
4 during which they would have daily sessions in the dissecting room revising all aspects of  
5 anatomy before proceeding to clinical school. While this course remains under review  
6 dependent on further Government directives, extensive preparations were being made to  
7 deliver the teaching online if necessary. Graduate Entry Medicine and Biomedical Science  
8 students were also significantly affected. Final year medical students graduated early so that  
9 they could start helping on the NHS frontline. The body donation programme was suspended  
10 and locked down, with a small number of technical staff permitted to access the building  
11 regularly for monitoring of the current donors. The Nuffield Department of Surgery training  
12 course was cancelled, during which experienced surgeons would come for an intensive week  
13 to undertake cadaveric procedures in their specialty, an invaluable resource for junior surgical  
14 trainees.

15

16 *Royal College of Surgeons in Ireland (RCSI):* An Irish Government directive required the  
17 closure of all schools and universities from 12 March. As a result, all campus-based anatomy  
18 teaching ceased for 375 Year 1 medical and physiotherapy students and 15 postgraduate  
19 Physician Associate students, who had 4 weeks of teaching term still to run. In addition, a  
20 Policy Statement from the Surgical Royal Colleges on 16 March postponed MRCS  
21 Examinations and training courses, affecting c.200 trainees.

22

### 23 **Body donation programmes**

24 *Aberdeen:* The University of Aberdeen suspended its body donation programme from the  
25 evening of 13 March. This decision was taken in conjunction with other anatomy units in

1 Scotland and Her Majesty's Inspector of Anatomy for Scotland (HMIAS). The rationale for this  
2 was two-fold: an inadequate knowledge of the potential risks from COVID-19 donors to staff,  
3 and the increased risk from a continued need to re-enter the anatomy facility on the Aberdeen  
4 Royal Infirmary campus. Planned cremations and burials for March and April were also put on  
5 hold. Subsequently, the Scottish Government relaxed the requirement to dispose of donated  
6 cadavers within 3 years, extending this by 6 months in the first instance. The annual memorial  
7 service for families of donors, which was scheduled for late March, had already been cancelled  
8 ahead of the University-wide closure, as many attendees would be from the vulnerable  
9 population. Notification of two bodies was received on 13 March and these were accepted into  
10 the facility on 16 March. While both were elderly and stated to be COVID-19 negative, they  
11 had not been tested for confirmation. The Bequeathal Secretary continued to accept  
12 completed bequeathal forms and deal with enquiries while working from home. Import of  
13 frozen anatomical material from Science Care USA was suspended, with an offer to hold  
14 material for 6 months in the first instance.

15

16 *Cambridge:* Acceptance of body donations ceased on 18 March, but a donor who had already  
17 been processed was accepted on 19 March. Teaching of first year medical students, with  
18 hands-on cadaveric dissection, had already been completed in the first two terms (from  
19 October 2019 to mid-March 2020) of the academic year. Therefore, the decision was made to  
20 manage the current donors by performing retention of parts with the appropriate consent for  
21 future teaching and research, completing cremation paperwork, purchasing coffins and  
22 booking cremation slots as soon as possible. This would enable respectful disposal of donors,  
23 as well as fulfilling their wishes for the use of their bodies for teaching and research. As these  
24 donors had already been dissected by students, their remaining in the dissection room (DR)  
25 for a prolonged lockdown would constitute a health and safety hazard. In addition, existing  
26 holdings of anatomical prosections needed to be secured, as many were stored in cabinets  
27 and required weekly spraying. The decision was made to submerge these prosections in

1 preserving fluid within sealed containers to obviate the need for staff to make regular journeys  
2 to the facility. To achieve the above, staff members with access to the DR during the week  
3 commencing 23 March were the Bequeathal Secretary and Clinical Anatomist, to complete  
4 and check cremation documentation for 42 donors, and subsequently the Senior Technician  
5 and Clinical Anatomist on selected days for retention of tissue, encoffining of donors and  
6 supervising transport to the crematorium. Cremations were completed by the end of April, at  
7 least six weeks earlier than in previous years. The Committal Service for students and staff  
8 was delivered online via our secure Virtual Learning Environment (VLE) platform. Students  
9 provided a donor tribute from each table group, with two representatives giving general tributes  
10 on behalf of the whole cohort. Tributes and biographical material from donors' relatives were  
11 also included.

