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T:1 | Decline of oligodendrogenesis in the murine and human white matter

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Oligodendrocytes (OLs) are specialised glial cells that myelinate axons in the central nervous system (CNS). Myelinated axons are bundled together into white matter (WM) tracts that are essential for rapid, integrated neronal communication and cognitive function. A population of adult oligodendrocyte progenitor cells (OPCs) is responsible for the life-long generation of OLs, which is essential to replace myelin lost in pathology. Recently, we have demonstrated that there is a marked loss of OPCs in the ageing murine bran, which is associated with the loss of WM and cognitive decline. To examine the underlying causes of age-related myelin loss in humans, we performed an *in silico* transcriptomic analysis of Intralobular WM of human samples from the UK Brain Expression Consortium (UKBEC), and samples were assigned to one of two age groups: young (18–31, n = 20) or old (71–96, n = 20). Differential expression (DE) analysis identified a marked decline in oligodendroglial genes, including the OPC gene *PDGFRA* and the myelin genes *MBP* and *MOBP*, supporting our recent findings in mice. Functional protein–protein network and Gene Ontology (GO) analyses highlighted that the biological pathways most disrupted in ageing human WM were involved in Neurogenesis, Cognition and CNS Development. Moreover, pathway analysis identified age-related perturbation of G-Protein Receptor Signalling and MAPK Signalling pathways, which are known to be key regulators of oligodendrogenesis and myelination. Next, we used a pharmacogenomic and functional protein–chemical network analysis approach to discover potential therapies for rejuvenating OPCs in the ageing human brain, and the result shows that the PI3K/AKT/MTOR signalling pathway was one of the most important therapeutic targets to stimulate oligodendrogenesis in the ageing human WM. To test this, we used the WM model of mouse optic nerve organotypic culture and demonstrate the PI3K/AKT modulator LY294002 profoundly promotes oligodendrogenesis. These studies determine key changes in OLs that underlie the decline in myelination in the ageing brain. Furthermore, we identify drugs that target pro-oligodendroglial signalling pathways as potential new therapies for promoting the life-long generation of OLs and maintaining cognitive function. Human Data were obtained from publicly available datasets (GSE46706). Animal studies were performed in accordance UK Animals Scientific Procedures Act, 1984.

T:3 | 3D imaging reveals novel organisational insights into the mouse outer retina

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The retinal pigment epithelium (RPE) maintains the light-sensitive photoreceptors of the retina and forms the outer blood–retinal barrier. Amongst its functions, RPE cells internalise and degrade discarded outer segments (OS) from overlying photoreceptors as part of the daily photoreceptor renewal. Pathogenic changes to the RPE monolayer and its underlying Bruch's membrane (BrM) are linked with irreversibly blinding conditions including age-related macular degeneration (AMD), which is the most common cause of sight loss in the United Kingdom. The current understanding of RPE anatomy and adjacent tissues in the outer retina is largely derived from conventional 2D electron microscopy studies. Here, we used serial blockface scanning electron microscopy (SBF-SEM) to reconstruct RPE cells from the central retina of C57BL/6 mice (n = 3 eyes from three animals). 3D reconstructed OS revealed larger bi-nucleate RPE cells to support more photoreceptors, although their cytoplasmic volume was comparable to smaller mono-nucleate RPE maintaining fewer photoreceptors. However, irrespective of their nuclei numbers, RPE cells supported larger numbers of photoreceptors than previously thought. 3D data enabled us to calculate the angle and surface area of contact between apical RPE microvilli and interdigitating OS. 3D reconstructed mitochondria revealed novel organisational details of these organelles in healthy RPE cells. Bi-nucleate RPE contained more mitochondria, which appeared to be fragmented. Bi-nucleate cells also contained large sub-RPE spaces that support a likely association with pathogenic changes in the RPE–BrM interface linked with

age and AMD. Use of macros quantified cell–cell interactions in the RPE monolayer. 3D-in formation also enabled the reconstruction of a user-manipulable virtual RPE cell and to print RPE cells in 3D. The use of perfusion-fixed tissues ensured the highest possible standard of preservation and a benchmark for comparing diseased retinal tissues from patients with AMD and other retinopathies. Our discoveries pave the way for further 3D-scrutiny of RPE anatomy, so pathogenic changes linked with age and retinopathy can be better understood. Ethics statement: Animal studies were approved by the local Ethical Research Committee (Home Office licence #P395C9E5F) and carried out in accordance with the UK Animal (Scientific Procedures) Act of 1986. Experiments conformed to the ARVO statement for the use of animals in Ophthalmic and Vision Research.

T:4 | COVID-19 Neuropathology: Evidence for SARS-CoV-2 invasion of anatomically defined regions in the human CNS

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SARS-CoV-2 is a novel strain of Coronavirus that mainly targets the respiratory tract, but with important implications also for the CNS. Data deriving from previous autopsy studies support the neuroinvasive potential of SARS-CoV-2, even though infection appears to be limited to sparse cells within the brainstem and was not associated with the severity of neuropathological changes.

In the following study, we assess the neuropathological changes and viral neurotropism of 24 patients who died following a diagnosis of Sars-CoV-2 infection in Padova, Italy from March 2020 to January 2021. Cases predating COVID-19 and matched for age, sex and prior medical conditions were included as controls. The cerebrum, cerebellum, brainstem, cranial nerves, meninges and choroid plexus were sampled and histopathological evaluation was performed by the means of histochemistry and immunohistochemistry for GFAP, CD3, CD20, CD61, CD68 and HLA-DR. SARS-CoV-2 proteins and RNA were investigated through immunohistochemistry, RT-PCR, in situ hybridisation and punch-biopsy electron microscopy. COVID-19 subjects presented characteristic patterns of astrogliosis and microglial activation within anatomically defined regions of the brainstem. HLA-DR+ microglia, microglial stars and CD68+ macrophage clusters were suggestive of neuronophagia in 18 cases within the area postrema, nucleus ambiguus, solitary tract nucleus, basilar pons and substantia nigra. Viral proteins were detected at the level of the cerebellar meninges in four (4) cases and within the brainstem in six (6) cases. RT-PCR confirmed viral RNA within the IHC+ sections. In three cases, viral proteins were detectable within the anatomical boundaries of the solitary tract nucleus, nucleus ambiguus and substantia nigra. In one case with prior HCV+ hepatic encephalopathy, viral proteins were also detected within the basilar pons and mesencephalic tegmentum. Three cases displayed viral protein immunoreactivity in areas of recent ischaemic injury within the cerebellum and cerebral cortex. Our findings strongly support the neuroinvasive potential of SARS-CoV-2, likely following anatomically defined pathways to reach the centres of the medullary tegmentum and the brainstem. However, within the COVID-19 group, neuropathological changes did not correlate with viral invasion. This can be ascribed not only to the systemic effects of infection, i.e. cytokine storm, but also to the relatively short interval between infection and death. Human autopsy tissue study was authorised by the ethical committee of the University Hospital of Padova. Human brain tissue for the control cohort was collected according to the ethical standards of the Body Donation Program of the University of Padova. All procedures were carried out in accordance with the Declaration of Helsinki.

FT:1 | Assessing human anatomy students' perceptions of the interim online teaching and assessment measures, during the COVID-19 pandemic, at the University of Glasgow

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At the University of Glasgow, students acquire programme specific knowledge/skills from year 3 with the first 2 years providing a scientific overview. The BSc in Anatomy year 3 entails hands-on cadaveric dissection and histology along with scientific skills. With the onset of the COVID-19 pandemic, we introduced a range of interim online measures in year 3. These included synchronous and asynchronous virtual labs, utilising electronic resources (eResources), recorded lectures and alternative online assessments. The primary aim of this research project was to assess anatomy students' perspectives of these interim measures. An anonymous survey, using a mixture of Likert scale questions (rated out of 5 as the highest/best score) and open-text feedback, was used to collect data in April/May 2021 on the following themes: communication, eResources, assessment, feedback and inclusion and diversity. Ethics was granted by the MVLS College (application number: 200200083). Overall, 23 responses have been received out of 38 (61% response rate). The majority felt that communication was excellent (12/38, 52%) or very good (10/38, 43%) with MS teams rated as the best tool in terms of accessibility (78% rated 5/5), ease of use (74% rated 5/5) and interactivity (83% rated 5/5). All participants said that they were able to access the eResources and found them helpful for learning with open-text comments highlighting their usefulness as online alternatives for consolidation of theoretical knowledge and appreciation of 3D anatomy. Cadaveric dissection videos and the real-time 3D atlas were noted as the most useful eResources. Compared to

synchronous and asynchronous labs, on-campus labs had the highest rating (83% rated 5/5) for learning usefulness. Seventy-eight percentage (18/23) of participants found the recorded lectures engaging and 91% (21/38) felt that the assessments supported learning with reflection rated the highest as a developed skill (78% rated 5/5) followed by anatomy knowledge and writing (48% rated 5/5), presenting (44% rated 5/5) and ethics (13% rated 5/5). The average score for feedback experience was 4.13 out of 5. All participants felt that the course was inclusive and diverse. These findings stress the usefulness of eResources, while also highlighting the importance of on-campus lab experience in anatomy.

FT:2 | A novel three-dimensional papercraft modelling activity for hands-on remote learning of reproductive anatomy during coronavirus restrictions

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Anatomical knowledge and understanding can be hard to acquire, even before coronavirus (COVID-19) restrictions limited access to standard physical resources, such as plastic and cadaveric models. Low fidelity models, such as papercraft, can effectively teach anatomical knowledge and be made at home. The potential for students to construct physical models remotely was investigated as a means of three-dimensional (3D) anatomical learning during the COVID-19 era. The aim was to create 3D papercraft model resources for learning human reproductive anatomy and evaluate their ease of use and usefulness when implemented remotely at Exeter Medical School. The study method used a questionnaire design to evaluate students learning from a papercraft assembling activity. Novel papercraft models of the male and female reproductive anatomy were created using anatomy textbooks, 3D Adam Rouilly anatomical models and anatomical teaching software. Instructional booklets and videos of real-time construction for remote independent construction were also created. Twenty-five second-year medical students participated in learning activities including completing the models before attending an expert-led tutor session for consolidation. A formative multiple-choice question (MCQ) test was provided. This study ran as a mixed-method single-case experimental design, with data provided via focus group interviews and questionnaires. The questionnaire assessed core subsections of the project using a 5-point Likert scale. The total mean for the questionnaire subsections was calculated (mean ± SD), given the statements' positive weighting, participants found the model making resource: easy to use (4.06 ± 0.48), useful in learning anatomy (3.93 ± 0.56), having no significant logistical or administrative issues (4.18 ± 0.54). The focus group interview showed participants believed the activity had potential future applications and found the MCQ beneficial. Clinical content, colouring and peer work were also raised as potential additions to the learning activity. The novel papercraft

models allowed hands-on, remote, anatomical teaching, were easy to use, improved participants' confidence in anatomical understanding and also highlighted the potential for overcoming barriers created by COVID-19 restrictions. This study demonstrates the potential for implementing low fidelity papercraft teaching in a Medical School curriculum. Ethical approval was granted by the University of Exeter College of Medicine and Health Research Ethics Committee.

FT:3 | Anatomy teaching in the times of COVID: Do students perceive online teaching as experiential learning?

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The COVID pandemic has caused unprecedented disruption to education. Social distancing measures have led to rapid and substantial changes in higher education. There is clear recognition that practical skills are difficult to deliver in an online format. Anatomy presents an interesting topic for this discussion, as the content is knowledge-based, however, it is traditionally taught experientially. Teaching students experientially offers educational benefits and also enhances student's professionalism and group working. However, many online methods of education reduce the social aspect of learning and curtail student's ability to learn from their peers or develop their professionalism. Over the past year, the authors have redesigned delivery to create a blended approach based on Kolb's experiential cycle. This comprises asynchronous online lectures, synchronous online webinars, socially distanced in-person lab classes and asynchronous online e-learning packages. To maximise future curriculum delivery, it is key to understand how students are using these resources and is experiential learning happening online or in the lab? Students registered on the MBBS programme in years 1, 2 or graduate entry were sent a survey comprised of Likert style questions and free text boxes to evaluate their use of these different educational resources and methods. Students were asked which resources were most useful for each stage of Kolb's cycle, concrete experience, reflective observation, abstract conceptualisation and critical reflection. Evaluation of responses (n = 86) demonstrates students have high levels of satisfaction with 66% saying they were very satisfied with anatomy delivery. When asked which resource they used for each phase of Kolb's cycle students most frequently selected lab classes for a Concrete experience (76%), e-learning for reflective observation (44%), webinars for both abstract conceptualisation (30%) and critical reflection (49%). Students also expressed a significantly higher degree of confidence to ask questions in an online environment, but significantly higher levels of professionalism in lab classes. These results highlight the importance of in-person laboratory teaching in anatomy learning, for creating experiences to learn from and promoting professional values in medical students. This study was reviewed and approved by the research ethics committee of QMUL, reference: QMERC20.330.

FT:4 | Evaluating student perceptions of anatomy teaching methods before and during the COVID-19 pandemic to improve the direction of anatomy teaching at the University of Manchester

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Due to COVID-19, lack of cadaver availability and social distancing regulations have changed the way anatomy is taught. At the University of Manchester, anatomy is traditionally taught as a weekly full-body dissection session, facilitated by a demonstrator. Anatomy teaching this year has included online tutorials supplementing shorter, socially distanced dissection room (DR) sessions. Second-year medical students have experienced anatomy teaching both before and during the pandemic, making them a unique and valuable cohort that can be utilised to evaluate which teaching methods are better. An online questionnaire was formulated by evaluating perceptions of anatomy teaching methods and was distributed to students. Data collected were analysed using Microsoft Excel. There were 215 responses to the questionnaire. Two-thirds of students enjoyed the traditional method of anatomy teaching more. In particular, over 80% of students enjoyed dissection and the group learning aspect. Over 70% enjoyed having their dissection sessions led by a demonstrator. Over half of the students preferred face–to-face teaching. However, two-thirds of students found the current method of anatomy teaching to be more useful. In particular, 80% of students found an online tutorial supplementing their DR session useful. Students also strongly favoured multiple, shorter sessions. Interestingly, we found significant differences between teaching methods students enjoyed and found useful. Traditional teaching methods allowed for more social interaction which may play a role in the students' enjoyment. When evaluating student well-being, 38.5% reported struggling to make friends and missing social interactions with peers. Students found current teaching methods more useful, in particular, they found the online tutorial session valuable. This may be because it allowed for better preparation for their time with prosections in the DR. Using the data from this study will help ascertain which aspects of anatomy teaching students have enjoyed and found useful for learning. Combining both teaching methods to improve the anatomy curriculum at Manchester will allow for a better educational experience and provide a blended learning model for other institutions to adopt. No identifiable information was collated, and the University of Manchester Ethical Approval Tool confirmed that no formal ethical approval was required for this study.

FT:5 | Can UDL principles be successfully employed for an online tooth morphology module during the COVID-19 pandemic?

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Tooth morphology is an integral component of dental education and is traditionally taught with lectures supported by practical study sessions using extracted/plastic teeth, tooth drawings and carvings. Following government travel restrictions due to the COVID-19 pandemic, the delivery of the tooth morphology module at the University College Cork (UCC) was conducted online for the academic year 2020–2021. The teaching tools provided to students for tooth morphology were centred around the Universal Design for Learning (UDL) principles. The students were provided with a range of teaching tools such as lecture notes, lecture recordings, 2D cue cards, 3D tooth models with identification points, interactive live sessions and online quizzes. Multiple means of engagement were employed and students were provided with a wide choice of learning tools to cater to individual choices, satisfying the learning objectives and outcomes of the module and providing feedback to the students along with opportunities for self-assessment, improvement and motivation. Multiple means of representation were offered to the students by generating an interactive dental arch grid representing permanent or deciduous dentitions. Each button on the grid was linked to a Canvas LMS page containing either a 2D flashcard or a 3D interactive model for each tooth. Lecture recordings, lecture notes and recordings of live sessions also all satisfied the various checkpoints under this UDL principle. Multiple means of action and expression were employed by using an online live quiz providing instant feedback, discussion and staff-led interactive sessions with discussion with the students. Examination for the module was conducted by using spot quiz exam, short answers and image-based questions. In conclusion, dental students were empowered through the learning process by the provision of multiple means of engagement, representation and action and expression, in line with the UDL principle. The goal is to develop students as learners who are not only resourceful, purposeful, knowledgeable and motivated but are also goal-oriented and can become strategic learners.

Ethical approval was obtained from Social Research Ethics Committee, UCC.

FT:6 | Pandemic Anatomy Education: The changing study habits of students Learning Anatomy in the United Kingdom and Ireland

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The sudden upheaval to student life caused by Covid-19 drastically changed how and where medical students study. Consequently, many anatomy educators chose to deliver their teaching via a blended format – a common recommendation by many institutions.

This investigation aimed to explore the behavioural changes to student's study environments and the challenges experienced as a result of learning anatomy remotely. This work also collated student's opinions of online anatomical resources, to inform future online teaching strategies. A 48-item survey instrument, containing a 33-item adapted Anatomy Learning Experience Questionnaire (ALEQ) was completed by 242 medical students from seven universities. The results revealed a statistically significant change in chosen study environment [X^2 (20, $n = 211$) = 217.7, $p \leq 0.001$] with the majority of students choosing to return to live with their parents/guardians (81.6%) from their local rented shared accommodation (38.9%). Two hundred and thirty-two respondents (96.7%) stated that they faced more than one challenge with online learning, while only four (1.7%) experienced no challenges or disruption. About 65.4% of students indicated that their confidence in anatomy decreased due to a lack of cadaveric exposure and changes to assessment formats. While the majority of students agreed (or strongly agreed) that all online resources were effective tools to learn anatomy, findings from the thematic analysis revealed that 'no-one size fitted all' in terms of resources. Chi-squared analysis revealed that students had a clear preference for formative examination opportunities created by their own instructors X^2 (4, $n = 113$) = 21.74, $p = 0.0002$]. However, there was no significant difference between preferences for asynchronous compared to synchronous lectures and educational videos made by instructors compared to those sourced online. In addition, students desired explicit and clear guidance on how to find and utilise accurate and reliable online resources, including advice on how to integrate them within their own learning approaches. This investigation suggests that online learning in anatomy can be successful, but that students are lacking confidence due to less hands-on teaching. Although online tools are an acceptable replacement in some instances, students welcome metacognitive strategies from their tutors to enable them to utilise such resources effectively and efficiently. Ethical approval was granted by BSMS Research Governance Ethics Committee (ER/BSMS9GHM/1).

FT:7 | Student and educator perceptions of remote anatomy learning

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The use of human cadaveric specimens in practical laboratory learning and teaching environments, supplemented by large group present-in-person lectures, have traditionally been the core approaches for the delivery of anatomy. Within the modern pedagogic landscape, the development and introduction of technology-enhanced learning strategies have enhanced the provision of remote anatomy learning resources. More recently, the Covid-19 pandemic has further increased the need for effective online provision. With a view to this, we aimed to investigate stakeholder perceptions of remote anatomy learning, the impact of Covid-19 on the availability and development of asynchronous resources, and the perspectives of participants with respect to the future directions and strategies for remote anatomy learning within post-pandemic curricula. A student-partner strategy enabled undergraduate project students to develop knowledge, skills and abilities during contributions to research design, implementation and data analysis. A mixed-methods approach was conducted within a pragmatic theoretical framework. A questionnaire instrument consisting of a 7-point Likert-type scale and free-text items was administered to a second-year medical cohort ($n = 340$), who had experienced remote anatomy learning both pre-Covid-19 and during the pandemic. Two focus groups involving medical student ($n = 10$) and anatomy educator ($n = 3$) participants, respectively, were conducted virtually via videoconference in February 2021 to explore richer and deeper perceptions of remote anatomy learning. Data were analysed statistically and by double-coded semi-quantitative or qualitative thematic analysis as appropriate. Responding students ($n = 145$) perceived that the guidance and provision of pre-pandemic and Covid-19-era remote anatomy resources were largely effective for their learning. Focus groups identified improvements in the variety and accessibility of detailed and relevant multimodal content since the pandemic began. From the student perspective, a curriculum of in-person teaching blended with high-quality remote resources would be welcomed in future. Educators noted that rapid responses to Covid-19 had resulted in the creation of more effective remote resources, despite technological challenges and concerns regarding the online delivery of cadaveric teaching. These findings will have implications for the design, development and implementation of remote anatomy learning resources within post-pandemic blended curricula. Institutional ethical approval was obtained for this work.

FT:8 | Assessing student opinion of online, case-based gross anatomy learning for abdominal cavity utilising MRI and XR technology

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COVID-19 pandemic caused an accelerated need to provide effective medical education remotely to a wide range of student populations. Delivery of Cadaver-based anatomy education was particularly compromised and required an alternative approach. The purpose of this study was to develop and implement an online case-based anatomy education workflow and deliver it cross-culturally. Two medical

student cohorts were utilised including second-year students from the University of Hawaii JABSOM (n = 78) while a Turkish cohort (n = 16) consisted of first- and second-year English language proficient medical students. The workflow consisted of MR scanning cadavers, uploading to a website (rad3d.com), creating case reports based on abdominal anatomy, radiology and pathology findings, developing XR assets, posting (sketchfab.com) and delivering the cases remotely to students via Zoom. The case information was presented to the large group and then students were divided into small groups and placed into break-out rooms where they generated and recorded hypotheses. They returned to the main room where they presented their findings to the consolidated class. An optional survey was completed consisting of six prompts (5-point Likert scale) and median scores were compared between groups using the Mann-Whitney U test as well as open-ended questions. Median scores showed that Turkish students rated using the MR scans as an online tool for understanding anatomy higher than JABSOM students (p < 0.01) as well as the benefit of using MR scans for understanding relevant anatomy (p < 0.01). Turkish students also rated 3D online models for providing a better understanding of anatomy higher than JABSOM students (p < 0.01). Turkish students were more likely to use this type of system (p < 0.01) and wanted to see more opportunities in the future (p < 0.01). Turkish students rated the ability to communicate in the breakout rooms somewhat lower than JABSOM students (p < 0.04). All median scores were 4 or above indicating a positive experience overall. These results indicate that cadaver case-based learning utilising MRI and XR technology was considered useful by both groups suggesting that this approach could be effective for remote instruction amongst culturally diverse student groups. This study was institutionally reviewed and approved (IRB 2018-00120).

FT:9 | Evaluating whether medical student knowledge of clinical ear anatomy meets learning objectives, and whether it can be improved using dissected specimens during the COVID-19 pandemic

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The purpose of this study is to establish whether ear anatomy teaching for medical students at St George's University of London (SGUL) is sufficient to meet learning objectives set by SGUL and the General Medical Council (GMC) in their 'Tomorrow's Doctors' guidelines and whether it can be improved using cadaver specimens. Participants first completed an online survey. This consisted of a Likert scale containing nine questions to assess satisfaction with anatomy teaching, and other survey items exploring opinions on different teaching methods. Participants also completed an online exam with 10 questions to assess baseline ear anatomy knowledge. Following this, participants attended an online lecture covering ear anatomy and clinical ear, nose and throat (ENT) presentations,

blueprinted against SGUL learning objectives. Finally, participants completed a second online exam to assess their new knowledge and completed a second survey to enable the comparison of the new teaching session against previous SGUL teaching. Pre-teaching Likert scale responses were low, with an average of 2.51/7 (low scores indicate lower satisfaction), and the mean exam result was 6.47/10. About 69.8% of students wanted cadaver dissection to form a larger component of their teaching, and 96.3% of students reported plastinated models as being beneficial to learning. Post-teaching, Likert scale responses increased by 3.20 points to 5.71/7, 95% CI [2.61–3.80], t(20) = 11.20, p = 0.001 and examination scores also increased to by 1.65 points to 8.12/10, 95% CI [0.69–2.61], t(16) = 3.63, p = 0.002. Student satisfaction with ENT teaching is low and there is a desire for new teaching methods, indicating an exciting opportunity to innovate and improve the curriculum. This study's results demonstrate the benefit to students of incorporating new teaching resources into the curriculum, including giving greater access to cadaver specimens and utilising pre-recorded teaching sessions. This study was given a favourable ethical opinion by the Joint Research and Enterprise Services at SGUL (REC Reference: 2020:0286).

FT:10 | Rapid and medium-term adaptations to Covid-19: Insights from an undergraduate medical programme

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Anatomy education at Newcastle University is delivered within the 'Essentials of Medical Practice' (EOMP) phase of the medical programme, which comprises the first 2 years of undergraduate study. This period is designed to support entrants in their transition from further education into the study of practical clinical medicine. The EOMP curriculum is structured in a case-based format in which anatomy, life sciences, clinical and communications skills and early clinical experience are integrated. Prior to the onset of the Covid-19 pandemic in March 2020, EOMP teaching was primarily delivered in a present-in-person format, and supplementary resources were provided for self-directed learning via the bespoke virtual Medical Learning Environment. Students were regularly, summatively and formatively assessed on their knowledge, skills and professionalism. The Covid-19 pandemic resulted in the immediate cancellation of present-in-person teaching and the rapid transfer of taught content to remote online delivery during the final period of teaching in the academic year 2019-20. Subsequently, and during 2020–2021, blended curricula have been developed for the delivery of effective student learning within necessary institutional frameworks. This blended approach has combined practical present-in-person classes with online synchronous and asynchronous learning. Here, we report examples of adaptations that were rapidly developed and utilised to deliver the learning, teaching and assessment of EOMP

anatomy during the early weeks of the Covid-19 pandemic in 2019–2020. We also describe the medium-term measures that have been implemented to support blended anatomy learning during 2020–2021. For each case study presented, we describe the problems that arose due to Covid-19, the adaptations we implemented to solve these issues and our reflections on the impact and relative success of our interventions. Furthermore, we explore the extent to which we were able to utilise a scholarly and research-informed basis for the development of such adaptations, given the required urgency and logistical limitations that arose when reacting to unprecedented events. In addition to providing a record of this unique educational situation, we propose that the insights we have gained from responding to Covid-19 can inform the development of long-term educational strategies to support the delivery of post-pandemic anatomy curricula. Institutional ethical approval was not required.

FT:11 | Collaborative, two-directional live streaming to deliver hands-on human and canine cadaveric dissection experience during the COVID-19 lockdown

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Cadaveric dissection is a widely used tool in anatomy teaching, worldwide. The method has been shown to develop anatomical knowledge and practical dissection skill as well as communication and team-working skills. At the School of Anatomy, two of our units depend on dissection as a teaching tool; Advanced Dissection employs full-body human dissection, while Anatomy by Dissection focuses on comparative anatomy, with both human and canine cadaveric dissection. Social distancing guidelines brought about by the COVID-19 pandemic brought challenges to these units and meant it was not possible for all students to be present around a cadaver. We adapted with secure, two-way live streaming of our dissections, facilitated by ceiling-mounted cameras. A reduced number of students entered the dissection room on a rota, engaging with the practical element of the course. Those not scheduled to attend in person attended via Zoom. The dissectors were expected to narrate and ensure visibility of the dissection while posing questions to those at home. The homegroup provided feedback, generated discussion and conducted research. During 'full' lockdown, essential staff streamed the scheduled dissections to the whole group. Students appreciated being able to participate in practical teaching and understood the need for the changes. Most were satisfied with the capabilities of the software, though some commented on the difficulties appreciating deeper or more complex structures on the screen. Communication and team-working skills were maintained as essential learning points during the teaching. It is anticipated in-person practical sessions will resume in 2021–2022, though investment in this technology enables us to rapidly pivot to a reduced in-person, or an entirely online delivery, where required. Appropriate HTA licenses were in place throughout this unit. Institutional ethics were not appropriate as feedback was not formal.

FT:12 | Building a Community of Practice during pandemic anatomy teaching: Combining a face–to-face and remote Near-Peer Teaching programme to support clinical neuroanatomy education in Medicine

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At Southampton, the Near-Peer Teaching network (NPT) was created to provide a supportive teaching community for second-year BM5 medical students. Neuroanatomy is known to be a challenging topic in the curriculum and COVID-19 restrictions brought with it several obstacles for delivering medical education – particularly where students were unable to participate in face-to-face teaching. Historically, it has been the face-to-face practical element of teaching which has always provided a foundation for students to build their knowledge base in this subject area. Previous evidence has indicated that student-led teaching in medicine enhances the student experience and can reinforce knowledge in preparation for assessments. Establishing this type of learning community felt much more necessary this year, and so students partnered with staff to develop a series of remote neuroanatomy practical sessions. These involved using the breakout room function within Microsoft Teams (approximately ten students to two NPTs). Additionally, two socially distanced laboratory face-to-face sessions were offered, using carefully selected prosections that would have been challenging to study without three-dimensional appreciation. The module evaluation revealed that ($n = 67$), 66% of students strongly agreed or agreed that NPT involvement enabled them to feel part of a learning community during remote teaching, while 63% strongly agreed or agreed that peer-assisted teaching made them feel more comfortable to interact, particularly online. The majority of students (87%) considered the implementation of mock assessments within a practical setting as a valuable aspect of the blended approach. Despite this, feedback showed that 66% of the cohort remained concerned about their level of anatomical knowledge due to remote learning. The highest-ranked delivery methods for online sessions were PowerPoint presentations, interactive quizzes and live drawings. Although there were difficulties in adapting the NPT programme for remote learning, overall student satisfaction remained statistically unchanged ($p = 0.474$). This finding suggests that the student experience has been preserved by the NPT model despite Covid-19 restrictions. However, students are most likely lacking in confidence compared with other year groups.
This data utilised routine module evaluation data as part of a service evaluation and therefore ethical approval was not required.

YIO:1 | Identifying novel molecular mechanisms underlying electrosensory vs. mechanosensory lateral line organ development in a sturgeon, *Acipenser ruthenus*

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In all fishes and aquatic-stage amphibians, the mechanosensory lateral line system detects local water movement. Many species also have an electrosensory lateral line division that detects weak electric fields. In electroreceptive non-teleost jawed vertebrates, electroreceptor cells reside within 'ampullary organs' distributed in fields on the head, which flank lines of 'neuromasts' containing mechanosensory hair cells. Both ampullary organs and neuromasts develop from lateral line placodes that elongate over the head to form sensory ridges. Their shared origin makes the system a useful model to investigate cell fate decisions during development. However, electroreception was lost in the lineages leading to teleost ray-finned fishes and frogs, so the electrosensory vs. mechanosensory fate choice cannot be studied in the classic aquatic model vertebrates, zebrafish and *Xenopus*. To identify genes involved in ampullary organ development, we previously used differential RNA-seq in late-larval stages of a chondrostean ray-finned fish, the Mississippi paddlefish (*Polyodon spathula*), to generate a dataset of around 500 genes putatively expressed in lateral line organs. Our published and ongoing analysis of candidates from this dataset, including many transcription factor genes, suggests that electroreceptors and hair cells are closely related cell types. The paddlefish dataset also contains around 50 genes encoding transmembrane receptors, ligands or secreted Bmp/Wnt-pathway inhibitors. To gain insight into signalling pathways potentially involved in ampullary organ vs. neuromast development, cDNA fragments of most of these genes, plus additional signalling pathway candidates, were cloned in an experimentally tractable chondrostean, the sterlet (*Acipenser ruthenus*, a sturgeon). In situ hybridisation identified 24 genes expressed within developing lateral line organs, with several being expressed exclusively in the mechanosensory neuromasts. Ten of these genes were targeted for CRISPR-/Cas9-mediated mutagenesis in F0-injected embryos. For six genes, 25–40% of targeted embryos showed reduced ampullary organ development and/or mislocalised neuromasts, suggesting these genes are involved in lateral line organ development. Furthermore, DMH1-mediated inhibition of Bmp signalling for 20 hours before the first ampullary organs usually form led to precocious ampullary organ formation, suggesting that Bmp signalling normally delays ampullary organ development. Overall, this work provides new insight into the molecular mechanisms underlying the development of electrosensory vs. mechanosensory lateral-line organs.

Ethics statement: All experimental procedures were approved by the Animal Research Committee of the Faculty of Fisheries and Protection of Waters, University of South Bohemia in České Budějovice (Vodňany, Czech Republic) and by the Ministry of Agriculture of the Czech Republic.

YIO:2 | Understanding the role of Wnts during the regeneration of the murine tympanic membrane

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Tympanic membrane (TM) perforations are a common and debilitating issue, especially amongst children. Although the majority of perforations heals on their own, around 6% do not and become chronic. How does the TM reform its complex tri-layered anatomy? It has been postulated that a stem cell or progenitor population must reside in the TM and be responsible for this temperamental regeneration. These chronic perforations are currently corrected by invasive surgery, although alternative approaches involving the manipulation of signalling pathways are beginning to be investigated. Here we analyse the role of Wnt signalling during eardrum repair. Wnt signalling has been implicated in the regeneration of many different organs in the body and, as such, is a good target for investigation. Here we show that Wnt responding cells reside in the presumptive stem cell niches of the adult murine TM. Using Axin2 lineage mice, we show that these Wnt responding cells and their progeny contribute to the repair of TM perforations and appear to actively migrate to the wound site. In the future, we aim to undertake functional experiments to dissect how manipulation of Wnt signalling can enhance and disrupt the healing of perforations. Understanding how Wnt signalling is involved in this process is of fundamental importance to not only enhance knowledge of how regeneration takes place but also in the discovery of novel pharmacological approaches to treat human TM perforations. All procedures were carried out under Home Office licences and approved by the Kings College ethics committee.

YIO:3 | Do age-related differences in healthy and osteoarthritic mouse tibias show future imaging biomarkers?

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Novel imaging biomarkers are required to advance research into, and treatment of, knee joint osteoarthritis (OA). Early stage OA is undetectable in humans, and treatment effectiveness cannot be reliably

monitored. STR/Ort mice are an age-related model of progressive OA in which predisposition (at 10 weeks of age), early stage onset (at 20 weeks) and late-stage OA (at 40 weeks) are well-defined. Using STR/Ort (OA) and CBA (healthy parental control strain) mice at these age intervals, knee joints were non-invasively µCT imaged with an effective pixel size of 5 µm. Tibial epiphyses were semi-automatically segmented from knee joints and separated into their constituent anatomical components: cortical bone, trabecular bone and marrow space volume. These bony features can be detected in human knees using clinical *in vivo* scanners (XtremeCT II HR-pQCT, Scanco Medical), making translation of our research realistically attainable in the near future. 3D analyses of tibial epiphyses followed by two-way ANOVA confirmed significant age- and/or strain-related differences in epiphyseal cortical bone volume ($p \leq 0.001$), trabecular bone volume ($p \leq 0.001$), mean trabecular and cortical bone thicknesses (both p-values ≤ 0.010), trabecular volume relative to cortical volume ($p \leq 0.001$) and degree of anisotropy, a descriptive measurement of trabecular orientation ($p = 0.001$). The two mouse strains had different epiphyseal growth patterns throughout life with respect to total epiphyseal volume ($p = 0.023$), marrow space volume ($p = 0.002$) and trabecular volume relative to epiphyseal interior volume ($p = 0.024$) as well as changes in trabecular anisotropy indicating divergent age-related interactions in these two mouse strains. Our findings disclose new imaging biomarkers of pre-OA, OA onset and OA progression in the STR/Ort mouse, an established animal model of spontaneous age-related OA. Due to our exploitation of only gross anatomical features in the tibial epiphysis, which can also be segmented from clinical CT scans, we anticipate future translation of this promising research into human clinical practice. Ethical approval for animal procedures were carried out in accordance with the Animals (Scientific Procedures) Act 1986, an Act of Parliament of the United Kingdom, approved by the Royal Veterinary College Ethical Review Committee and the United Kingdom Government Home Office under specific project license.

YIO:4 | Morphological investigation of endothelial and sub-endothelial alterations associated with sickle cell trait in a mouse model.