12

13 *Dundee:* From 13 March, increased mortuary health and safety measures were instituted in  
14 Dundee, including non-acceptance of suspected or confirmed COVID-19 cases, deep  
15 cleaning after embalming, and full PPE to be worn at all times when accepting bodies for  
16 anatomical examination. Due to the submersion of bodies in a Thiel tank for six months, the  
17 risk from COVID-19 was considered to be relatively low, except at the time of embalming.  
18 However, on 16 March, HMIAS, after consultation with all the anatomy centres in Scotland  
19 and to ensure a consistent approach across the country, suspended all acceptance of body  
20 donations until further notice. The Inspector also proposed extending the law compelling  
21 cremation or burial of donors within 3 years of their date of death. As this required passing  
22 through the Scottish Parliament, the provision was heard and approved as part of the  
23 Coronavirus (Scotland) Bill on 1 April. Information on COVID-19 and the risks associated with  
24 the deceased was sparse, except for the Royal College of Pathologists' guidance for mortuary  
25 staff dealing with COVID-19 bodies (Royal College of Pathologists, 2020). Subsequently, the  
26 International Committee of the Red Cross published general guidance on the management of  
27 the deceased with COVID-19 (Finegan *et al.*, 2020). In view of the vulnerability of the

1 attendees at our thanksgiving memorial event, due to be held in May, the decision was made  
2 to postpone this until the autumn, which would also allow students to attend. The response  
3 from both potential donors and relatives of current donors has been one of complete  
4 understanding in all respects. Some phoned to ask whether a COVID-19 patient would be  
5 accepted, others to enquire whether the donor programme had been suspended and whether  
6 bequeathal forms were still available, and others got in touch with regards to collection of their  
7 loved one's ashes. In order to free up the dissecting room and other secure spaces which may  
8 be required for body storage due to the current crisis, donor cremations continued.

9

10 *Edinburgh:* Following local discussions with other Scottish Anatomy Departments, the  
11 Licensed Teachers took the collective decision to suspend the Anatomy@Edinburgh body  
12 donation programme from the evening of the 12 March, with immediate effect. This decision  
13 was communicated to HMIAS and senior colleagues at the University of Edinburgh, and was  
14 swiftly enacted due to the significant amount of fresh frozen material handled by the facility  
15 that does not undergo fixation. Formal notices of the suspension were placed on the  
16 Anatomy@Edinburgh website, social media channels, and as an answerphone message on  
17 the bequest telephone line. At this stage, to ensure that all donor material coming close to the  
18 3-year retention rule enforced by the Human Tissue [Scotland] Act 2006 would not be held  
19 beyond this period, cremation was prioritised for the longest held donors. At the same time,  
20 the decision was taken to postpone the annual Anatomy Memorial Service, due to take place  
21 in late April, until a later date. There was sufficient embalmed donor material to meet teaching  
22 requirements for the 2020-21 academic year, although the impact on fresh frozen material,  
23 largely used for postgraduate and professional courses, remained unclear.

24

25 *Glasgow:* On the evening of the 12 March, as the crisis began to escalate in the UK, the  
26 decision was taken to suspend the acceptance of donors until further notice from the following

1 day. A notice was placed online and on the Bequest Coordinator's telephone answering  
2 machine as well as in an out-of-office reply to emails. The suspension was based on the  
3 following considerations: i) the unknown COVID-19 status of each donor, as every donor in a  
4 pandemic could be a potential carrier of the infection and this could have presented a high risk  
5 to the safety of staff handling the donors and subsequent students; ii) the regular practice to  
6 exercise extreme caution to protect against potential infectious diseases; iii) information about  
7 the infectivity and virulence of the virus in the deceased was sparse; iv) formaldehyde  
8 embalming kills most pathogens and is likely to include SARS-CoV-2, but this has not yet been  
9 verified; v) c.55% of the donor cohort is normally fresh frozen for use in clinical skill courses,  
10 so the potential biocidal benefit of embalming would not apply; and vi) in the present crisis,  
11 the potential difficulties faced in communicating with doctors who sign the Medical Certificate  
12 of the Cause of Death, in order to inform decisions regarding donor acceptance. On 16 March,  
13 official advice was issued from the Scottish Government to suspend all donor related activities,  
14 including cremations, which was immediately actioned in Glasgow. No information was  
15 immediately available concerning the response of donors and relatives regarding suspension  
16 of the donor programme. The Donor Commemoration Service in Glasgow, which normally  
17 takes place in the autumn, may still go ahead subject to circumstances.