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Sickle cell disease (SCD) is a haemoglobinopathy caused by a single nucleotide mutation in the beta-globin gene. Erythrocytes containing altered haemoglobin (HbS) can undergo changes in shape, plasticity and function if exposed to the reduction of plasma pH, oxygenation and temperature or dehydration. Homozygous subjects (HbSS) develop the multiorgan ischaemic disease, but recent data reveal a decline in glomerular filtration even in heterozygotes human subjects, although the mechanisms are not well understood. To date, the chimaera mouse developed by T.M. Townes, expressing human HbS, is one of the most used disease models to study SCD, but an exhaustive analysis of the morphology and histopathology of heterozygous animals (HbSA) has not been published to date. Three HbSS, 3HbSA and 3HbAA (controls) mice were investigated. A blood sample was obtained from each animal and, after sacrifice, liver, lung, heart, kidney and spleen were explanted, sectioned and fixed in 10% formalin for pathological examination after Haematoxylin and Eosin stain. Sections of liver and spleen from HbSA and HbAA mice were also fixed in 2.5% glutaraldehyde for Transmission Electron Microscopy. Histological examination of tissues from HbSS mice confirmed the presence of multi-focal necrosis in all organs, except in the heart and lung, where prevailed inflammatory changes; no significant changes were observed in HbSA mice. *Transmission electron microscopy:* compared to HbAA, HbSA mice showed thickened liver endothelial cells. Furthermore, it was found that the hepatocyte microvilli were compressed in the space of Disse. In the spleen, a thickening of the endothelial basal lamina of the marginal zone vessels was observed. These data could represent a form of tissue adaptation to the increased endothelial adhesion of red blood cells and increased oxidative stress with a consequent reduction of plasma diffusion. Our results suggest the usefulness of this heterozygous mouse model to study the mechanisms by which subclinical vascular changes may occur in asymptomatic patients with SC trait when subjected to particular environmental risk factors. All procedures were performed according to the Guidelines for the Care and Use of Laboratory Animals and were approved by the Italian Ministry of Health.

YIO:5 | Neuroanatomical evaluation of the therapeutic potential of rutin and gefitinib in β-amyloid oligomer-induced Alzheimer disease in Swiss albino mice and to probe the neuroanatomical parallels between lissencephalic Alzheimer mice brain with gyrencephalic human brains

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Animal models such as mice and rats were widely used for the understanding and development of therapeutic agents for Alzheimer's disease (AD). Although these models provide unequivocal histological, radiological and biochemical parameters similar to human brains but the gross neuroanatomical changes of lissencephalic AD mice brains

in comparison with the gyrencephalic human brains were seldom explored. Aim: The present study was designed to investigate the neuroanatomical effects of test drugs rutin and gefitinib in beta-amyloid (Aβ) oligomer-induced AD in male Swiss albino mice and to further explore the gross anatomical similarities of lissencephalic AD mice brain with the gyrencephalic human brain. AD was induced by i.c.v. injection of Aβ oligomer into the lateral ventricles of mice brain. The test compound i.e., rutin (50 and 100 mg/kg of body weight) and gefitinib (2 and 4 mg/kg of body weight) was administered orally (p.o.). The reference compound i.e., donepezil (1 mg/kg; p.o.) was administered for comparison of test compound results. At the end of experiment, animals were sacrificed, the mice brain was carefully dissected, length and breadth dimensions were measured and under the stereo microscope different parts of brain such as cerebral cortex, hippocampus, cerebellum and brainstem were precisely dissected and weighed. The AD-associated neuroanatomical changes were assessed by analysing the brain weight, body weight ratio and the ratio of different parts of brain with the whole brain. Data analysis has shown that administration of rutin and gefitinib had ameliorated the Aβ induced neuroanatomical changes Therefore, rutin and gefitinib can be an effective medicine for the management of Aβ-associated AD neuroanatomical changes and because the lissencephalic AD mice brain exhibited some similar gross anatomical changes of gyrencephalic human brain, these gross neuroanatomical findings of mice brain can be an additional parameter along with routine histological, radiological and biochemical parameters in the analysis of AD pathology.

The experimental protocol was approved by AIMST University Animal Ethics (AUAEC/FOM 2020/02 – Amendment No. 1). The caring of animals was taken as per guidelines of AUAEC.

T:5 | Preliminary notes on a human eared skull

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The purpose of this study is to detail the unique case of the so-called eared skull, which resembles the 'Memento Mori' mosaic displayed at Museo Archeologico Nazionale (MANN) in Naples (Italy). The analysed skull is currently exhibited in the hypogeum of the musealised Church of Santa Luciella ai Librai in Naples (Italy). This study used a multidisciplinary approach combining archaeo-anthropological, chronological, entomological, palaeopathological and photogrammetric analyses.

Here we report some preliminary results. Human remains in the hypogeum were [14]C 1631-1668-1s. Entomological analysis revealed insects associated with body decomposition as well as with wooden coffins. Because of its fragility, in order to avoid any contact with the skull and to obtain a reliable and accurate 3D model, a photogrammetric survey was performed using a calibrated steel scale bar. The preserved skull consists of the neurocranium, while most of its splanchnocranium is absent (only the nasal bones are present). The temporal bones were outwardly rotated, which had been wrongly assumed to be mummified auricular structures in the past. The morphological study of the skull revealed it is that of an adult male, based on the application of the anthropological methods to determine sex and estimate age at death. Since the skull showed some pathological features and only the coronal suture was clearly visible, a more precise range for age at death of this individual cannot be estimated. Palaeopathologically, the absence of the sagittal suture and porotic hyperostosis were described. Taphonomically, bright white salty encrustations, possibly linked to the humid environment, were seen as well as a cerebral fragment was found inside the cranial cavity. Photogrammetric setup was realized by introducing calibrated scale bars on the survey scene, and rendering software was used to produce a digital 3D model. No ethical approval was required.

T:6 | Neuronal wiring length and brain shape in *Homo sapiens* and *Macaca mulatta* during postnatal development

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The minimisation of neuronal wiring length has long been proposed as a major constraint on brain shape in highly encephalised species. We investigated the potential link between brain shape and a measure of overall neuronal wiring length during postnatal development in modern humans and Rhesus macaques. We analysed data from 58 humans (age 3–13 years) and 152 macaques (age 0.04–3 years). Diffusion tensor imaging (DTI) was used to create a measure of overall wiring length by combining fibre tract length measurements for the internal capsule and corpus callosum taken from diffusion tractography in a 3D slicer. A set of 17 anatomical landmarks representing the brain were placed in 3D Slicer using a T1-weighted MRI. Geometric morphometric (GMM) analyses were carried out on the landmarks in MorphoJ. In humans, there was little increase

of neuronal wiring length after 'adult' brain size was achieved (~3 years). In contrast, in macaques neuronal wiring length continued to increase beyond near-cessation of brain growth (~0.5 years). This suggests a possible continued and unconstrained restructuring of the brain in macaques beyond this age. We therefore hypothesised that shape change would be greater in the macaques than in humans. GMM analyses confirmed that this was so, for the given developmental period and brain areas studied. These findings demonstrate an uncoupling of brain size from shape and connectivity in macaques. The absence of this decoupling effect in humans suggests that the proposed neuronal wiring constraint condition is indeed a problem for highly encephalised species such as great apes. This may require the precocious formation, though not necessarily functional maturation, of major neuroanatomical pathways, meaning that wiring length may remain relatively fixed from an earlier age in great apes compared with other primate species. The study used ethically approved datasets from anonymised consenting humans in the NDAR (https://ndar.nih.gov) database and of *Macaca mulatta* from the UNC-Wisconsin Neurodevelopment Rhesus MRI Database (https://www.nitrc.org).

T:7 | Tessier Clefts – Numbers 3 and 4: Presentation of soft tissue and bony deformities in a South African population

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Tessier cleft numbers 3 and 4 are rare congenital craniofacial deformities. Tessier cleft number 3 runs from the philtrum of the superior lip, traverses the ala of the nose and ends at the medial canthus of the eye. Tessier cleft number 4 commences between the philtrum and the oral commissure in the superior lip and ascends into the orbit, remaining medial to the infraorbital foramen. The associated clinical manifestation of each type of cleft varies amongst patients. This study documented the soft tissue and bony deformities of Tessier cleft numbers 3 and 4 in a selected South African population. The study group was selected from retrospectively reviewed CT scan records, which were made available via the repository of the Department of Clinical Anatomy at the Westville campus of the University of KwaZulu-Natal. Seven out of 50 CT scans that met the inclusion criteria were assessed and analysed. The patient records associated with the selected scans were reviewed. The soft tissue and bony deformities characteristic of Tessier cleft numbers 3 and 4 were documented. The bony deformities present in the cases of this study included alveolar clefts, nasal septum deviation, hypertelorism and maxillary bone defects. The soft tissue deformities included cleft lip, nasolacrimal abnormalities, eye dystopia, anophthalmia and nasal ala defects. The extent of the associated deformities of each case varied; however, the primarily affected regions remained constant i.e. the orbital, nasal and oral regions. The variation in soft tissue and bony presentation warranted the need to document these clefts.

This study will contribute to the anatomical interpretation of Tessier cleft numbers 3 and 4 in South Africa and aid medical doctors in the assessment, diagnosis and management of such clefts. Ethical approval for this study was obtained from the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal and the relevant authorities (Ethical approval number: BE363/19). This study involved the use of retrospective CT scans and therefore posed no risks to the patients. The data obtained were anonymised.

T:8 | *morphoHeart*: A novel tool to capture, quantify and link 3D asymmetric heart morphogenesis with spatiotemporal extracellular matrix dynamics in zebrafish cardiac development

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Heart development entails the complex morphogenesis of a linear tube that transforms into an asymmetric looped and ballooned organ. During early cardiac morphogenesis, the heart tube is comprised of two cellular layers, an outer myocardium and an inner endocardium, between which lies a layer of specialised extracellular matrix (ECM) called the cardiac jelly. Cardiac morphogenesis requires tight spatiotemporal coordination of chemical and biomechanical signals that shape this early heart tube into a three-dimensional (3D) organ. The ECM is highly dynamic during development, allowing the regional generation of specialised extracellular environments important in mediating this signalling at cellular/tissue levels. Furthermore, the timely deposition and degradation of ECM are critical in fine-tuning organ morphology. To describe complex and dynamic processes such as heart development, advances in high-resolution microscopy now provide the possibility to image 3D organs in live organisms over time. In line with these advances, the characterisation of cardiac morphogenesis has started to evolve, and previously used simple classifications are not sufficient to fully describe and understand tissue morphogenesis in wild type and defective scenarios. To precisely understand how the ECM helps sculpt the heart during cardiac morphogenesis, we need to be able to describe comprehensively in 3D and throughout development cardiac morphology and ECM positioning and use such information to link morphology and ECM dynamics to heart development and the onset of cardiac defects. Consequently, we developed *morphoHeart*, a quantitative image analysis tool that allows the segmentation of the heart layers, including the cardiac jelly, and quantification of heart development processes (e.g. looping, ballooning) during development from light-sheet images. Analysis of zebrafish cardiac morphogenesis using *morphoHeart* identified dynamic changes in ECM regionalisation throughout development linked to chamber ballooning and oriented by laterality cues. *morphoHeart* offers a standardised framework for the characterisation of heart morphogenesis, capturing spatiotemporal changes in heart morphology and the ECM throughout development. The use of this tool, in combination with candidate-driven functional analysis, allowed us to better comprehend the

relationship between ECM asymmetry, embryonic laterality and heart morphogenesis. Its further use will enhance the description of mutant heart phenotypes and the understanding of the synergies that underpin heart development. Experimental work complied with ASPA legislation.

T:9 | Anthropometric orbital measurements in a paediatric population.

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The orbital cavity is pyramidal shaped, having a base and a long axis directed posteromedially. It is perforated by several foramina and fissures through which vital neurovascular structures exit the skull from the brain to reach the eye and face and vice versa. This study aimed to document the bony anthropometric orbital measurements in a normal South African paediatric population using computed tomography (CT) scans. A total of 90 paediatric CT scans (59 males and 31 females) were obtained and grouped by age and sex. The CT scans were analysed and intercanthal, interorbital and lateral wall interorbital distances were measured using a RadiAnt DICOM viewer. The R statistical computing software was used for all statistical analyses. In this study, the interorbital, intercanthal and lateral wall interorbital distances increased with increasing age groups. Furthermore, for intercanthal and interorbital distances, males had greater distances than females in the 0–<2 years age group, and as the age group increased, females had greater distances than males in the 10–<14 years and 14+ years age groups. With regards to the lateral wall interorbital distance, males had greater distances than females between the ages 0–4 years and after 8 years of age. After 17 years of age, both males and females reflected approximately similar lateral wall interorbital distances. This study reports anthropometric orbital measurements in a normal paediatric population using axial CT scans. These normal measurements may be useful to clinicians when evaluating the presence of hypertelorism, hypotelorism and telecanthus and will help serve as reference measurements for surgeons when performing reconstructive surgeries, allowing them to perform safe and precise internal orbital dissection. Institutional ethical clearance for this study was obtained from the Biomedical Research Ethics Committee at the University of KwaZulu-Natal and relevant authorities (Ethical approval number: BE357/19). There were no risks to patients as this study involved the use of retrospective CT scans.

T:11 | A Mesozoic 'woodpecker'? Functional morphology of the neck in *Zalambdalestes lechei* (Mammalia: Eutheria) informed by micro-CT study

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Zalambdalestidae are a group of Late Cretaceous eutherians endemic to Asia. Most Zalambdalestids are known from teeth and fragmentary mandibular/maxillary remains, but *Zalambdalestes* is represented by some nearly complete skeletons. Specifically, the postcranial remains of *Zalambdalestes*, which we analysed with microcomputed tomography, include an almost complete set of the neck vertebrae (C2–C7), and the atlas is known for its sister genus *Barunlestes*. The cervicals of *Zalambdalestes* are much longer than those of typically ricochetal mammals, thus contradicting ricochetal locomotion proposed earlier for *Zalambdalestes*. The most striking feature of *Zalambdalestes* neck is, however, the epistropheus with a very elongated but slender spinous process directed strongly caudally. We compared the shape of the epistropheus with that of 85 species of extant mammals (monotremes, marsupials and placentals) using 3D landmark analysis. All inclusive analysis places on *Zalambdalestes* in morphospace near small carnivorous mammals. However, the analysis concerning the craniocaudal aspects of the spinous process places *Zalambdalestes* outside of most of the studied taxa. Virtual range of motion analysis indicates a limited dorsal extension in the neck of *Zalambdalestes* caused by the vertebral arches getting quickly into contact rather than by the C2 spinous process blocking the motion. The ventral flexion is substantial, nearly 90° relative to the osteological neutral posture, rendering neck mobility much higher than previously thought. The reconstructed neck musculature indicates large rectus capitis dorsalis superficialis and obliquus capitis caudalis muscles; both are major rotators of the head and atlas. This suggests that the C2 spinous process was involved in fast head shaking/rotation, which may have been connected with feeding behaviour, e.g. wrestling larvae from under the bark, killing prey by powerful shaking head movements or, less likely, tearing parts of a larger prey. Overall, functional morphology suggests forces exerted by *Zalambdalestes* neck that are unusually high for a mammal of its size. Its C2 is peculiar amongst mammals and we may only deduce its function due to the lack of a living proxy. Thus, it represents a unique window into the early eutherian neck diversity. Institutional ethical approval was not required.

T:12 | A study on the morphological variations of the human liver and its clinical implications in the Gujarat region

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Morphological variations of the liver are irregularities in form such as the occurrence of one or more accessory lobes or the presence of cysts. Less common is atrophy or the complete absence of one of the lobes. Accessory lobes can occur in numerous places. The exact reason for the origin of accessory lobes of the liver in man is unknown. In most cases, the accessory lobe is found in the infrahepatic position. Riedel's lobe is the best known example of a sessile accessory lobe. Accessory lobes may also trigger tumour formation. In this study, a total of 100 formalin-fixed adult human livers, irrespective of the sex, were studied over a period of 3 years. These livers were specifically observed for any variant or anomalous surface morphology. Thirty-two specimens of cadaveric liver were shown to be normal, 28 livers has accessory fissures, 20 livers presented with Riedel's lobe and 20 livers presented with pons hepatis. An understanding of these types of morphological variations is very important in cases of laparoscopic removal or thermal ablation of the liver mass. Accessory hepatic fissures/sulci are potential sources of diagnostic errors during imaging. On ultrasound or computerised tomography, any collection of fluid in these fissures may be mistaken for a liver cyst, intrahepatic hematoma or liver abscess, which would require further radiological workup. Cadaveric liver from the Dr M.K. Shah Medical College dissection hall were used for this study with permission from the College ethical committee.

T:13 | Relationship between buccal branches of the facial nerve, parotid duct, buccal fat pad and Zuker's point on human cadavers

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The aim of this study was to determine the relationship of the buccal branches of the facial nerve with the parotid duct, the buccal fat pad and the Zuker's point and to reveal the incidence of the neural communications of the buccal branch with the zygomatic and marginal mandibular branches of the facial nerve. Fifteen formalin-fixed cadaveric heads (eight females and seven males) with a mean age of 73.93 ± 14.42 years were dissected bilaterally to reveal the buccal, zygomatic and marginal mandibular branches of the facial nerve, the parotid duct and the buccal fat pad. Positional relationships of these structures and the anatomical features of buccal and zygomatic branches were evaluated. The mean number of buccal and zygomatic branches was 2.40 ± 0.62 and 1.90 ± 0.60, respectively. Buccal branches crossed the parotid duct in 67%, formed a plexus along with the parotid duct in 27% and coursed superior or inferior to the parotid duct without crossing in 6% of the dissected specimens. The mean number of intersection points of buccal branches on the parotid duct was 4.03 ± 1.03. Parotid duct crossed along with the superior border of the buccal fat pad in 66%, deep to the buccal fat pad in 27% and between the superior and inferior lobes of the buccal fat pad in 7%. Buccal branches crossed superficial to the buccal fat pad in 80% and some branches passed superficial and through the buccal fat pad in 20%. It is essential to know the positional interrelations of the buccal branches of the facial nerve with the parotid duct and buccal fat pad for clinical implications. The relation of Zuker's point with zygomatic and buccal branches and with parotid duct should not be overlooked. Clinical Research Ethics Committee of Mersin University approved the study (2018/289).