18

19 *Imperial College London:* Imperial College London is part of a consortium, together with Anglia  
20 Ruskin University, Brighton and Sussex Medical School, King's College London, Queen Mary  
21 University of London, St George's University of London and University College London, that  
22 runs a common donation programme from the London Anatomy Office (LAO). In view of the  
23 fact that the SARS-CoV-2 virus that causes COVID-19 is classified as a Hazard Group 3  
24 pathogen that may survive for days in cold damp conditions (Kampf *et al.*, 2020), a decision  
25 was taken by the consortium on 12 March not to accept confirmed or suspected COVID-19  
26 cases for Anatomical Examination. However, that decision was superseded by the closure of  
27 the LAO on 18 March on advice from its undertakers who no longer had capacity to transport,

1 store or cremate our donors. The LAO staff continued to respond to telephone calls and emails  
2 from donors' families and potential donors to explain the current situation and postponement  
3 of the annual Commemoration Service due to take place on 15 May. The Faculty of Medicine  
4 at Imperial College London (ICL) was placed in lockdown on 20 March, which was the last day  
5 of the Spring Term. ICL should have sufficient donors for teaching in the academic year 2020-  
6 21, but was unable to release donors for funerals. Although the Human Anatomy Unit was in  
7 lockdown, several members of staff, as designated key workers, were permitted access to the  
8 facilities to ensure that donor material was maintained in accordance with the provisions of  
9 the UK Human Tissue Act (2004).

10

11 *Münich (LMU):* The body donation program in München was not suspended. However, SARS-  
12 CoV-2 infected potential donors were not accepted and incoming donors were subject to a  
13 virus test. All cadavers designated for use in anatomical teaching were fixed with a formalin  
14 and alcohol solution, and then stored for several weeks in embalming solution prior to  
15 dissection. Cadavers for clinical courses in surgical procedures were usually embalmed with  
16 an alcohol glycerine solution. Fresh frozen human material is currently only used for research  
17 purposes and not for teaching.

18

19 *NUI Galway:* The intake of donations had already been suspended in November 2019 until  
20 January 2021 due to storage capacity issues. Sufficient pre-COVID-19 donations exist for the  
21 next 2 years, based upon current usage. The annual Memorial Service planned for 26 March  
22 had already been cancelled on 6 March due to concerns over the potential risk to vulnerable  
23 elderly attendees. Monitoring and spraying of prosected specimens contained in cabinets in  
24 the department was continued by key workers on the anatomy staff team. Planned burial of  
25 donors was suspended until further notice.

1

2 *Oxford:* Acceptance of all new donations was suspended from 13 March with the escalation  
3 of the COVID-19 crisis across the UK. This decision was taken by the Director of Anatomy  
4 with the Head of Department. A number of donor families, both current and prospective, were  
5 informed prior to the suspension and all understood the reasons for it. The message on the  
6 bequeathal answerphone was changed to provide an explanation for the suspension of  
7 donations, with information on the procedure to be followed in the event of a donor's death.  
8 An emergency contingency planning meeting was held to ensure that all technical staff were  
9 conversant with the new procedures during the period of lockdown and a rota was established  
10 to ensure that current donors would receive regular and dignified care. An emergency contact  
11 system was in place at all times, ultimately leading to the Director of Anatomy, in order that  
12 any environmental changes in the dissection room could be managed expeditiously.

13

14 *RCSI:* It was planned to suspend acceptance of body donations due to COVID-19, but the  
15 decision had already been taken two days ahead of the enforced closure, as full capacity for  
16 body storage had already been reached. The decision was taken in consultation with College  
17 management. Prior to the suspension, information was provided for both current and  
18 prospective donor families, who understood the immediate reason and the COVID-19  
19 situation. A Memorial Service for donors is held every second year and as the next event will  
20 be held in 2021, it is unlikely to be affected.

21

## 22 **Moving to online delivery of anatomy education**

23 *Aberdeen:* The immediate priorities were the summer spotter examinations for science and  
24 medical students, which had originally been scheduled for March and April. The Medical  
25 School had clear plans at all levels at an early stage, but a centralised message from the