YIO:6 | Human Cadaver-specific 3D printing of abdominal anatomy

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Since the first publication in 2008 of patient-specific nephrolithotomy training models, there has been a 10-fold increase per year in publications relating to 3D printing in abdominal surgery. This escalation is a result of the improvements in additive manufacturing methods and in the availability of open-source segmentation and digital modelling software and the expiry of patents related to 3D printing. Combining post-mortem CT imaging with 3D printing techniques we describe a 'cutting edge' method to produce dimensionally accurate patient-specific dissectible models to facilitate anatomical examination and surgical simulation. Two anatomical donors from University College Dublin, Medical School were imaged using contrast CT imaging at the Mater Hospital, Ireland. CT datasets were segmented in ITK-SNAP© to obtain digital models. A 3D polygon mesh was optimised in the computer graphics software: Autodesk© (Meshmixer and Fusion 360). Upper abdominal viscera models were produced using novel polyvinyl alcohol (PVA) injection moulding method. Three 3D printers (Prusa© MK2.5S, Ultimaker© S5 Pro and Peopoly© Phenom) were used to manufacture a dissolvable mould of the digital models. Moulds were injected with coloured silicones Smooth-on© (Ecoflex© 00-10 and Dragon Skin© 10) and dissolved in water to reveal the multicolour/multi-material models. To evaluate dimensional accuracy between CT datasets and the final models, the internal diameters of the catheter containing contrast dye were measured. The silicone models retained the anatomical detail of the digitally segmented CT datasets. A discrepancy of 24.5% was recorded between the catheter's (2.28 mm) and the models' (2.82 mm) internal diameters. The multicolour models were achieved with a single print and at a very low cost (approx. €50/ model) and possessed varying shore hardness between viscera recreating lifelike fidelity. The hybrid 3D printing/injection moulding method offers an avenue to realistic surgical and anatomical simulation. The dimensional error can be rectified by scaling in computer graphics software. 3D physical models may provide an enhanced surgical experience for preoperative planning allowing patient-specific rehearsal.

Primary written consent was obtained from each donor in this study for use of their bodies in medical research and education. Donor consent was also given regarding the use of images of their body or body parts and understood that they will not be identifiable in

these images and that they will be used for education or training relating to the structure of the human body and human health and anatomical research into the structure, function and disorders of the human body.

YIO:7 | Characterisation of the earliest thalamocortical interactions in the human fetal brain

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The degree to which intrinsic versus extrinsic factors control the development of the cerebral cortex is the subject of sustained research. The early thalamocortical afferents (TCA) provide most of the extrinsic signals that modulate cortical development. In the human brain, the thalamocortical interactions start very early and they take place over a prolonged period, therefore potentially influencing the intrinsic neurogenic programme in a crucial manner. The transient circuits established by TCA with their first cortical target, the subplate (SP), are essential for the correct development and maturation of the cerebral cortex, as disruption of these early connections underly the onset of neurodevelopmental disorders. An equally relevant role in cortical evolution and development has been described for the germinal zone adjacent to the incoming TCA, the outer subventricular zone (OSVZ). This enlarged compartment contains specific progenitors (outer radial glial cells, oRGC) associated with the dramatic expansion of the human cerebral cortex. Hence, their potential interaction would support the hypothesis of a major role played by extrinsic factors in modulating human corticogenesis. We traced early thalamocortical projections with carbocyanine dye (DiI) in fixed post-mortem human brains at midgestation (one 16 and two 17 post-conception weeks, PCWs). DiI crystals were placed to the dorsal thalamus or internal capsule and after 6–9 months incubation at room temperature, coronal sections were cut by vibratome and immunostained for specific cell markers. TCAs already reached their prospective cortical area by 16–17 PCWs before most of the cortical plate neurons have not been born. Thalamic axons not only innervated the overlying subplate but also developed projections towards the HOPX-immunoreactive oRGCs of the OSVZ. Our studies suggest that in addition to SP, the OSVZ might also represent transient compartments that integrate the influence of the extrinsic signals mediated through TCAs with the intrinsic neurogenic programme at different levels. We now aim to characterise the mechanisms underlying these early thalamocortical interactions at molecular and cellular levels by validating candidate pathways that we identified from available transcriptomic datasets of the human developing brain. Our study will contribute not only to understand cortical specialisation but shall also reveal mechanisms underlying neurodevelopmental disorders.

All tissue was collected with appropriate maternal consent and approval from the Newcastle and North Tyneside NHS Health Authority Joint Ethics Committee. The tissue was shipped to Oxford according to the terms of the Material Transfer Agreement between the collaborating universities.

YIO:8 | The vertebral artery blood supply to the brain and its relationship with cognition across the taxonomic classes: Mammalia and Aves

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Human brains require the most energy per unit of mass of any animal and also have the largest cortical neuron count, which is afforded by having the largest primate brain and abiding by economic scaling rules. Cortical neuron count is one of the most useful biological indicators of intelligence but providing neurons with enough energy requires a high blood supply (achieved through internal carotid and vertebral arteries). Vertebral arteries pass through cervical vertebrae transverse foramina before joining to form the basilar artery, which, with several connecting arteries and the internal carotids, forms the circle of Willis. The circle of Willis, although highly variable in humans, exhibits a less well-developed connection in animals considered 'less intelligent', such as Artiodactyls. We hypothesised that if viable neuron count has a relationship with total cerebral circulation, then a relationship may exist between vertebral blood flow and animal cognition. We conducted geometric morphometrics on 40 Mammalia and 26 Aves, measuring cervical vertebrae transverse foramen area, as a proxy to vessel size and an accurate representation of arterial blood flow to the brain. Foramen area was subsequently calculated as a proportion of the vertebral canal, to adjust for organism size across the dataset. We then compared the foramen area with a measure of 'cognitive complexity', obtained by counting how many of 12 indicators of complex cognition (broadly encompassing theory of mind, social/emotional intelligence, tool use and mental time travel) each species demonstrated within the literature. Linear regressions showed a positive significant relationship within Mammalia but not when assessed within taxonomic order. Aves also showed a positive relationship between foramen area and cognition, but this should be interpreted with caution due to the low sample size. AIC models and regressions assessed this study's indicators of cognition against established literature-sourced indicators and showed our ranking system was an accurate representation of what currently constitutes intelligence within the literature. The foramen area also showed a positive correlation with literature-sourced indicators but was influenced by brain size. This study's results provide an insight into the role of the cerebral circulation and its relationship to Mammalian cognition and might have implications for our own evolution.

YIO:10 | Investigating factors that can influence the rate of neuromuscular junction degeneration in injury using murine models

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Neurodegenerative disease or traumatic injury to the nervous system frequently results in the degeneration of axons and synapses. Identifying factors that can alter the rate of synaptic breakdown represents an opportunity to identify targets to slow or prevent neurodegeneration. In this project, we hypothesise that factors such as age and motor unit intrinsic properties will alter the rate of synaptic degeneration following injury. We utilise an ex vivo model of nerve injury, whereby the mouse nerve is severed, and the distal nerve and muscles that it innervates are maintained in oxygenated physiological solutions for 24 hours. Nerve/muscle preparations are then fixed and the levels of degeneration can be assessed. We have studied the rate of synaptic degeneration following injury and profiled the impact of variables such as postnatal age and nerve/muscle choice. We first show that synaptic loss is slower during early postnatal development. For example, significantly more neuromuscular junctions remain innervated in cranial muscle preparations at postnatal day (P)15 than at P25. We further show that the rate of synaptic degeneration following injury is affected by motor unit intrinsic properties. For example, the rate of synaptic degeneration is consistently slower in abdominal muscles compared to cranial or hind paw muscles. Changes in mitochondrial dynamics have previously been correlated with increased rates of synaptic loss after injury. Here, analysis of mtDNA levels, a surrogate for the quantity of mitochondria, revealed a correlation with postnatal age. Furthermore, although increased mtDNA levels did not correlate with increased rates of synaptic degeneration in specific muscles, there was a correlation with levels of proteins forming complex I of the mitochondrial respiratory chain. Together, this work reveals a correlation between mitochondria number and/or activity and the rate of synaptic degeneration. This work lays the foundation for further mechanistic experiments to investigate the causality of this correlation. In summary, we present a powerful tool to study factors that can influence the rate of synaptic degeneration under different physiological scenarios. Animal procedures were performed in accordance with UK Home Office guidelines. This work was funded by the Anatomical Society studentship programme and MDA.

YIO:11 | Collagen-based scaffolds as 3D breast cancer models for investigation of epithelial-to-mesenchymal transition progression

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Treatment options for triple-negative breast cancer (TNBC) are limited to chemotherapy. Traditionally, monolayer cell culture is used to study tumorigenic mechanisms but lacks the structural environment required for cell–cell/cell–extracellular matrix interactions, while animal models have various limitations including failure to fully mimic the human scenario. This highlights the need for a more representative *in vitro* model to study TNBC behaviour and identify new treatment targets. Alterations to extracellular matrix composition have been shown to play a role in the epithelial-mesenchymal transition (EMT) and cancer progression. Therefore, this project aims to develop a 3D tissue-engineered model composed of components of breast tissue such as collagen, hyaluronic acid (HyA) and chondroitin sulphate (CS), to investigate their potential role in the EMT process in TNBC. Collagen-based slurries comprised of two concentrations of HyA or CS were freeze-dried and crosslinked using previously optimised protocols to develop low and high collagen-HyA and collagen-CS scaffolds with comparable stiffness to cancerous breast tissue. Scaffold characterisation was performed using scanning electron microscopy, porosity measurements, pore size analysis and mechanical testing. The ability of each scaffold to support the growth and proliferation of TNBC cell lines, MDA-MB-231 and MDA-MB-436 and breast epithelial cell line MCF10a was assessed using metabolic activity and DNA quantification assays. Cytokine profiles in response to changes in HyA and CS concentrations were assessed using cytokine antibody arrays. PCR was performed to determine changes in EMT gene expression. The interconnected porous scaffolds had a porosity of 99% with a mean pore size ranging from 26 μm to 29 μm and stiffness of 1.0 kPa. They were capable of supporting the growth and proliferation of each cell line. TNBC cells were found to be more metabolically active on collagen-HyA scaffolds than collagen-CS scaffolds. While the concentrations of HyA and CS did not alter cellular proliferation. This study demonstrates the ability of scaffolds with different concentrations of breast ECM components to support the growth and proliferation of TNBC cell lines. The results demonstrate the suitability of these scaffolds to act as platforms to investigate the role of HyA and CS in the EMT process of TNBC. Funding: Health Research Board ILP-POR-2019-023.

YIO:12 | Changes in the visceral adipose tissue proteome in experimental type 2 diabetes and the impact of Roux-en-Y-gastric bypass surgery

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Visceral adipose tissue (VAT) dysfunction is implicated in the pathogenesis of Type 2 Diabetes (T2D). Roux-en-Y gastric bypass (RYGB) surgery is a highly effective means of treating obesity and T2D, but

its impact on VAT health remains underexplored. To address this, we sought to characterise changes in the VAT proteome arising during the development of T2D in the Zucker Diabetic Sprague Dawley (ZDSD) rat and investigate the impact of RYGB on the VAT proteome therein. Epididymal fat pad VAT was obtained from male ZDSD rats ($n = 32$) euthanised at 26, 32 and 38 weeks of age and used to characterise histological and proteomic correlates of T2D progression. A separate cohort of weight and glycaemia matched male ZDSD rats ($n = 13$) were assigned at 29 weeks of age to Sham surgery (laparotomy) ($n = 7$) and RYGB surgery groups ($n = 5$). Sprague Dawley rats ($n = 3$) served as controls. The VAT proteome profiles were then compared at 8 weeks follow-up. An LC-MS/MS approach was used to detect peptides, with quantification, annotation and identification of differentially abundant proteins achieved using MaxQuant and Perseus. Bioinformatic gene set enrichment analysis (GSEA) was conducted using g:profiler. In rats with decompensated T2D (random plasma glucose $\geq$ 11 mmol/L), epididymal VAT weight and individual adipocyte diameter were significantly decreased relative to non-diabetic control animals. Relative to non-diabetic rats, the VAT proteome in decompensated T2D was characterised by an increased abundance in 73 proteins and a decreased abundance in 75 proteins. GSEA revealed a reduced abundance of proteins involved in oxidative phosphorylation (OXPHOS) and an increased abundance of alternative complement activation pathway proteins. Relative to Sham-operated rats, the VAT proteome following RYGB was characterised by an increase in 59 proteins and a decrease in 50 proteins. RYGB did not alter the OXPHOS proteins but did increase proteins involved in the regulation of lipolysis. There was also an increased abundance of alternative complement activation pathway proteins. This proteomics interrogation highlighted altered pathways in VAT that may contribute to a worsening VAT metabolic profile, and proteins altered by RYGB that may contribute to the restoration of metabolic control.

All experiments were carried out with the approval of the University College Dublin Animal Research Ethics Committee following the guidelines of the EU Directive 2010/63/EU for the protection of animals used for scientific purposes.

T:14 | Does teaching with digital 3D models enhance student's anatomical understanding compared to 2D images?

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Covid-19 catalysed the use of digital 3D models in anatomical education and many universities purchased licenses for 3D software at high costs to compensate for the closure of dissecting rooms. However, the educational benefit and level of student satisfaction from using digital 3D models compared to 2D images, such as illustrations and diagrams, to teach anatomy remains underevaluated. The first aim of this study was to compare student satisfaction and learner gain of 2D versus 3D visualisation tools using Kirkpatrick's model of evaluation. The second aim was to investigate if anatomy teaching using 2D images or 3D digital models to teach anatomy online can translate into the accurate interpretation of cadaveric images. This was a preliminary study in which students ($n = 63$) were randomly allocated into 10 groups, undertaking peer-led teaching of five anatomical regions, using either 2D images or 3D digital models. Student satisfaction was evaluated through Likert style pre- and post-tutorial questionnaires. Learner gain was calculated from pre- and post-tutorial test scores, using cadaveric image-based questions. The post-tutorial test contained five questions from the pre-tutorial test, and seven supplementary questions, to determine if the 2D and/or 3D resources can directly translate into cadaveric image understanding. Students responded positively to all levels of Kirkpatrick's model for both the 2D and 3D tutorials. After the tutorial, 100% (in the 2D group) and 83% (in the 3D group) agreed that satisfaction would be higher if 3D models were incorporated into anatomical teaching. No significant difference in average learner gain was reported between the 2D (+0.29) and 3D (0.30) tutorials. Students correctly answered 51.15% and 53.13% of the supplementary cadaveric image questions after 2D and 3D tutorials, respectively. Digital 3D models can improve overall student satisfaction when teaching anatomy online. However, they do not necessarily result in a perceived educational advantage over 2D images. Therefore, while digital 3D models are visually appealing, they may not always be as intellectually stimulating when teaching through a didact online format. This study was given a favourable ethics opinion by the St. George's, University of London Research Ethics Committee (ref. number 2021.0082).

T:15 | Impact of digital dissection tools on learner gain of lumbosacral and brachial nerve plexuses

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Technology-enhanced learning (TEL) tools such as digital dissection tools offer novel approaches to teaching anatomy. Digital dissection permits a deconstructive approach whereby students remove layers to see what lies beneath and also a constructive approach where students construct a region digitally. Thus, the aim of this study is to assess learner gain between two different methods of teaching nerve plexuses (deconstructive and constructive) using Anatomage (Anatomage, Inc.) a 3D digital dissection software. This study included 50 first-year medical students ($n = 50$). To assess learner gain with teaching option a) constructing or b) deconstructing the plexuses, three tests were completed, a pre-test, a post-test after the teaching session (T0) and again after a 6-week interval (lumbosacral plexus) or a 12-week interval (brachial plexus). The discrepancy in time points was due to inherent curricular constraints. Statistical analysis was completed with a two-way mixed ANOVA. For the lumbosacral plexus, there was a significant increase with both teaching

methods between pre-test and post-test T0 ($p < 0.001$) and between pre-test and post-test after 6 weeks ($p < 0.05$): Constructive: pre-test, 55.2% ± 3.0 SEM; post-test T0, 76.6% ± 3.3 SEM; post-test T6 weeks, 72.4% ± 3.1 SEM and Deconstructive: pre-test, 51.1% ± 3.5 SEM; post-test T0, 75.6% ± 3.8 SEM; post-test T6 weeks, 66.6% ± 3.7 SEM. With regards to the brachial plexus, there was a significant increase with both teaching methods between pre-test and post-test T0 ($p < 0.001$). However, after 12 weeks, this increase had diminished (Constructive: pre-test, 41.8% ±3.3 SEM; post-test T0, 59.1% ± 3.9 SEM; post-test T12 weeks, 48.8% ±3.6 SEM and Deconstructive: pre-test, 40.8% ±3.1 SEM; post-test T0, 60.5% ±3.6 SEM; post-test T12 weeks, 46.4% ± 3.3 SEM). These results suggest that both options lead to an increase in learner gain and that educators can be confident in the utilisation of both approaches. It also suggests that spaced repetition testing may be an important element to integrate into our curriculum. As both methods are of equal value, our next steps are to a) investigate what approaches students prefer when using digital dissection tools and b) compare digital dissection with a cadaveric specimen. This student-led qualitative and quantitative data will help drive our new blended learning curriculum. Ethics for this study was granted by the University of Sunderland (ref. no. 008189).

T:16 | The Canine Abdomen Wiki Dissection as a novel group activity for learning veterinary anatomy

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Following the imposed COVID-19 regulations, an innovative group sequential dissection of the canine abdomen was developed to facilitate social distancing in the dissection room. To ensure students addressed all learning outcomes, students developed a collaborative wiki-style portfolio of learning materials, such as images and videos, to supplement their dissection experience. This study aimed to evaluate this novel educational intervention and address if students would meet learning outcomes relating to the anatomy of the dog abdomen via this innovative approach. In groups of six, students dissected one part of the same canine cadaver in different sessions across five independent days. Each session corresponded to one region of the canine abdomen to be dissected, totalling six episodes of dissection. Students worked in socially distanced pairs, one dissecting while the other assisted and recorded images and videos of the cadaver. As a final submission, students curated their recordings and materials into a collaborative online wiki (MS Teams). A formative multiple-choice test was conducted online to assess student knowledge and to confirm if students had met the learning outcomes. The six-part test contained a total of thirty questions specific to the learning outcomes of each test section. Attendance at practical sessions was 100%, with an average mark of 80.2%.

The average marks from the parts that students dissected, assisted and learned via the wiki were 86.19%, 84.86% and 77.54%, respectively. There were no significant differences between student marks from sections dissected versus sections assisted (t test, $p > 0.05$). Average marks from sections learned through the wiki were lower compared to that of sections dissected or assisted (ANOVA and t tests, $p < 0.05$). Interestingly, there were no significant differences between the final average marks of students on campus (80.97%) and that of students who were not able to attend the practical sessions and learned solely through the wiki (79.33%), suggesting that in both scenarios, students were equally able to achieve the learning outcomes (t test, $p > 0.05$). Our results show that the collaborative wiki dissection positively impacts student learning of the anatomy of the canine abdomen and strengthens the evidence that students need a practical element of learning anatomy for optimum success. All experimental procedures were approved by the Social Science Research Ethical Review Board at the Royal Veterinary College (URN SR2020-0326).

T:17 | Ethnic representation amongst anatomical teaching resources: Students' perceptions of inclusivity

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Ethnic diversity and inclusivity are key topics within higher education, linked to a student's sense of belonging, achievement and representation at the institutional level. To facilitate anatomical education, a variety of resources are used, however, recent evidence has demonstrated a lack of racial diversity within these study materials, with a large underrepresentation in the imagery of individuals with darker skin tones. To investigate this issue further, a study was designed to determine students' perceptions of racial inclusivity within current teaching and learning practices within Anatomy modules at the University of Sheffield. Qualitative and quantitative data were collected via surveys and semi-structured interviews. Ethical approval was administered by the Biomedical Science Department via the University of Sheffield's Ethics Review Procedure. Analysis of this data demonstrated key trends with 71% of respondents ($n = 38$) highlighting the importance of ethnic representation and its causal link with feelings of 'value', 'identity' and 'positive self-esteem' within the higher education environment. Students commented the majority of resources used to teach them were not ethnically diverse. The postgraduate cohort commented that timetabled opportunities on their course used to explore racial equality and inclusive teaching practices with peers and staff positively enhanced their racial awareness within teaching design, whereas undergraduates were less aware of diversity and inclusion discussion platforms. Both undergraduates and postgraduates commented on the lack of skin tone diversity used within anatomical images in online live sessions, textbooks, powerpoints and worksheets provided within modules. From the exploration of resources external to the University of Sheffield, such

as those created by publishing houses and digital learning resource companies, lack of diversity in anatomical imagery seems to be a sector trend. It is suggested that one simple technique to begin to create more inclusive learning environment would be a greater incorporation of anatomical images with diverse skin tones into teaching and learning resources. The development of a collection of ethnically diverse anatomical images for teaching purposes that could be shared across the sector would significantly accelerate this work.

T:18 | A novel cadaveric embalming technique for enhancing visualisation of human anatomy

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The use of human cadavers for dissection- and prosection-based anatomical learning activities is typically described as the 'gold standard' resource for supporting student understanding of anatomy. A combination of historical and pedagogic factors underpins the traditional status of cadaveric approaches as the teaching methods against which alternative learning modalities and resources in anatomical education are judged. To prepare and preserve human cadaveric tissues for teaching purposes, donor bodies are embalmed with fixative agents. Embalmed cadavers can then be dissected by students or can be prosected or plastinated to produce anatomy teaching resources. We have explored the history of cadaveric preservation in anatomy education while considering the practical strengths and limitations of current embalming approaches for the preparation of human bodies. Furthermore, we have investigated the pedagogic benefits of a range of established modern embalming techniques. We have also addressed a variety of relevant cadaveric attributes and their impacts on learning, such as the importance of colour, texture, smell and joint mobility. Moreover, we have identified emotional and humanistic elements of the use of human donors in anatomy education and the relative presence and impact of all these factors when different embalming techniques are utilised. Based on a rationale supported by our investigations, we present a technical description of our modern Newcastle-WhitWell embalming process, which involves the use of Dodge reagents. By sharing our procedure and protocol, we aim to inform anatomy educators and technical staff seeking to embalm human donors rapidly, safely and at reduced costs while enhancing both visual and haptic tissue characteristics. We propose that our Newcastle-Whitwell approach has logistical and pedagogic implications both for the ongoing development of embalming techniques and for the student visualisation and learning. In our future work, we plan to investigate the nature and extent of such elements by comparing student perceptions of cadavers preserved using the Newcastle-Whitwell technique with those embalmed with traditional formaldehyde-based methods. The use of human cadaveric material for teaching and research at Newcastle University is licensed by the Human Tissue Authority. Institutional ethical approval was not required for this work.

P1 | Anatomical study of the innervation of the cadaver gluteus medius muscle and its correlation with miofascial trigger points: preliminary results

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Myofascial pain syndrome (MPS) is the most frequent cause of chronic musculoskeletal pain. This syndrome presents clinically as referred pain, a limited range of motion in joints and a local twitch response following mechanical stimulation of certain muscular and fascial areas, known as myofascial trigger points (MTPs). Though MPS is associated with motor endplates, formal, widely accepted, the criterion-based diagnostic scheme remains a serious impediment to proper diagnosis, clinical communication and research related to this topic. The MTPs of the gluteus medius muscle are prevalent in patellofemoral pain and low backaches, whose clinical significance is related to the muscle function during gait, i.e. to maintain the pelvis level, whereas the ipsilateral limb supports weight and moves to the opposite side. In addition to the gluteal spontaneous pain, weakness in the leg abduction and increased sensitivity may occur. The gluteus medius muscle displays three trigger points (anterior, middle and posterior). Gluteus medius muscles of six adult cadavers were carefully dissected to observe the point where the branches of the superior gluteal nerve entered the muscle belly. As muscle size varies amongst individuals, we calculated the relative entry point of the nerve into the muscle by defining four different quadrants in the muscle belly: two superior (I, II) and two inferior (III, IV), beginning at the posterior margin of the muscle. Statistical analysis of anatomical data was obtained by Poisson distribution and logarithm link function followed by Bonferroni multiple comparisons ($p < 0.05$). Most nerve points entry sites were located in quadrants I and IV (mean of four sites each, 36%), followed by quadrants II (mean of two sites, 18%) and quadrant III (mean of one site, 9%). The penetration areas of the superior gluteus nerve have been established and MTPs correlate to the innervation zones, thus allowing diagnostic and therapeutic procedures to be undertaken on an anatomical basis. This research was approved by the Committee of Ethics on Research of the Faculty of Medicine of the University of São Paulo.

P2 | Innervation of the glenoid labrum: A Human Cadaveric Study

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Pain and proprioceptive properties of the glenoid labrum have not yet received much attention in the literature. Quantification of labral regional innervation differences could help in understanding the pain associated with labral injuries and highlight its role in proprioceptive function in shoulder articulation. Therefore, this study aims to quantitatively analyse glenoid labrum innervation. A total of 11 shoulders from four males and two females (mean age of 75 years) were dissected and the glenoid articular face was segmented into eight regions. Each region contained a cross-sectional view of the labrum, capsule, articular cartilage and bone. These regions were decalcified, embedded in wax blocks then sectioned. Immunohistochemistry staining of the nerves was conducted using an Anti-p75 receptor antibody. After slide scanning, the nerve count and labral nerve density, which was calculated in relation to the labral area (nerve/mm^2), was carried out using Fiji software. Kruskal–Wallis test was done to highlight the difference between the different regions then followed by Dunn's post hoc test with Bonferroni adjustment for each pair of regions. Kruskal–Wallis test showed that there was a significant difference between different regions in nerve count ($p < 0.001$) where the posteroinferior region had significantly lower nerve count than the superior and anterosuperior regions ($p = 0.021$ and $p = 0.014$, respectively) and the posterior region had a significantly lower nerve count than the anterosuperior region ($p = 0.040$). In terms of nerve density, there was a significant difference between different regions ($p = 0.011$) with the posteroinferior region being significantly lower than the anterior and anterosuperior regions ($p = 0.027$ and $p = 0.043$, respectively). These data suggest that although the labrum is innervated throughout its circumference, the superior and anterior regions tend to have higher nerve counts and densities. Furthermore, the innervation of the labrum suggests that the labrum itself contributes to the pain associated with labral pathologies including labral tears.

The study was carried out at the Anatomy Department, the University of Edinburgh, which is regulated by the Human Tissue Act (Scotland) 2006.

P3 | Neurovascular mapping of the acetabular labrum in grades of hip joint osteoarthritis: A human cadaveric study

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The acetabular labrum plays an important role in hip joint biomechanics. However, its contribution during osteoarthritis (OA) remains to be fully elucidated. The aim of this study was to analyse the association between regional differences of hip joint grades of OA and regional and zonal distribution of blood vessels and sensory nerves in the acetabular labrum. Ninety-six labral sections from 12 cadaveric hips (six males and six females, mean age 84.5) were included in this study. The acetabulum, including the labrum, fibrous capsule and articular cartilage, were cut perpendicularly into eight regions. Each region was decalcified, embedded in a wax block then sectioned at 10 μm prior to staining and analysis. The Osteoarthritis Research Society International (OARSI) grading and staging system was employed in the histological analysis of OA using Safranin-O staining. Immunohistochemical staining of blood vessels and sensory nerve endings was performed using antibodies against vascular alpha-smooth muscle actin (αSMA) and low affinity nerve growth factor (p75), respectively. Neurovascular mapping was performed using FIJI software. Labral area was measured and zones identified by dividing each regional labrum into an inner zone, near the chondral attachment and an outer zone, near the fibrous capsule. The distribution of blood vessels and sensory nerves increased significantly with increased cartilage grades ($p < 0.05$). There was a positive correlation between the number of blood vessels and free nerve endings ($p < 0.05$). The number of blood vessels and nerves were significantly higher in the outer labral zones in all eight regions ($p < 0.05$). The data show that the acetabular labrum was well vascularised and innervated across all regions. Nevertheless, neurovascular mapping showed that the majority of α-SMA and p75 labelling was present within the outer labral zone. In contrast, the inner labral zone showed significantly less vascularity which may make it more prone to tears and incomplete healing. Cadaveric specimens used were obtained from Anatomy, University of Edinburgh, which is regulated by The Human Tissue (Scotland) Act 2006.

P4 | Methods of embalming and restoration of the specimens, stored in the museum of the Human Anatomy Department of Kharkiv National Medical University

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There are about 3000 educational and scientific preparations in the dry and wet forms in the funds of the educational museum of the Human Anatomy Department of Kharkiv National Medical University. Most of the wet preparations are stored in hermetically sealed jars with a 10% formalin solution. When the jar is depressurised, formalin evaporates quickly enough and the specimen placed inside undergoes mummification. The restoration of the 1.5-year-old child's head embalmed in the early 1920s by academician Vorobiev was carried out. This specimen was in an extreme degree of mummification and deposition of dust particles, as well as an adipocere, due to the depressurisation of the containers in which they were stored. The number of the following procedures were consistently carried out: 1. preparation, 2. conducting the preparation through a number of modified fluids in order to restore the natural tissues' volume of the head and eyeballs, 3. cosmetic restoration of the facial tissues and auricles using 3D modelling, 4. placement of the specimen in a

hermetically sealed container. After nine stages of chemical treatment, the specimen returned to its original volume, the soft tissues of the head and especially the face acquired a natural colour and elasticity, parchment dark spots and traces of the formed adipocere during mummification practically disappeared. For complete restoration of the integrity and clarity of the preparation, we applied a cosmetic natural liquid latex tinted to the general colour of the preparation on the missing skin areas. After latex coagulation, the places of its application became practically indistinguishable from the main skin surface of the restored preparation of the child's head. To restore the missing left auricle, we applied its 3D modelling by scanning the right auricle with a professional 3D scanner Artec3D, followed by mirror modelling and creating a mould on the 3D printer FlashForge Guider. The left auricle was made of natural latex using a 3D printed mould. Using universal adhesive, based on cyanoacrylate, it was assembled in place of the missing one. This method can serve as a fundamental approach for the preservation of such preparations amongst the anatomical museums of the world. Despite the digitalisation of education due to the pandemic, real specimens are of great value and must be preserved for centuries for future generations of students and medical workers.

The embalming of all specimens of the Kharkiv National Medical University was done according to the ethical rules and the approved decree (1918) of the conditions and procedure for using the buried bodies of the deceased and their remains for educational purposes.

P5 | Moving to the future: Incorporating ultrasound as a teaching tool of anatomy to medical imaging students

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Undergraduate medical imaging education has recently moved towards making anatomy course content directly applicable to future clinical practice. Teaching anatomy to medical imaging students can prove challenging. Being a 'dry subject', the link between theory and practice is not always appreciated by students. Furthermore, the use of cadaveric dissection as a teaching tool is rare. Ultrasound provides real-time two-dimensional visualisation of regional gross anatomical structures, making it potentially beneficial as a teaching tool for anatomy. This study aimed to determine the effectiveness of using ultrasound to support the teaching of anatomy to medical imaging students, from a student perspective. This study included 31 students from the year two Medical Imaging programme at Unitec Institute of Technology. The students were invited to participate in three ultrasound demonstration sessions during their anatomy block course. Ultrasound scanning covered the abdominal regions, shoulder and ankle. At the end of the course, students were asked to complete a questionnaire focusing on the benefits and effectiveness of the introduction of ultrasound as a teaching tool of anatomy. About 93.5% of the students felt strongly that ultrasound is an important learning tool and complements a more traditional teaching method. The students also strongly agreed that ultrasound reinforced and consolidated their knowledge of anatomical structures. Moreover, students strongly agreed that ultrasound helped them relate surface anatomy to underlying anatomical structures. Conversely, 6.5% of the students strongly identified that it was too early to learn about ultrasound in an undergraduate course, recommending it for postgraduate study. This study showed that it is possible to introduce the use of ultrasound into the anatomy curriculum of a medical imaging programme to support student learning. It demonstrated that understanding anatomy via ultrasound helps medical imaging students enhance their knowledge and understanding of normal gross anatomy in the absence of cadaveric dissection. Through the implementation of ultrasound as a complementary teaching tool, we believe that we have successfully revised the pedagogical approach to teaching anatomy in the Medical Imaging programme at Unitec. Creating an approach in which the link between theory and clinical practice is made more overt to our students.

I confirm that this study was ethically approved by Unitec Research Ethic Committee (UREC), Unitec Institute of Technology, New Zealand.

P6 | Morpho-functional organisation of the Human Subthalamic Nucleus: From MRI to immunohistochemistry

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The subthalamic nucleus (STh) is a lens-shaped diencephalic structure playing a fundamental role in the circuitry of the basal ganglia. In addition to being involved in the pathophysiology of several neurodegenerative disorders, such as Parkinson's disease, the STh is one of the target nuclei for deep brain stimulation. However, most of the anatomical evidence available derives from non-human primate studies. In order to characterise the morphological and functional anatomy of the human STh, 15 human brains deriving from the Body Donation Programme of the Institute of Human Anatomy (University of Padua) were evaluated through a combined approach employing histochemistry, immunohistochemistry, unbiased stereology, 3D reconstruction and Ultra-High-Field (7 Tesla) MRI. The following morphometrical parameters were estimated (mean): volume, 84 mm^3; neuronal density, 5.26×10^3/mm^3; total neuronal population,

441.8×110^3. 3D rendering of the histological sections revealed an almond-shaped structure coherent with its typical depiction in anatomical literature. Immunohistochemistry for A2a adenosine receptors and D2 dopamine receptors revealed a distinct topographical organisation: A2a receptor immunoreactive structures were found sparsely in the whole rostrocaudal extent of the nucleus; D2 receptor immunoreactivity was more abundant at the level of the posteromedial aspect of the STh, in proximity to the dorsolateral margin of the substantia nigra. Hence, the STh was investigated by integrating different methodologies, revealing a peculiar distribution of D2 and A2a receptors within the structure. Furthermore, unbiased stereological data, integrated with MRI findings, contribute to define the morphometrical parameters of the structure, which has been investigated in a few studies in the literature.

Ethical statement: Human tissue was used according to the ethical regulations of the Body Donation Programme of the University of Padova and the Declaration of Helsinki.

P7 | 'Covering' the pharyngeal arches during chick development

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The pharyngeal arches are a key feature of vertebrate embryos. They are a series of swellings on the lateral sides of the embryonic head, formed of cells from the endoderm, mesoderm, ectoderm and neural crest. They contribute to adult structures including endocrine glands, blood vessels and cartilage. As the pharynx develops, the second pharyngeal arch increases in size and grows backwards to cover the posterior arches – an evolutionary conserved event found across the jawed vertebrates. There are also many human developmental disorders that present with pharyngeal abnormalities (such as the branchial fistulae in Branchio-oto-renal syndrome), so studying pharyngeal development impacts our understanding of birth defects. Our research centres on pharyngeal development in chick embryos. The chick is an amniote, like us, and is ideal for the analysis of the relevant development time points (HH12–21). We characterised the expression patterning of key developmental signalling molecules (SHH, BMP7 and FGF8) during the expansion of the second arch using *in situ* hybridisation ($n > 25$). We find that these genes are co-expressed at the site of the endodermal/ectodermal interface during expansion. We also characterised the expression of downstream molecules (PTC1, MSX1 and ETV4, respectively). To establish whether these pathways are necessary for the expansion of the second arch, we assessed the effect of small molecule inhibitors on the growth of the second arch. Our results show that the SHH and FGF8 pathways interact during the onset of second arch expansion ($n = 7$) and that this interaction occurs downstream of ligand expression ($n = 9$). We have also found that TSKU, an SLRP protein, is expressed in the mesenchyme at the posterior margin of the second arch, adjacent to the sites of BMP7, FGF8 and SHH expression. This is intriguing as this molecule is known to act as a BMP and FGF inhibitor and may play a similar role here. We showed that TSKU is SHH-dependent in the second pharyngeal arch ($n = 13$). As such, we show that there is a nexus of signalling pathways that control the expansion of the second pharyngeal arch. We are grateful to the Anatomical Society for supporting this work with a PhD Studentship.