1 University did not fit well with healthcare programmes, which have a different tempo and  
2 timescale to other university courses. Therefore, considerable work had to be spent on  
3 designing online alternatives for the summer examinations. Immediately prior to lockdown,  
4 some science course spotters had already been conducted in an electronic format in lecture  
5 theatres as usual. A final decision was made to convert all year 1-3 medical summative  
6 spotters into formative assessments. While these were open for 2 weeks to allow for  
7 circumstances such as illness, having to care for relatives and differing time zones, each  
8 student would be required to select a shorter time frame within this period to take the paper.  
9 These results were principally used to identify students who needed additional support. It was  
10 accepted that more time was needed to enable students to reach the necessary level of  
11 knowledge, and that conventional end-of-year exams covering a wider range of material may  
12 still be required, with extensive validation from internal quality audit. A combination of MSCAA  
13 (Medicine), Practique™ (Physician Associate) and Examsoft™ (Dentistry) platforms were  
14 used across the School of Medicine, Medical Sciences and Nutrition. As each platform has a  
15 different set of operating parameters, examinations had to be modified in each case to suit the  
16 platform. For example, using the MSCAA platform, only a mark of 0 or 1 can be awarded,  
17 while a mark out of 2 would usually be given, with a half-mark of 1 given as an option. Being  
18 a condensed 2-year course, the Physician Associate programme was most severely affected.  
19 The national final examination was cancelled and students offered NHS bank hours until  
20 examinations resume. Cadaveric images from Anatomy TV ((™) Primal Pictures) were used  
21 under licence. This had been put in place in advance of the lockdown.

22 Existing, self-directed, supported workbooks (Findlater *et al.*, 2012), which support all anatomy  
23 practical classes, were converted into e-workbooks. These have cadaveric online content,  
24 from Acland's Video Atlas of Anatomy and again, Anatomy-TV linked, where there would  
25 previously have been a cadaver or a labelled specimen available for examination. Radiological  
26 images were relatively easy to put online, and online versions of current face-to-face teaching  
27 with expert clinical input were developed. These were augmented with linked existing bespoke

1 3D photogrammetry material, which can be delivered through the Medical School's bespoke  
2 VLE (MyMBChB). Online Panopto™ lectures were delivered at the usual times. In addition,  
3 Blackboard Collaborate™ was used to host small group, interactive sessions during timetabled  
4 practical class slots, to enable face-to face discussion of areas of difficulty and  
5 misunderstanding, and to provide elements of essential discourse. Regular, formative quizzes  
6 were offered through the Moodle™ platform. All content was linked from the bespoke  
7 MyMBchB platform. The musculoskeletal system, which was taught after the Easter vacation,  
8 was an important test bed for online anatomy teaching. In the longer term, it will be desirable  
9 for students to catch-up on the experience of handling and dissecting cadaveric material, but  
10 the timing and practicalities remain to be determined. For surgical skills courses, blended  
11 courses continued to be held online, with completion of the practical, workshop components  
12 deferred to whenever possible in the future. Equality of internet access, presumed to be a key  
13 issue for students, has also been a significant issue for many staff residing in rural  
14 Aberdeenshire.

15

16 *Cambridge:* For the first year medical course, hands-on cadaveric dissection was completed  
17 in the first two terms of the academic year, with the third term being reserved mainly for  
18 revision sessions. These would previously have comprised prosections but now consist of  
19 online images and videos, some of which had already been made during class demonstrations  
20 throughout the year. As the cadaveric dissection course had been complemented by the  
21 Visible Body® 3D Human Anatomy Atlas for all medical students, as well as tutorials created  
22 using the VH Dissector Touch (Touch of Life Technologies, Inc.) software throughout the year,  
23 the transition to online course provision was not too difficult for students. In addition,  
24 enrichment sessions with talks on the history of anatomical dissection, the process of body  
25 donation and embalming methods were held using the screen sharing function on the Zoom  
26 platform (Zoom Video Communications, Inc.). These sessions also used Breakout Rooms to  
27 divide students according to donor table groups for discussions of causes of death and end of

1 life trajectories, facilitated by Year 5 clinical students and anatomy demonstrators. Anatomy  
2 revision sessions based on specific clinical scenarios for Year 4 and 5 clinical students were  
3 delivered online. Second year anatomy exams had already taken place prior to lockdown, and  
4 the precise online mode of first year summative assessments was still being discussed. The  
5 University made the Panopto™ system available for lecturers to create video recordings on  
6 desktop or laptop devices and deliver them to students via our VLE Moodle platform that  
7 students already use. The Cambridge Centre for Teaching and Learning produced a specific  
8 guide to moving to online teaching, as well as regular webinars for teaching staff. The move  
9 to online teaching provision was definitely a steep learning curve for everyone. Concerns had  
10 also been raised regarding the difficulties some students faced in accessing online educational  
11 resources due to factors such as domestic circumstances and internet availability, as well as  
12 the possibility of compromised mental health due to prolonged isolation.