P8 | Soft tissue constraints of the feline elbow comparison to the canine

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The objective of this research was to investigate how flexion and extension of the feline elbow joint are constrained by soft tissue attachments and deep fascia. Extensive research has been published regarding the anatomical structure of the feline elbow and how it compares to the canine, although limited literature has been published regarding the mechanical function of the structures that surround the feline elbow joint. Many standardised surgical techniques used for the feline elbow are based on studies of injury extrapolated directly from canine research. Using adult feline cadavers ($n = 6$ limbs), the skin, fascia and extensor carpi radialis m. were sequentially transected from the brachium and antebrachium of both forelimbs over a series of steps. At each step, repeat measurements for flexion and extension were recorded using a goniometer. The statistical significance of the present study was then compared to the findings from a study which investigated the soft tissue constraints of the canine elbow. Findings suggested a significant increase in both flexion and extension following the removal of the skin (–7.08°, $p = 0.018$ and +7.03°, $p = 0.003$, respectively) and transection of the extensor carpi radialis m. (–9.11°, $p = 0.029$ and +5.18°, $p = 0.004$, respectively). These results suggest that the skin, deep fascial connections and extensor carpi radialis m. play significant roles in preventing the elbow joint from overextension. These findings not only support prior research on canine elbow constraints but also demonstrate the differences between species, which may enhance the understanding of the mechanical effects of injury, surgical procedures or abnormal morphology. All cadavers were from cats euthanised for reasons not associated with the research and donated for use in teaching and research.

P11 | Cardiovascular consequences of myocardial bridging in hypertrophic cardiomyopathy in humans: A systematic review and meta-analysis

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Myocardial bridging (MB) is a congenital variant in which a segment of a coronary artery follows an atypical intramural course under a 'bridge' of the myocardium and is notably common in hypertrophic cardiomyopathy (HCM). The association between MB and numerous adverse cardiac events has been the focus of previous meta-analyses, however, these have focused on more general populations. This systematic review and meta-analysis explored the clinical consequences of MB only in patients with HCM. In doing so, three outcome domains were investigated: cardiovascular mortality, non-fatal adverse cardiac events and indicators of myocardial ischaemia. A meta-analysis was performed on nine observational studies that met strict criteria comparing outcomes in HCM patients with and without MB. Studies were identified through a systematic search of four databases (PubMed, Scopus, Medline Complete and Web of Science). The quality of the studies was assessed using a modified version of the Downs and Black tool, which was a 22-item checklist from which studies could score a maximum of 23 points. The mean score was 17.3 ± 3.2 (good). This meta-analysis has shown that MB was not associated with cardiovascular mortality (OR: 1.71, 95% CI: 0.56–5.15, p = 0.35) or non-fatal adverse cardiac events (OR: 1.63, 95% CI: 0.73–3.63, p = 0.23) but was associated with myocardial ischaemia (OR: 1.97, 95% CI: 1.22–3.16; p = 0.005). In conclusion, MB is unlikely to adversely influence prognosis in the majority of individuals with MB but may do so in select individuals with haemodynamically significant bridges and/or severe underlying disease. In developing a management protocol for this subgroup of patients, future research should focus on establishing functional and morphological thresholds by which MB may adversely influence prognosis.

P12 | A review of the anatomy of neurofeedback: A novel therapy using brainwaves to treat the cognitive symptoms of Alzheimer's disease in humans

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Neurofeedback training is a concept that has been developed over several decades with the aim of improving cognitive functions amongst patients with various conditions. Many of the current conventional therapies used today result in AD patients suffering from side effects including loss of appetite, nausea, vomiting and diarrhoea. These side effects can affect the quality of life of the patients and consequently; new therapies must be developed to combat the shortcomings of these therapies. Neurofeedback training could help overcome the limitations of current therapies by utilising brainwaves to treat the cognitive symptoms of Alzheimer's disease. Through these brainwaves, patients should be able to improve memory and associate cognitive symptoms of Alzheimer's disease including anxiety and aggression. The aim of this review is to help provide greater insight into the use of neurofeedback training in aiding Alzheimer's patients to improve their memory and subsequently improve their quality of life. Currently, no review has looked at neurofeedback

from an anatomical perspective, so this paper helps to provide build upon the neuroanatomy affected by the training. A literature search of the databases MEDLINE and SCOPUS was performed from inception to the present. Subsequently, 13 papers came under the restrictions of the exclusion criteria and a further four full-text articles were excluded with reasons; leaving 14 studies to be included in the review. From the literature, several themes became apparent, including the fact that some subjects will see improvements in their memory whilst others have seen improvements in behaviours of patients in Alzheimer's disease.

P13 | Avian vertebral fusion occurs during chicken post-hatching development

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Adaptations required for flight in avian dinosaurs include lightening bones and the evolution of highly fused regions in the vertebral column, such as the synsacrum in chickens; comprised of one thoracic, four lumbar (L), four sacral (S) and five sacralised caudal vertebrae. The timing of intervertebral disc degeneration and eventual fusion of these vertebrae is unknown. We hypothesize that the remodelling required to transform separate vertebrae into fused regions occurs in the post-hatch chicken. To test this, we tracked vertebral development from 1 to 10 weeks post-hatching using raw images and micro-computed tomography of the dissected synsacrum to determine the spatiotemporal ossification events. Reconstructed false-coloured three-dimensional images in wholemount and in cross-section provided additional data, resulting in novel insights into the timing and regionalisation of ankylosis mechanisms during post-hatch development. Fusion is first observed in L3–S8 sacral vertebrae, occurring in an anterior to posterior direction from 4 weeks post-hatching, progressing until completed at 10 weeks of age. Histological stains of the sectioned synsacrum visualised the cascade of changes in the intervertebral discs and vertebral endplates during remodelling. The remodelling of the cartilaginous intervertebral disc tissues occurs in a characteristic cascade leading to osteogenesis and eventual vertebral fusion. Combined, these data reveal fresh insights into critical adaptations during avian vertebral evolution and development. This study was approved by Clemson University's Institutional Animal Care and Use Committee, protocol number 2019-047.

P14 | Dermatoglyphics in human cleft lip and cleft palate

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Palates develop as a primary palate from intermaxillary segment and the secondary palate from the fusion of palatine process of maxilla across the midline. Lip is formed by fusion of maxillary prominence

with medial nasal prominence. Any defect in the formation results in the cleft palate (1/2500 birth and common in females [67%]) and cleft lip (1/1000 birth and common in males [80%]). The development of the primary palate and the lip is completed by the seventh week of intrauterine (i.u.) life and that of the secondary palate by 12th week of i.u. life. The dermal ridges, developing in relation to the alveolar pads, are formed by the sixth week of gestation and reach a maximum size between the 12th and the 13th weeks. This means that the genetic message contained in the genome—normal or abnormal—deciphered during this period might also be reflected by dermatoglyphics which is a helpful adjunct to other diagnostic methods in identifying specific syndromes of genetic origin. Two hundred children (100 children with cleft lip and palate from Owaisi Hospital and GSK Hospital, Hyderabad as a study group and 100 normal children from Delhi Public School, Hyderabad as a control group) are included in the study whose age is varying between 10 and 15 years. Before the study, the informed consent and history is taken from the parents. The fingerprints are taken using the Ink method after proper cleaning of the hand with Dettol and clean water. The frequency of loops, arches and whorls are studied Chana at tips of fingers, interdigital areas and atd angle is measured. An increase in the frequency of ulnar loops in fingertips and atd angle is noted. The radial loops and arches are less comparatively in the children with oral clefts. The t value is 1.15 between the oral cleft and normal children which statistically signifies that there are dermatoglyphic differences between normal children and children with cleft lip and palate. The study was done with complete approval from the ethical committee. As the study is done in children, the consent is taken from the parents and all the details are explained in the local language orally also.

P15 | A novel neuroanatomy E-learning pedagogical programme to address neurophobia undergraduate medical students' feedback during the COVID-19 pandemic

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Medical students and doctors find it challenging to learn neuroanatomy (neuroanatomyphobia). Earlier, Jozefowicz et al. coined the term neurophobia to highlight the prevailing fear amongst students and junior doctors when managing neurology patients. Since, neuroanatomyphobia is a precursor to the prevailing neurophobia, hence, investigating measures to reduce neuroanatomyphobia could help equip health practitioners with knowledge and skills required for enhanced neurology patient care. In this context, a questionnaire-based study, with a mixed qualitative and quantitative research design (open-ended and Likert scale questions), was conducted to inquire about undergraduate medical students' opinions regarding various aspects of the neuroanatomy curriculum. The research was undertaken in the context of a newly developed, interactive,

blended neuroanatomy delivery programme, as part of the wider neurology teaching for third year MBCBH students. Non-parametric (Friedman's, Wilcoxon's) testing and thematic data analyses were employed. Results showed that students felt motivated to learn neuroanatomy. They ranked, comprehension of intricate neuroanatomical concepts, visualisation of the brain in 3D and extensive content of neuroanatomy syllabus, equally challenging barriers to learning. Students preferred their time in the lab to learn neuroanatomy. They rated studying with prosections and brain models more useful vs. case discussions, pre-recorded videos, SBA quizzes, Q/A sessions, while emails and discussion boards were perceived least useful. With regards to assessment, students exhibited higher satisfaction with anatomy spot tests organised in the dissection room (3.96 ± 0.23) vs. remote AFL strategies, namely online quizzes (3.27 ± 0.26) and clinical case discussions (3.5 ± 0.24). Moreover, they requested additional SBA quizzes, summative exams-related guidance, prosection-based videos and on-campus interactive anatomy lab sessions. With regards to their confidence in their knowledge of neuroanatomy clinical correlates, their confidence scores significantly dropped when asked about their ability to localise neurological lesions during exams ($p < 0.01$) and real patient examinations ($p < 0.01$). To conclude, student feedback with regards to their learning experience has informed the neuroanatomy pedagogical construct. A blended and clinically contextualised, assessment-led interactive neuroanatomy curriculum, with greater and effective employment of lab-based prosection resources, will likely enhance neuroanatomy learning and prevent the ongoing neuroanatomyphobia from feeding into neurophobia.

The authors declare that they have obtained consent for the research project from Anglia Ruskin University; School of Medicine, Social Research Ethics Panel (SREP) (ref. no. AH-SREP-20-48), under the terms of Anglia Ruskin University's Research Ethics Policy (dated 24 July 2019, Version 1.11). This application has also been approved by Faculty Research Ethics Panel (FREP). Written informed consent was obtained from all participants after they were provided with a participant information sheet.

P16 | The role of the mesentery in the innervation of the gut and enteric nervous system during embryological development of the rat

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Recent clarification of mesenteric anatomy has indicated that unlike classical descriptions, the intestines are enveloped in a continuous rather than a fragmented mesentery. This has prompted a need to re-examine its development and anatomical relationships with the developing gastrointestinal tract (GIT). Advances in understanding the development of the mesenteric tissues have also highlighted its potential role as a facilitator of neural crest cell migration during enteric nervous system development. The aim of this research is to

describe the development of the mesentery, gut and enteric nervous system independently and subsequently determine how each of these components relates to each other during development. Of particular interest is clarifying the way efferent and afferent autonomic fibres traverse the primitive mesentery and ultimately innervate the gut and the enteric nervous system. Histological and immunohistochemical approaches are being employed to highlight autonomic neurons and axons and mesenteric components of rat tissue at different embryonic ages. Immunohistochemical analysis of neuronal and mesodermal structures of serially sectioned rat embryos at embryonic days 12, 14 and 16 have been undertaken. This survey of innervation is being extended to embryonic day 10 to visualise the early interaction between the tissues that give rise to the neural and epithelial elements of the GIT. This will allow detailed microscopic confirmation of the continuous mesenteric structure, arising from its primitive mesodermal framework, and will illuminate the process underpinning how autonomic fibres are distributed to the GIT. A further objective is to advance this study of mesenteric development in rodent tissue to human embryonic tissue and, ultimately, to describe key molecular determinants of mesenteric-directed axonal pathfinding. This will address the paucity of information available on the development and anatomical course of peripheral nerves through the mesentery in the human. An understanding of the developmental innervation of the mesentery and gut has implications for advancing knowledge of normal anatomy as well as relevant pathological states such as Hirschsprung's disease. Animal procedures were in accordance with the Republic of Ireland Department of Health and Children license.

P17 | Assessing student attitudes towards pair-learning of cadaveric thorax, abdomen and pelvis anatomy practicals: A Covid-19 intervention

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Prior to the challenges imposed by the COVID-19 pandemic, our anatomy practical sessions entailed 8–10 students per donor station, rotating between digital learning, anatomical models/osteology specimen and dissection/prosection learning activities for 3 h. To maintain cadaveric participation in the dissection theatre (DT) while adhering to social distancing guidelines, a transition to pair learning (PL) was implemented. This mode of delivery allowed two students to spend 1 h/week with a donor body, anatomical models and osteology specimen. These sessions were repeated and the ratio of teaching assistants to students was eight to one. All digital learning elements were transferred to the VLE as pre- and post-practical learning activities. To determine the effectiveness of hybrid practical sessions and reduced donor to student ratios, we gauged 195 first-year medical students opinions after their thorax, abdomen and pelvis practical curriculum using an online questionnaire with a 51% response rate. The majority of students (93.5%) reported that they enjoyed working in pairs and that this facilitated their understanding of anatomy. Despite a significant reduction in practical time, students (67.7%) agreed that their online practical exams provided a fair assessment. About 97.8% reported that they had enough time with the donor body at their station, and most students (74.2%) reported that they still felt connected to their classmates. Thematic analysis revealed that PL provided students with sufficient hands-on experience with donors. The students also indicated that extra time in the DT outside scheduled classes would be beneficial. Key insights revealed that an opportunity to experience more anatomical variation would have been beneficial. Student also indicated their lack of confidence in undertaking dissection and the frustration that they experienced as a result. This study emphasises the importance of gauging students' preferences to optimise satisfaction and learning output when pivoting to blended learning strategies in anatomy education. The School of Medicine Research Ethics Committee TCD approved this study.

P18 | An anatomy outreach project: An anthropometric study of mouth shape and accent

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This study is an example of an Anatomical outreach type project produced by two secondary school students in Galway as part of the 50th BT Young Scientist Competition. The aim of this study was to obtain an up to date picture of regional vowel variation in Ireland using objective anthropometric and acoustic measurements. This study provides quantitative baseline data on regional Irish accents. This information may be of interest to linguists who may be interested in the evolution of English, but perhaps of more practical benefit to Speech and Language Therapists. In a clinical sense, it can afford an objective way to assess the degree of damage and indeed recovery following pathological events such as a stroke. This study investigated vowel sounds of four regional Irish accents (Galway Dublin Donegal and Cork) through anthropometric and acoustic measurements. This study consisted of two groups of male first-year Medical students at NUI Galway. In the first part of the study ($n = 8$, 2 from each region), we made video and audio recordings of subjects saying vowels a, e, i, o and u. Height and width of lips was also measured. In the second part of the study ($n = 8$, two from each region), we were able to indirectly access the other main components of the vocal tract using Formant analysis by employing a computer programme Speech Analyser 3.1. In this more detailed study, we used only audio recordings on a wider range of vowel sounds. This study provides quantitative baseline data on regional Irish accents. This information may be of interest to linguists and also of practical use to Speech and Language therapists in that it highlights the potential that formant analysis can provide in identifying different anatomical elements that are important in speech production. In a clinical sense,

it can afford an objective way to assess the degree of damage and also recovery following pathological events such as a stroke. This study was carried out with informed consent and full local ethics committee approval.

P19 | A stereological study of the optic nerve in the wobbler mouse model of motor neuron disease

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The Wobbler mouse has been used in studies as an animal model for motor neuron disease. Previous investigations of the Wobbler mouse optic nerve reported an increased number of unmyelinated axons in comparison with their control counterparts. In the present study, we use a systematic random sampling protocol combined with morphometric and stereological methods to document changes in the anatomy of the optic nerve axons. In this study, five wobblers (3-month-old stage 4) and five age-matched controls were examined. Animals were anaesthetised and perfused with fixative. The tissues were processed for electron microscopy. The following features were estimated: volume fraction (Vv) of mitochondria and vesicles and microtubule number and density in both myelinated and non-myelinated axons. The number of non-myelinated axons in the optic nerve was increased in the wobblers, although there was no difference in the myelinated axon number or degree of myelination. There is no evidence that changes in axonal architecture can account for the previously reported increase in non-myelinated axons in the Wobbler mouse optic nerve. The increased number of myelinated axons in the wobbler group may be related to changes in body composition resulting in a developmental delay to the process of myelination. This study had appropriate ethics committee approval.

P20 | Can virtual reality virtually replace anatomy examinations?

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Due to COVID-19 restrictions, many of the medical assessments have been moved to online platforms. The anatomy component of the assessment mainly consists of either short answers or MCQs after analysing a 2D image which could be of dissected cadaveric image. It is thought that this form of assessment fails to assess the main 3D arrangement and spatial orientation of different complex anatomical structures. Moreover, the students find it challenging to interpret the cadaveric image depending on the source of the images, i.e. picture clarity and lack of complete bodily orientation as only a part of the anatomical structure fits the picture frame. Can

virtual reality (VR) help replace the traditional 2D exam assessment style? To make the examination fair and close to cadaveric/prosected material, it is proposed that each question station/bays are equipped with VR devices that help the students to rotate and orientate the structure better thus giving them a better understanding of the question. It is also thought that such a presentation would enhance the student knowledge and confidence in answering questions.