13

14 *Dundee:* All anatomy teaching moved online immediately after suspension of face-to-face  
15 teaching. While anatomy provision is heavily dissection-based, only relatively few dissections  
16 remained uncompleted, as closure came shortly before the end of the semester, when revision  
17 sessions are often scheduled. Although several practical classes had to be cancelled, some  
18 were histology classes that were easily delivered via the existing 'virtual microscope' system,  
19 normally accessible to students online. A variety of communication tools were swiftly brought  
20 into play, including audio PowerPoint presentations to replace lectures, and the use of VLE  
21 (Blackboard) to hold classes in Collaborate. All modules were set up in Microsoft Teams,  
22 which allows live events with presentations and/or Q&A, meetings for specific groups or the  
23 whole class, and group or personal 'chat' channels. Students also had access to a wealth of  
24 in-house online 3D anatomy learning models and resources, created by in-house medical art  
25 and other students. The whole university worked on an alternative assessment plan at module  
26 level to cater for the fact that written and practical examinations were no longer possible; this  
27 plan was completed, approved and communicated to all students on 26 March. In anatomy,  
28 several staff took a 'conveyor belt' approach to photographing all existing prosections on the

1 final day at work to ensure a good variety of digital images for use in online spotters, which  
2 replaced the end of year practical tests. Most written examinations were conducted online,  
3 with some in modified formats. For medical students, the School of Medicine made the  
4 decision to cancel all examinations and replace them with 'enhanced formative assessments'  
5 to be held in the next academic year. Final year medical students were permitted to graduate  
6 early in order to join the NHS workforce.

7

8 *Edinburgh:* All anatomy teaching at the University of Edinburgh moved online immediately  
9 following closure of the campus. The University made available significant resources and  
10 support for academic staff to obtain remote access training using both commercial and  
11 bespoke/in-house platforms, including the secure, password-protected VLE (LEARN),  
12 Microsoft Teams, and Kaltura Capture. It was decided to take different approaches for  
13 postgraduate and undergraduate students. For the former, given the smaller cohort size,  
14 lectures were live-streamed at a mutually convenient time using Skype, with screen sharing  
15 by the academic to show their PowerPoint presentation, with slides made available to students  
16 in advance. This allowed for real-time discussion with students, which was felt to be beneficial.  
17 As this approach would not be feasible for the larger undergraduate cohorts, LEARN was used  
18 to upload pre-recorded lectures and associated materials, including access to online textbooks  
19 and videos. To ensure that a human/personal touch was retained within remote delivery, a  
20 short 'to camera' introductory video for each session was given by an academic. The transition  
21 to online teaching was aided greatly by having an established online Anatomical Sciences  
22 postgraduate programme (Kelsey *et al.*, 2020), from which it was possible to repurpose  
23 materials, and to obtain mentoring and support from academics with experience of delivering  
24 online anatomy teaching. None of the online materials contains images of Edinburgh donor  
25 material, but comprised only images from published resources.

26

27 To date, the main issue that was identified was a low level of student engagement with online  
28 resources, with the vast majority of lectures and other material having been accessed by only

1 c.25% of the student cohort, even after numerous email and LEARN reminders. As all practical  
2 spotter examinations were cancelled, anatomy questions were embedded into online MBChB  
3 and Biomedical Sciences papers in the form of both multiple choice and short essay questions.  
4 A decision was taken not to attempt replication of practical, lab-based examinations online, or  
5 online replacement for hands-on dissection classes for our MSc student cohort. Similarly,  
6 attempts were not made to reconfigure anatomy-based CPD or commercial courses and  
7 activities using online approaches. Early, anecdotal feedback from students that were moved  
8 to an online environment, excluding those who are already enrolled on online courses,  
9 suggested that they were missing the face-to-face contact with Anatomy staff and the ability  
10 to physically interact with specimens (Gillingwater, 2008) in the Anatomy Teaching Laboratory.

11

12 *Glasgow:* The crisis started at a time when the bulk of cadaveric Gross Anatomy teaching in  
13 Glasgow had already been delivered and dissection had been completed for the majority of  
14 students. Had the crisis started 4 to 6 weeks earlier, disruption of cadaveric practical teaching  
15 would have been much more severe. Once the crisis is over, dissection experience will be  
16 offered to the latter group. In general, practical cadaveric anatomy sessions were replaced by  
17 online resources, and students given access to lecture material, with additional explanations  
18 and links to existing material available in the public domain. For spotter examinations, images  
19 of specimens were used. Where practical cadaveric anatomy sessions were replaced by  
20 online resources, students were given access to further electronic reading material and  
21 resources, with additional explanations, and links to existing educational material already  
22 available in the public domain. This was complemented by interactive live sessions delivered  
23 online, as a 'virtual' replacement for dissection classes, and also interactive discussions in a  
24 virtual learning environment platform (Moodle and Canvas).