The aims of this study were to evaluate if VR stations are employed as part of regular summative assessments amongst medical schools and to assess if VR helps the student to answer the question better by enhancing the knowledge and confidence levels. An electronic search was conducted in databases such as PubMed, Google Scholar, CINHAL, EMBASE, Scopus and Cochrane scientific. Following this, the criteria-based selection process was used to shortlist the most appropriate literature. The analysis of published literature found that medical schools within the United Kingdom employ limited VR stations as part of teaching but no evidence to suggest that VR stations are employed in anatomy assessments. As VR stations are not routinely employed in anatomy assessments, the following are proposed: 1. integrate VR stations along with traditional assessments and 2. conduct comparative studies to assess the effectiveness of VR stations in knowledge acquisition, retention and recall.

P22 | Understanding the development of human embryonic muscle anatomy and the mechanisms controlling muscle morphogenesis using 3D modelling tools

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Muscles must develop with high fidelity to achieve their correct size, shape and position within the musculoskeletal system. During muscle tissue development, muscle fibres undergo a sequential process of orientation and compaction to form discrete bundles, which in some instances can be followed by splitting of a single muscle bundle to produce two distinct, daughter muscles. We have demonstrated using mouse models that conditional *Tbx5* gene deletion, specifically in the irregular connective tissue (ICT) fibroblast cell population embedded within and around forming muscle precursors, leads to muscle fibres failing to align and forming bundles with abnormal morphology and, in some cases, failing to undergo muscle splitting. To further understand how individual muscle bundles form, we have mapped the anatomy of human embryonic muscles as they are beginning to form. We have used 3D Optical projection tomography (OPT) imaging to generate datasets of muscles in embryonic upper and lower limbs from Carnegie Stage (CS) 18–22 that are reconstructed into 3D models. Individual muscles are characterised by their morphology and the specific events that form individual muscle bundles are followed. We demonstrate that some muscles translocate to reach their correct anatomical position and

can split from a single bundle to form the individual muscles found in the mature musculoskeletal system. In addition, we described variations between embryonic samples, such as the absence of the *Palmaris Longus* muscle in the upper limb. Understanding the normal events of muscle development will improve our understanding of tissue morphogenesis, explain the origins of the variation in muscle anatomy observed in the general population and can explain how disruption of embryonic events leads to muscle aplasia or dysplasia associated with congenital limb defects.

Ethics statement: All animal tissue was used in accordance with the Animal (Scientific Procedures) Act 1986. All human embryonic tissue was obtained from the Medical Research Council – Wellcome Trust Human Developmental Biology Resource (HDBR). The HDBR is regulated by the Human Tissue Authority (HTA) and operates under its code of practice. All work carried out with human tissue was used in accordance with the Human Tissue Authority Act 2004 and the Declaration of Helsinki.

P23 | Foetal development of the human clavicle: A geometric morphometric approach

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Age estimation is of the utmost importance when trying to positively identify foetal remains in both forensic and healthcare contexts. Several methods have been developed (e.g. crown-rump measurements and dental age), but most of them are subject to large variations in applicability as foetal size varies amongst and between populations. A geometric morphometric approach, which prioritizes shape over size is therefore more likely to be widely applicable than linear metric approaches developed on isolated samples from a small subset of modern populations. In this study, the clavicle was chosen as it is of considerable developmental interest, as it is the first long bone to start ossifying during the fifth week *in utero*. Our aim was to pilot a method of creating shape descriptor markers using 3D geometric morphometrics (GMM) which may be more applicable across different populations than linear measurements alone. This study used a sample of 32 left clavicles from the 19th century Liverpool identified foetal collection with gestational ages ranging from 4 to 9 months. Specimens were split into three groups: 4–5, 6–7 and 8–9 months. The specimens were landmarked with a combination of type 1 landmarks and curve markers, using the SlicerMorph extension of a 3D slicer. Subsequent analysis including Principal Components Analysis and two-block partial least squares regression was conducted using MorphoJ and the R package Morpho. We found that size-correlated shape changes and biological sex of the specimens were not a key factor in a grouping of specimens and that the sternal end of the clavicle was the anatomical region which showed the most shape variation. Two block PLS of shape data revealed that the youngest age group clearly separated from the latter age groups.

Further work to refine landmarking protocols and expand to earlier *in utero* stages is currently in progress.

Ethical approval for this study was attained from the Anglia Ruskin University Ethics panel.

P24 | Genetic mutations underlying congenital stationary night blindness: Loss of phototransduction and synaptogenesis

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Development of the eye relies on complex and coordinated driving forces throughout the embryonic period. Any disruption to this initial patterning and differentiation of specialised cells may culminate as a congenital abnormality. Congenital stationary night blindness (CSNB) is both a clinically and a genetically heterogeneous inherited retinal disease that arises as a result of mutations in one of several genes. This paper aims to comprehensively analyse mutations of the genes implicated in CSNB and with respect to *CACNA1F*, identify the anatomical implications these mutations have. A literature search of the database PubMed was performed from inception to present and the references of all included studies were searched for relevant literature. Nine hundred and ninety-seven articles were initially identified with 81 articles being included in the review, after both the inclusion and exclusion criteria were applied. Results have shown that mutations in the genes involved in the phototransduction cascade (*GNAT1*, *RHO* and *PDE6B*) cause autosomal-dominant CSNB, whilst those arising downstream from this cascade present as complete (*GRM6* and *NYX*) and incomplete (*CACNA1F*, *CABP4* and *CACNA2D4*) CSNB. Mutations in *CACNA1F*, which encodes the alpha1-subunit of the Cav1.4 channel, lead to X-linked CSNB. In addition to functional changes in this channels ability to conduct calcium and thus 'propagate' electrical signals, disruption of synaptogenesis between the photoreceptor and the bipolar cell synapses is likely to occur as a result of these mutations, offering a potential target for future therapeutic options, which could aim to treat synaptopathic abnormalities.

P25 | KV55-Akhenaton: Reassessment of the anthropological literature and a novel facial reconstruction

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The famous 'mummy KV 55' (Cairo CG 61075) found in 1907 is responsible for a long-lasting identification controversy in the fields of egyptology, anatomy and biological anthropology. Historical and egyptological research has ascribed this skeleton to the heretic pharaoh Akhenaton, the inventor of an early form of monotheism, while anthropological studies have questioned such an attribution since the skeleton belongs to an individual in his early 20s, which represents a chronological problem given Akhenaton's alleged age at death (about 40 years old). The existing controversy is also increased by the fact that 2010 palaeogenetic analyses determined the remains to belong to the biological father of Tutankhamun, a result which was subsequently questioned by some palaeomolecular experts.

By reassessing all the available anthropological literature on KV55 and reexamining all available photographs of diagnostic skeletal districts, we conclude that an age at death comprised between adolescent and young adult, 19–22 years, as previously suggested by the late Czech anthropologist Eugen Strouhal can be reasonably suggested. While this can be problematic when trying to reconcile it with the chronology of Akhenaton's reign, although it does not entirely dismiss the possibility that he ascended to the throne at a very young age. In the context of this reassessment, we also reconstructed KV55's face using up-to-date forensic techniques based on the application of soft tissues on the digital image of the skull acquired from photos dating back to Grafton Elliot Smith's pivotal 1912 publication *The Royal mummies*. Through this approach, we also manage to bring back to 'life' the facial traits of one of the most controversial skeletons of antiquity, potentially those of a pharaoh that changed the course of history, although a final certain identification will only be possible thanks to the implementation of new genetic tests on the remains held in Egypt.

P27 | Toughness as a criterion of resistance to deformation of rats' cancellous bone tissue in conditions of functional disorders

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The architectonics of spongy bone tissue is an individual integral response of the bone to the stresses and strains it undergoes under various loads. Spongy bone tissue by its mechanical properties is inhomogeneous, non-linear and anisotropic. In addition, its mechanical properties can vary significantly depending on age, sex, structural and functional state of bone tissue, the presence of local and systemic pathological processes. The aim of this study is to adapt the method of determining toughness as a criterion for resistance to deformation of cancellous bone tissue in terms of functional disorders. Six samples of rats' heel bone with a perforated defect on the 24th day of reparative regeneration were fixed in aluminium frames of cylindrical shape with epoxy glue. Rodents were withdrawn from the experiment by cervical dislocation. Bone fixation was performed at the fixation-regeneration zone boundary. The experiment used a pendulum hammer weighing 5 kg. The MPB-2 microscope was used to measure the fracture plane of the bone formed by the action of the pendulum hammer. The toughness a_n was determined by the formula $a_n = A_n/F$, where A_n is the work, F is the cross-sectional area. The main purpose of determining the toughness during bending is to assess the performance of the material in difficult load conditions and its susceptibility to brittle fracture. Fixing the mandrels with bone allows to determine the amount of fracture work, which is spent per unit area of the sample in the plane of impact. The values of toughness characterise the values of crack resistance of the cancellous bone, which varied in the range of 8.82-7.42 kg • m/ cm^2. The obtained values of toughness in terms of functional changes can be used in further investigations to study other pathological conditions.

The maintenance and manipulation of animals were carried out in compliance with the requirements of bioethics and the requirements of bioethics and the 'General Ethical Principles of Animal Experiments' adopted by the First National Congress on Bioethics (Kyiv, 2001), the requirements of the 'European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes' (Strasbourg, 1986).

P28 | The use of ultrasound imaging in medical and undergraduate science teaching

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Apart from teaching medical students the clinical practicalities of ultrasound (US) imaging, there is an obvious application in an educational setting for visualising both gross anatomy and physiology. It is a non-invasive and painless technique that can be used to integrate anatomy and physiology teaching. A systematic review was conducted to gather information regarding the current uses of US in medical and science education. Additionally, original research in the form of a survey of academics instructing on anatomy and physiology courses in the United Kingdom and the Republic of Ireland was conducted (n = 31). The aim was to provide a comprehensive guide to help establish possible applications for US as a teaching tool and assess any evidence for its effectiveness as a teaching method. Results from the literature review and survey reveal that US is being used in a variety of ways all over the body for physiology and anatomy purposes. A strong interest in learning about possible uses of US was reported by survey respondents, and barriers to implementing US were identified. From student feedback questionnaires in the literature, it is evident that US is popular and highly valued as a teaching modality by students. Analysis of reported quantitative

knowledge-based tests suggests that US is a successful teaching tool, providing benefit to student learning. US is being used widely for all regions of the body and increasing in popularity, and further studies will help to increase exposure and assess any efficacy as a teaching method.

Ethical approval for the survey was granted by the Queen's University Belfast Faculty of Medicine, Health and Life Sciences Research Ethics Committee (Approval ID MHLS 20_155) and all survey participants gave their informed consent electronically via an itemised consent form.

P29 | The Trajectorial theory: Wolff's human hip faux pas

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One of the oldest and most confusing controversies in Orthopaedic Surgery is undoubtedly that of the functional anatomy of the upper femur. It is the one topic that can be guaranteed to produce dissension and argument in otherwise placid atmospheres. The structures which cause the most angst are the three internal condensations of trabecular bone which exist in the femoral neck of every physically normal human being viz. the two trabecular columns (vertical and horizontal) and the calcar femoral. These problem structures came to light some two centuries ago and have been argued about ever since. Although not the originator, the main initiating protagonist was Julius Wolff who propagated their functional concepts vehemently and proposed two theories – the Law of Bone Formation, that force through the bone stimulates bone formation and his Trajectorial theory, that bone formation aligns itself with the pathway of the force. It is alleged that the vertical column carries a compression force and the horizontal column a tension force. Today Wolff's concepts prevail and it is generally accepted that the two columns carry a compression and tension force, respectively, but the role of the calcar is mostly conjecture. Nevertheless, in proposing these theories, Wolff seems to have committed a serious *faux pas*. In the upper femur, the Law of Bone Formation and the Trajectorial Theory are mutually exclusive. How then does one explain the function of these internal trabeculae? Recent anatomical physical dissections of the upper femur gave an insight into how these internal trabecular structures are formed and function. The essential understanding gleaned from the dissections is that anatomically and functionally these three internal trabecular structures are not separate entities but one single, continuous structure. The study suggests that, because of the femur's shape, this internal trabecular bone is deposited in the femoral neck to cope with an excessive internal compression force which passes through it in response to the movements of the hip under load. At full-hip extension, the force is passing through the vertical column, and at full flexion, the force is passing through the horizontal column, while the calcar joins the two columns.

P30 | Online 3D model preference by medical students in Head and Neck anatomy education

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The definition, design and delivery of anatomy education changed significantly as a consequence of the COVID-19 outbreak and accelerated innovation as academic activities changed from face-to-face to online presentations. Online anatomy presentations that utilise 3D models are dominated by artistic-based models rather than real-time dissections, 3D models of dissections and plastination or MR/CT-segmented models. The purpose of this study is to determine medical student preference concerning 3D online teaching assets in an online Head and Neck anatomy block (Fall, 2020) generated from four sources including actual online dissections, dissection and plastination models; artistic models and CT/MR-segmented models. A workflow was developed to process asset primitives generated through photogrammetry of dissection and plastination models, artistic renderings using Autodesk Maya (Autodesk Inc., San Rafael, California, USA) or MR/CT with segmentation using Materialise Mimics (Materialise HQ, Leuven, Belgium). Models were posted to Sketchfab.com and presented as a component of online dissection presentations and broadcast to medical students via a secured university-based website hosting service. Technical requirements were limited and relied on several open source or limited subscription software packages. One hundred and eighty-one dissections and plastination models, 109 artistic models and 9 segmentation models were used during the Head and Neck anatomy block. A comparison of the perceived usefulness of the actual dissections, dissections and plastination models, artistic models and segmentation models was conducted using student surveys (*n* = 79). Compared to all learning resources, actual dissections were most preferred (34.1%). However, dissection and plastination models were considered most/more preferred (54.3%) compared to other assets suggesting a broader preference as a learning resource. Dissection and plastination models show true anatomical variation, disease and anomalies which might have helped students in the clinical application aspect. These results suggest that 3D online anatomy education resources using dissection and plastination models are effective and engaging tools for the instruction of gross anatomy for medical students.

This study respects ethical regulations, being institutionally reviewed and approved (IRB 2018-00120).

P31 | Does the quality of anatomical YouTube videos correlate to the popularity?

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There has been a steady change over time in the space of anatomy education, with courses moving away from traditional methods to those that encourage self-directed learning. YouTube has become a resource at the forefront of this change. The online video sharing platform is one of the most popular sites in the world and its influence has made its way into the field of education. The purpose of this study was to assess the correlation between the popularity of anatomical videos on YouTube to their quality. A search for anatomical terms on YouTube returned 150 results. In total, 57 videos were analysed after 93 videos were excluded for being unrelated, without sound, not in English, too general and repeated or regarding non-human anatomy. A novel tool was generated to assess the videos in three different domains as follows: general quality, anatomical content and educational quality. This tool was then applied to the included videos. The results indicate little correlation between quality and popularity measures used, with only the like to dislike ratio showing some statistically significant positive correlation across popularity measures, however, this was relatively weak. The results also demonstrated the poor standard of anatomical content in the videos analysed. Students should not use the popularity of videos as a guide for video selection and care should be taken when engaging with this resource. More reputable additions are needed to this resource to bring up the standard of anatomical content and overall quality. The tool generated may prove useful for educators and students to determine the quality of anatomical videos on YouTube as well as a guide for those wishing to create videos.

Ethics Statement: This project did not require ethical approval as it did not require human participation or the collection of personal data, all information retrieved was freely available in the public domain.

P32 | Parallels between the embryogenesis of the human optic canal and nerve

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Numerous studies have attempted to clarify the anatomy of the optic canal (OC) due to its proximity to many vulnerable structures. The objective was to determine the parallels between the embryogenesis of human optic nerve (ON) and OC. 210 OC on 75 human embryos were analysed. The diameters of ON and OC in its cranial, orbital aperture and middle part, the distance between OC walls, ON and an ophthalmic artery were measured with Bioscan AT+.

The consecutive change of OC wall stages was determined: mesenchymal, young precartilaginous, mature precartilaginous tissue, embryonic cartilage, differentiation of chondrocytes, calcification. Asynchronous differentiation and growth of the OC walls were evident: the upper one lagged behind the other walls. Heterochronia of OC development was established: the eyestalk was the first to appear (embryos 9-15 mm PCL), then the OC walls and ON sheaths were formed. The stages of ON sheaths embryogenesis were described: a general neural vagina, a two-layer (primary pia and dura mater) and a three-layer neural vagina. Uneven growth of OC compartments was evident: the formation of OC cranial compartment ahead of the development of OC orbital and middle parts. The orientation of OC walls was changed: the anterior OC wall was displaced medially, the posterior wall laterally. The OC growth occurred when a certain value of the ratio of the ON and OC sizes was reached. This was accompanied by periods of accelerated and slow increase in the OC compartments. The change in the distances between the OC walls and the ON corresponded to the formation of ON bends in the OC. Conclusions. There are certain stages reflecting the interrelation of the OC components in which infringement of one inevitably changes the others. The determined ON/OC diameter ratio was considered to become crucial for the normal formation of the ON and OC. The revealed patterns of OC and ON prenatal development will contribute to the understanding mutual relationship of the OC and ON in people of different ages and constitutions. The research was approved by the Committee on Biomedical Ethics of the Belarusian State Medical University (order 309 dated 15 June 2012).

P33 | The human eye drainage system: Development and structure

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The relevance of research is dictated by a high risk of blindness and disability because of glaucoma. Glaucoma pathogenesis is based on the infringement of eye hydrodynamics in which the eye drainage system plays the main role. The purpose of the work was to establish patterns of development and structure of the human eye drainage system. Research objectives were to determine the structural features of the human eye drainage system in embryogenesis and to identify structural options of the human eye drainage system in postnatal human ontogenesis. The human iris-corneal angles were studied on sections of 20 embryos from 10 to 70 mm of parietal-coccygeal length from the embryological collection of the Human Anatomy Department of the Belarusian State Medical University and on anatomical preparations of 46 heads. The patterns of human eye drainage system embryogenesis were established: the location of the transition zone cornea–sclera in relation to the Schlemm's canal, topography of the Brucke muscle, the structure of inner wall and the lumen of the Schlemm's canal and scleral vessels. They reflected the sequence of Schlemm's canal structures formation. Their infringement (the iris-corneal angle closure with the

persistent pectinate ligaments or with the not completely resolved mesoderm tissue; partial splitting iris, ciliary body and trabeculae; improper differentiation of trabecula tissue with the excessive collagen formation) can lead to congenital glaucoma development. Diagnostic guidelines of the normal structure of the human eye drainage system were determined: the location of the cornea–sclera zone relative to the Schlemm's canal, topography of the Brucke muscle, the severity of the Schlemm's canal inner wall and lumen and scleral vessels. The obtained data were considered to become crucial for the identification of their pathological changes in glaucoma, as well as for the interpretation of glaucoma formation and for the elaboration of the pathogenetically based treatment of this disease. The Committee on Biomedical Ethics (order no. 309 from 15 June 2012) of BSMU carried out ethical expertise of this research.