25

26 *Imperial College London:* The bulk of preclinical anatomy teaching for the current academic  
27 year had been completed before closure of the College. Therefore, the impact of the pandemic

1 on undergraduate anatomy teaching will depend largely on when the College reopens. If  
2 'normal service' is resumed for the beginning of the academic year 2020-21, the effect will not  
3 be significant. While there will be problems such as the lack of newly prepared prosections  
4 and the backlog of donors to be released for funerals, as well as the many 'housekeeping'  
5 tasks that would have been carried out in Anatomy Facilities over the summer months, these  
6 should be manageable. However, if the College does not reopen fully, considerable  
7 reorganisation of the curriculum will be required. This will inevitably involve more online  
8 learning and less direct staff-student contact. The College invested heavily in hosting external  
9 online resources and developing in-house ones. Subjects that are practical in nature are being  
10 delayed, at least in part, until the pandemic is over. This delay is likely to involve 'catch-up'  
11 summer schools in 2021. Final MBBS examinations were held online. The situation regarding  
12 postgraduate training remained unclear. Royal College membership is required for entry into  
13 specialist training, but on 16 March, the Surgical Royal Colleges announced the cancellation  
14 of the MRCS Part B examinations, which contain a substantial anatomy component, until  
15 further notice. In addition, there no training courses were available to prepare candidates for  
16 these examinations. Much uncertainty therefore remained concerning how entry into specialist  
17 training would be determined in the next round, in the absence of professional examinations.

18

19 *Münich (LMU)*: On 30 March, the issue of a German Ministry of Health directive regarding  
20 medical education provided the legal framework for preparations for a virtual summer term at  
21 the medical faculty of the LMU. The measures are expected to be in place until the clause of  
22 national importance relating to the COVID-19 crisis that was issued by the German Parliament  
23 on 28 March is withdrawn. The summer term at the LMU started on 20 April with online  
24 teaching. The university acquired a one-year campus licence from the commercial provider  
25 *Zoom* for all academic staff and this was used for preclinical teaching. Due to reported security  
26 problems *Zoom* was only used when no personalized data (i.e. patient data) was transmitted  
27 during teaching. For sensitive meetings a different system, *dfnconf*, was utilised. All medical

1 students, especially those who have passed their first major exam (M1 or Physikum) were  
2 asked to apply for a part-time contract of 19 hours a week at the university hospitals, which  
3 are expected to see high numbers of COVID-19 patients. These students were provided with  
4 an adapted curriculum adjusted to their clinical duties.

5

6 *NUI Galway*: There were only 3 weeks remaining in the NUI Galway term which would have  
7 ended on 4 April. The two Gastrointestinal and Renal system modules, which are taught to  
8 185 medical students were affected by the crisis. These are normally delivered in the last six  
9 weeks of the second semester, and are taught as integrated systems-based modules with  
10 lectures from Anatomy, Physiology, and Biochemistry as well as clinical disciplines. They  
11 would also include laboratory sessions in Anatomy and Physiology. While 60% of the  
12 Gastrointestinal System Anatomy practical components had been completed, the Renal  
13 System practical classes could not be held. Three BSc modules comprising 40 students were  
14 also affected. For these students, half of the lab component for the Gastrointestinal System  
15 module could not be completed, as well as half of the Head and Neck module. One Gross  
16 Anatomy demonstration session was cancelled for the 24 students taking the second year  
17 Podiatry module. Commercial Biomedical Device Gross Anatomy teaching was suspended,  
18 as were the remaining Gross Anatomy sessions for the 19 students enrolled on the  
19 MSc/Postgraduate Diploma in multidisciplinary Radiology. All teaching was delivered online,  
20 generally via VLE Blackboard using Blackboard Collaborate Ultra tool and Audio enhanced  
21 Lecture material delivered via Audio PowerPoint or MP4 files. Students were also supported  
22 via a host of e-learning materials: Acland's Video Atlas of Anatomy, Visible Body Atlas of  
23 Human Anatomy, OpenStax Anatomy and Physiology, Complete Anatomy, Anatomus,  
24 BioDigital Human, BioDigital Studio, and IMAIOS. All first year examinations for medical  
25 students in the second semester were conducted online in MCQ format, with cadaveric images  
26 from donors who had provided consent. In addition, Wolters Kluwer/Lippincott Williams &

1 Wilkins made many of their anatomy texts and resources freely available for use during the  
2 crisis.

3

4 *Oxford:* Much of the preclinical anatomy teaching for the current academic year had been  
5 completed before the lockdown. However, the final academic term was significantly affected.  
6 The longer-term impact of the pandemic on anatomy teaching will depend largely on when the  
7 University reopens. There is optimism for a return to the 'new normal' by the start of the  
8 academic year in October 2020, but if the situation extends beyond this, the level of disruption  
9 will be considerable. If the University does not reopen fully by then, considerable  
10 reorganisation of the medical curriculum will be required. Significant resources have already  
11 been devoted to developing online teaching, which migrated from a 'Weblearn' system to a  
12 new 'Canvas' application. The way in which online teaching might best be developed is  
13 currently being investigated within a broad framework offering a variety of learning resources,  
14 including Instant Anatomy and Acland's Anatomy as well as an extensive set of in-house  
15 notes, diagrams and videos to cover the curriculum. Intensive pre-professional examination  
16 preparation courses held in the evening for regional surgical trainees were suspended.

17

18 *RCSI:* Lectures with slides and commentaries were recorded on PowerPoint Show and  
19 additionally as MP4 movies, so that the laser dot was visible on Mac computers. A Research  
20 Lecturer, an engineer, was the Department 'Superuser' and liaised with staff and Information  
21 Technology. Bespoke online guides were produced for dissection and histology 'in-house'. A  
22 bespoke surface anatomy guide was made available as freeware on YouTube  
23 (<https://bit.ly/RCSISurfaceAnatomy>) to all anatomy students (Morris *et al.*, 2016). Staff  
24 communicated with students via email and conducted online Q&A sessions. Some students  
25 preferred recorded lectures, as they could pause and rewind at will. A number of students  
26 commented that they missed the personal tuition and 3D aspects of Anatomy Room teaching.

1 Anatomy examinations, first-sitting and supplemental, took place online in MCQ format, with  
2 only pass/fail grades being awarded. Examination dates were postponed and an exceptional  
3 third sitting was offered to mitigate against the disruption to students in view of home  
4 circumstances and adaptation to distance learning.

5

## 6 **Looking to the future**

7 Given the widespread disruption to Anatomy teaching and practice detailed above, the final  
8 section of this review discusses potentially important issues that are likely to need addressing  
9 as the anatomical community emerges from the COVID-19 pandemic.

10

11 It is perhaps fortuitous that the Anatomical Society has recently completed the process of  
12 design, revision and publication of core anatomy syllabi for a range of student populations  
13 (e.g. Smith et al., 2016; Connolly et al., 2018; Finn et al., 2018; Holland et al., 2019; Matthan  
14 et al., 2020). These syllabi provide a useful standardised framework for anatomy educators to  
15 design and assess the content of courses, whether delivered face-to-face or online, albeit with  
16 efforts to validate their potential application and usefulness currently ongoing (Smith et al.,  
17 2020). What remains unclear is the extent to which online replacement of anatomy teaching,  
18 or the uptake of blended learning models (combining on campus with online approaches), will  
19 leave unavoidable gaps in core content, knowledge and practical application. This issue will  
20 need to be investigated in significant detail over the coming months and years, together with  
21 the longer-term impact on student knowledge and professional capabilities. Whilst the move  
22 to online teaching is going to affect all subjects to a greater or lesser degree, the loss of hands-  
23 on practical teaching using cadaveric material is of particular importance and relevance for  
24 the study of Anatomy. Early, largely anecdotal, experience suggests that the online resources  
25 and opportunities being made available at short notice are not capable of replacing the face-

1 to-face, practical-based experience of an anatomy teaching laboratory. It will, therefore, be  
2 important to address how students that have been affected by the COVID-19 pandemic can  
3 replace or substitute these activities in the future, taking into consideration their own concerns  
4 and views. Such factors may also influence the decision-making process for students  
5 considering applying for enrolment on courses with an anatomical component over the coming  
6 years.

7

8 As a group, the authors hold the view that hands-on examination of cadaveric specimens, and  
9 where possible dissection, remains the gold standard for anatomical education. Such  
10 activities, with associated benefits concerning student engagement, cannot be replaced or  
11 substituted for by virtual/online methods alone. Moreover, considerations regarding the value  
12 of working with cadaveric specimens in terms of developing necessary professionalism and  
13 manual dexterity need to be considered, when students are missing the opportunity to have a  
14 platform for developing and practising empathy, hand and teamwork skills, as well as an  
15 appropriate professional attitude. The cancellation of practical-based examinations is also a  
16 concern. When such methods of assessment have been largely removed, with no detriment  
17 to student progression in many cases, it is important to try to assess students' practical skills  
18 and knowledge using other robust methodologies. In the long term, therefore, reinstatement  
19 of practical-based anatomy examinations will be one of the most important elements of  
20 resuming 'normality' once the pandemic is over. This situation is likely to be particularly  
21 pertinent with regards to surgical trainees, since Royal College Membership is required for  
22 entry into specialist training, but at present the Royal Colleges have suspended their MRCS  
23 Part B examinations (which by definition contain a substantial anatomy component) until  
24 further notice. This raises significant concerns in terms of the progression of trainees to  
25 surgical training with inherent workforce planning implications for the delivery of front-line  
26 medical care. Taken together, it is clear that the short- and medium-term consequences of

1 COVID-19 disruption for the assessment of anatomical knowledge and skills will need to be  
2 addressed by targeted, quantitative research studies over the coming months and years.

3

4 Given the importance of cadaveric donor material for all levels of anatomy teaching  
5 (undergraduate, postgraduate and CPD), the long-term supply of donors is of concern. There  
6 will need to be national/international guidance on the requirements to add coronavirus to other  
7 existing risk factors (e.g. prion/BSE, HIV and TB) as potential post-mortem risks for both staff  
8 and students. Given that a number of institutions rely on imported anatomical material to meet  
9 demand, the development of an internationally-recognised framework and reporting procedure  
10 (as well as best practice guidelines) will be important. Moreover, the resumption of bequeathal  
11 programmes will be important in order to meet demand for anatomy training over the coming  
12 years. Many universities and medical schools continue to receive several enquiries a day from  
13 donors and/or their relatives, despite the closure of body donation programmes. Fortunately,  
14 most potential donors do appear to understand that the cessation is temporary. Nevertheless,  
15 there is likely to be a decrease in donor acceptance rates due to COVID-19 as a cause of  
16 death and the increased mortality during this period, which may result in a decreased death  
17 rate among the donor base in future years. Therefore, when the pandemic is over, raising  
18 public awareness of the continuing need for donors for Anatomical Examination may be  
19 necessary. It should be noted that some elderly potential donors have been distressed at the  
20 thought they will not be able to complete their lifelong intention to donate their body for  
21 Anatomical Examination. Anatomists, as a community, must not forget what an important  
22 decision this is, both for them and their families.

23

24 Several options exist to deal with the issue of donor availability. It is possible, where facilities  
25 and skills are present, to introduce or reintroduce longer-term preservation techniques, such  
26 as plastination. This serves to increase the 'shelf-life' of specimens and may also permit future

1 sharing of resources between anatomy facilities, as long as traceability and secure transport  
2 facilities can be ensured. Such activities may be supplemented and supported by the use of  
3 emerging 3D printing technologies to generate anatomical 'specimens' from tomographic  
4 radiological data from donor or patient material. It may also be necessary to prioritise  
5 embalming of donors that would previously have been used for fresh-frozen work. Although  
6 the response of the SARS-CoV-2 virus to embalming and fixation is currently unknown, the  
7 wide range of embalming techniques available offers a good chance of finding at least one  
8 that can render COVID-19 donor material safe for anatomical examination. Of course, the  
9 process of embalming will still remain a high-risk activity for anatomy staff. Information and  
10 guidance papers are being published rapidly as the international community gains more  
11 experience and knowledge of the virus (e.g. Finegan et al., 2020; Kampf et al., 2020; Royal  
12 College of Pathologists, 2020), and the anatomy community will also be informed by these.  
13 Regardless, COVID-19 testing facilities may be required for anatomy mortuaries, as well as  
14 the provision of full PPE for all staff undertaking embalming activities.

15

## 16 **Conclusions**

17 The United Nations has described COVID-19 as the most significant event since the Second  
18 World War. Things will never be the same again. However, it affords both challenges and  
19 opportunities. One opportunity moving forward is for the anatomical community to cooperate  
20 more effectively and share resources (both physical and intellectual) more widely. Cooperation  
21 will be required to define best practice guidelines for embalming to deal with this new infectious  
22 agent. We also need to develop a protocol for dealing with future pandemics that will enable  
23 us to respond faster and better than at present. The current situation similarly presents an  
24 opportunity to test rigorously the strengths and weaknesses of online anatomical teaching in  
25 practice.

26

1 Anatomy has been at the heart of medical and scientific teaching and research for several  
2 centuries. There is no reason for this not to continue into the future. The strength and  
3 willingness of anatomists (including support staff as well as academics) to rise to the  
4 challenges that have presented has been a source of great pride within and outside the  
5 anatomical community. This is something that we all need to celebrate and recognise.

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