P34 | The microscopical changes seen in rat's thymus and parathyroidglands after immunostimulation using a dark-field microscope

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Hundreds of risk factors are faced every day by the human body that weighs and disrupt the immune system significantly. Medical research indicates that alterations in the endocrine homeostasis are consistent with haematological, oncological and immunologically identified diseases known for their immune pathogenesis. Twenty-four Matured male WAG rat's thymus and parathyroid glands were used. Two groups (G) were arranged, each randomly divided and consisted of animals of the same age and size. A drug indication for an immune-deficient disorder, Imunofan was given to the experimental group (G1) in the prescription of 0.7 mg/kg of body weight, on the third and 30th day of experimental trials duration by the intramuscular route of administration. In contrast to the G2 (control group) which were administered 0.9% of Normal Saline. The gland samples were obtained by cervical dislodgment (dislocation) and histological methods of treatment were used. Then the following slides were examined using an EM-125 electron microscope at a total of X8000 magnification. The architecture of the parathyroid gland of experimental animals (G1) was found to be slightly different from those of control rats evidenced by microscopy and morphometric analysis (G2). The active chief cell count rises dramatically on the third day following inoculation of the immunomodulatory treatment. As a result of elevated secretory activities, the cells are joined by several interdigitates to expand the surface area involved in the metabolism control. On the 30th day after the administration of Imunofan has shown that the experimental rat glands have large numbers of active cells as opposed to when administered to the thymus on the third day showing no significant increase in size, and this could be as a result of the pharmacokinetics of the drug or the time taken for thymus gland proliferation after invading pathogen. However, the thymus gland reveals the presence, at various levels of division, of substantial numbers of lymphocytes. The existence of active macrophages shows that the immunostimulating activity of Imunofan is highly lymphocytopoietic. Compared to control animals (G2) of the same size and age, the main change in the Parathyroid glands of experimental rats (G1) is the transition of the groups of inactive cells into action due to their stimulations. In that, substances such as low oestrogen infusion, isoproterenol, even calcitonin activate the active stage in the chief cells. Phagocytised cells of the thymus were restored with 2–4 weeks of immunostimulation, showing that immunostimulant drugs such as Imunofan could restore thymic structures.

The maintenance and manipulation of animals were carried out in compliance with the requirements of bioethics and the requirements of bioethics and the 'General Ethical Principles of Animal Experiments' adopted by the First National Congress on Bioethics (Kyiv, 2001), the requirements of the 'European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes' (Strasbourg, 1986).

P35 | Anatomy by dissection: Establishment of a fully comparative dissection unit

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The most effective way for anatomy to be taught continues to be a subject of debate in higher education institutes globally. At the School of Anatomy, we teach across three professional programmes, as well as our BSc and iBSc in Applied Anatomy and Functional and Clinical Anatomy, respectively. Across these programmes, a range of teaching styles is utilised, with both cadaveric dissection and specimen-based prosection teaching used. This year, we adapted our Anatomy by Dissection unit to a comparative dissection theme. Classically, second-year Applied Anatomy BSc students decided whether to pursue either human or veterinary dissection. However, as these students also study both human and veterinary anatomy in parallel sister units, a comparative dissection approach was considered to complement this content and their learning. Weekly 3-hour dissections were scheduled, with human and canine cadavers used in alternating weeks. The unit followed a topographical structure, with relevant large animal dissections introduced where appropriate. This allowed students to appreciate species-specific differences in the anatomy and to examine adaptations of the form with respect to function. Feedback was generally positive, with students commenting that appreciating comparative differences between the species aided recall, especially when supplemented with online lectures. Here, we present examples of how true comparative teaching has been achieved alongside informal student feedback about the unit and its novelties. Future iterations of the unit will aim to maintain the comparative element to the unit. Students on the Applied Anatomy BSc graduate as comparative anatomists, hence the experience of comparative dissection is appropriate. Appropriate HTA licenses were in place throughout this unit. Institutional ethics were not appropriate as feedback was not formal.

P36 | Development of three-dimensional scaffolds model suitable for the study of prostate cancer

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Prostate cancer (PC) is one of the leading causes of cancer-related death in men worldwide. In the early stages of advanced PC, cancer cells undergo epithelial-to-mesenchymal transition (EMT), a process, whereby epithelial cells lose their cell–cell adhesion, gain migratory and invasive characteristics and travel through the blood vessels to invade new tissue, leading to metastasis. Approximately 90.1% of those who die with PC have bone metastases. Unfortunately, the bony skeleton is especially problematic to treat. Studies suggest that combining docetaxel with hormone therapy helps in reducing PC progression and spread but ultimately only prolongs the length of survival. As a result, there is a major unmet clinical need to develop alternative treatments. The extracellular matrix of prostate tissue contains various constituents including chondroitin sulfate (CS), which is significantly increased in metastatic PC and therefore may be of interest for further investigation. This project aims to develop three-dimensional (3D) porous collagen/CS (Coll/CS) scaffolds suitable for studying *in vitro* PC EMT and as a platform to test and develop treatments for PC. Three Coll/CS scaffold compositions containing 0.5 weight/volume (w/v) collagen and 0.05, 0.55 and 1.05 w/v CS were prepared. These scaffolds will be subjected to rigorous scaffold characterisation, including mechanical testing, SEM, pore size analysis and porosity measurements. To determine the impact of CS on PC EMT processes and bone metastasis growth, osteolytic PC-3 PC cells were cultured on Coll/CS scaffolds. Additionally, EMT marker expression will be examined on the Coll/CS scaffolds and compared to 2D cultures to determine the impact of increasing CS concentrations on EMT marker expression. Furthermore, biochemical evaluations, such as metabolic activity, DNA quantitation and Live/Dead cell viability assays, will be used to determine their suitability for mimicking the ECM for PC and their ability to support cell growth and proliferation. Highly porous Coll/CS scaffolds have been successfully developed. Mechanical testing showed that the scaffolds can be used to simulate the stiffness of PC tumours. Initial findings demonstrate that the Coll/CS scaffolds support cell growth and proliferation, and therefore could be used as an in vitro platform for studying PC EMT processes and drug testing.

P37 | Student and educator perceptions of a digital 3D anatomy learning resource

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Within modern anatomical education, the development and introduction of technology-enhanced learning strategies have increased and enhanced the provision of anatomy learning resources. The digital anatomy application Complete Anatomy (3D4Medical Elsevier) enables visualisation, manipulation and interaction of layered 3D anatomical models. Complete Anatomy has been used by anatomy educators at Newcastle University (NU) since 2018/2019 to present 3D anatomy during in-person lectures and within online synchronous teaching sessions. Based on informal student feedback and educator experiences of using the resource, Faculty of Medical Sciences students at NU were provided with user access to Complete Anatomy from the start of the academic year 2020/2021. With a view to this, we aimed to investigate stakeholder perceptions of Complete Anatomy with respect to current usage and future strategies for embedding the resource in teaching and, for providing opportunities for self-directed learning with Complete Anatomy. A student–partner strategy enabled undergraduate project students to develop knowledge, skills and abilities during contributions to research design, implementation and data analysis. A mixed-method approach was conducted within a pragmatic theoretical framework. A questionnaire instrument consisting of a 7-point Likert-type scale and free-text items was administered to a second-year medical cohort (n = 340), who had experienced Complete Anatomy both when embedded in teaching and when used as a remote self-directed learning resource. Two focus groups involving medical student (n = 10) and anatomy educator (n = 3) participants, respectively, were conducted virtually via videoconference in February 2021 to explore richer and deeper perceptions of the Complete Anatomy resource. Data were analysed statistically and by double-coded semi-quantitative or qualitative thematic analysis as appropriate. Responding students (n = 145) reported that with appropriate training and guidance, Complete Anatomy could provide a valuable supplementary learning resource for revision and consolidation of learning. Furthermore, students perceived that Complete Anatomy could support effective 3D interactive visualisation and could enhance their understanding of spatial anatomical relationships. Focus groups further explored these themes, identified value in Complete Anatomy as effective preparation for the dissecting room and raised potential limitations of digital resources with respect to anatomical detail and variation. These findings will have implications for the design, development and implementation of digital anatomy resources within blended post-pandemic anatomy curricula. Institutional ethical approval was obtained for this work.

P38 | Notch controls the periodicity of neural segmentation and the stabilisation of a midbrain-hindbrain boundary in the basally branching chordate *Branchiostoma lanceolatum*

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During vertebrate development, transient segmentation of the hindbrain into rhombomeres is essential for establishing the serial arrangement of cranial nerves. However, the mechanisms that allowed neuronal segmentation to evolve in vertebrates remain unclear. Intriguingly, although the basally branching chordate amphioxus lacks rhombomeres, its neural tube contains serially arranged neurons. In vertebrates, Notch activation is essential for rhombomere boundary formation, however, its potential role in regulating iterative gene expression in amphioxus has never been studied. Hence, to study how repetitive patterns are established within the amphioxus neural tube, we focused on the role of Notch, finding it essential for the maintenance of the floor plate and neuronal progenitor identity. We show that Notch signalling regulates neural differentiation and that Notch-Delta lateral inhibition likely defines the periodicity of serially arranged neurons in the amphioxus neural tube. Additionally, we found that Notch signalling is essential for stabilising the anterior boundary of Gbx at the posterior limit of Otx, where we also show the co-expression of PAX2/5/8 and Engrailed, thereby revealing a long-sought-for midbrain–hindbrain boundary homologue in amphioxus. Our results suggest that Notch may be controlling the segmental organisation and numbers of nerves across chordates and that in vertebrates, these roles of Notch were incorporated into the process of rhombomere formation.

P39 | SARS-CoV-2 transmission through human body donors: What do we know?

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According to the World Health Organization (WHO), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the cause of coronavirus disease 2019 (COVID-19), emerged in Wuhan, China in December 2019 and was officially declared a global pandemic in January 2020. The spread of SARS-CoV-2 has had a significant negative impact on anatomy education due to the inability to conduct dissections on human cadavers. According to Medscape, the lack of information on the mechanisms of potential SARS-CoV-2 transmission through human body donors resulted in the shutdown of many academic body donation programmes. Due to how recently COVID-19 emerged, there is still a shortage of information in this area, and increasingly, questions have arisen as to whether the chemicals used to preserve a human body donor have the capacity to inactivate the virus and prevent transmission. A study in 2004 noted that the original SARS-CoV was inactivated when treated in collaboration with formalin, and newer findings show the effectiveness of formaldehyde inactivation in poliovirus. And while the effects of formaldehyde on virus receptor binding, antigenicity and viral RNA release are reasonably understood, more research must be conducted on virus inactivation to better elucidate the relationship between the retention of virus antigenicity and loss of virus infectivity. Other studies have also shown the effectiveness of formaldehyde-induced virus inactivation. In comparing formaldehyde to β-propiolactone, it was determined that there were no significant differences in the inactivation of West Nile Virus, based on differing processes. In comparing the inactivation of influenza A virus, adenovirus and cytomegalovirus with PAXgene tissue fixative and formalin, both methods effectively inactivated the three viruses. Based on the presented literature, it is safe to assume that formaldehyde as a chemical does have the capacity to inactivate viruses, but the question remains as to whether its use as an embalming agent could have the same impact on SARS-CoV-2. Currently, protocols are being developed at The Ohio State University to investigate the impact of formaldehyde on the ability of SARS-CoV-2 to be cultured after using a sample from a formalin embalmed body donor, but more research is necessary to obtain better clarity.

P40 | The facial nerve tube map

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The facial nerve (CN VII) has complex anatomy with inputs from three nuclei. Knowledge of this anatomy and its correlation with symptoms is useful for medical students when undertaking clinical examinations and for establishing the diagnosis. To aid with their neuroanatomy education, we created an illustration that demonstrates the clinical anatomy of the Facial Nerve in the style of the London Tube map. We conducted a curriculum development audit loop, using a medical illustration intervention. The illustration was drawn using Sketchable™ for Microsoft Surface Pro 4. Anatomical references were derived from reputed anatomy textbooks, cadaveric models and peer-reviewed journals. Evaluation of the tool was achieved through a voluntary questionnaire for the first-year medical students, posted to their student portal homepage, and ethical approval from the University was obtained. Fourteen first-year medical students responded to the questionnaire. About 85.7% of respondents found the facial nerve tube map helped them understand the anatomy better, and how lesion location leads to varying symptoms. A hundred percentage of respondents said that it appealed to their learning style. The map was edited based on student feedback and underwent further development to create the finished product. To conclude, the facial nerve tube map is an effective educational tool for first-year students and can be utilised as a method of teaching the anatomical basis for neural pathology. In the future, as part of curriculum development, anatomical schematics should be designed for the students with students. The tube map format is a recognisable and simplistic way to demonstrate neuroanatomy and could be utilised to represent other cranial nerves and the relation to nuclei in the brainstem.

P41 | Computed tomography (CT) analysis of the original Poland Syndrome hand reveals novel vascular anatomy anomalies

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Poland syndrome (PS) is a rare congenital condition that classically presents with unilateral aplasia of the upper limb and anterior thoracic abnormalities. The incidences of cases are estimated to be around 1 in 30,000–50,000 newborns and are more commonly seen in males than females (3:1). Characteristic features include ipsilateral hypoplastic development of the sternocostal bundle of the pectoralis major, pectoralis minor and hand symbrachydactyly. However, these malformations do not always present together in a PS individual and the severity of deformities can vary greatly. The defining features of what has become known as Poland Syndrome (PS) were first described by Alfred Poland, then a medical student at Guys' Hospital, in his description of the dissection of the cadaver of George Elt. Poland's original report describes left-sided hypoplasia of the sternocostal head of the pectoralis major muscle and ipsilateral brachysyndactyly of the hand. The underlying mechanisms and pathophysiology that cause PS are not well understood and require further investigation to understand the aetiology of this congenital condition. We have used computed tomography (CT) imaging to construct 3D models of the original George Elt hand, preserved at the Gordon Museum of Pathology, Kings' College London. Using this high-resolution imaging method, we identify previously unreported abnormal vascular anatomy in the Elt specimen and compare these to documented PS phenotypes. The mechanism underlying PS pathogenesis has been hypothesised to be of vascular origin, caused by disruption of the subclavian artery supply sequence (SASDs) phenomenon. As few studies are describing the hand vasculature in PS, our study sheds light on the malformations that can occur in PS. Ethics statement: All work carried out following the Human Tissue Authority Act 2004 and followed in accordance with the Declaration of Helsinki.

P42 | A gamified resource for learning anatomy terminology

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Anatomy terminology can pose a problem to students as it requires extensive memorisation. We aimed to apply the elements of game playing (competition, point-scoring and collaboration) to make this process easier and to encourage revision and student interaction. A card game called 'Hold your Nerve', was created and tested by students, the recall was tested before and after playing the game and an improvement was noted. The resource is a set of 722 cards, each bearing a term and its definition. A 'guesser' displays only the term to their group who must then offer mimes and clues to aid the guesser in determining the term. This present students with an opportunity to communicate with peers using anatomical terminology, contextualise terms via mime and explanation and to engage in peer learning. If the group is unfamiliar with the term, the definition can also be uncovered to aid clue generation. A competitive element can be incorporated in the game within and/or between groups. The cards were tested with 38 second-level Anatomical Sciences students at Queen's University Belfast. Students were placed in 'playing' and 'non-playing' groups and they completed a pre- and post-test relating to the terms on the cards. Average scores in the playing groups improved from 82% to 90% ($p < 0.05$, $n = 20$), while those in the non-playing group did not significantly improve (86% and 87% in the pre- and post-tests, respectively, $p = 0.43$, $n = 18$). Enthusiastic student engagement was noted and 95% agreed the game would be a useful addition to their studies, 100% agreed it was helpful for revising and 97% enjoyed playing the game. This resource is simple and cheap to deploy but is not available commercially. We have demonstrated positive student perceptions and a benefit of the game to short-term retention. This is a cheap and useful tool that can be used to help engage students in the revision of terminology and can serve as an 'ice-breaker' activity during practical sessions to encourage group interaction. An e-copy of 722 cards (focusing on several regions) can be obtained by contacting the corresponding author. Institutional ethical approval and informed consent were obtained prior to the study (Ref 19.31v2).

P43 | The effect of soybean administration on the expression of Zona Pellucida 2 of each phase in the female mice ovarium (*Mus musculus*) follicle during follicular development

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Isoflavones in soybeans are known to increase ovarian age and oocyte quality. However, specific research on the effect of dietary soybeans on Zona Pellucida 2 (ZP2) has not been widely studied. Therefore, the objectives of this research were to determine the effect of soybean administration on the expression of ZP2 in female mice, to identify the quality and quantity of each phase in the follicle and compared it with each phase of follicular development which was analysed using statistics. The novelty of this research is that

soybean administration can significantly improve the quality of oocytes in female mice with the expression of ZP2 immunohistochemistry. This research used Mus musculus, 6-week-old female SWISS strain mice divided into three groups (group without soybean administration, group with mixed feed (soybeans and pelleted) 50:50 and 25:75). Soybean feed for mice was 360 g/kg of mice body weight for 2 weeks. The percentage of follicles was measured and analysed using Haematoxylin-Eosin staining and the expression of ZP2 was analysed using immunohistochemistry. Data were evaluated using one-way ANOVA and paired t test with SPSS 17. Some of the follicles in the ovaries were not developing until the final stage of follicle maturation. The follicles counted and analysed in this research were primary, secondary, tertiary and atretic follicles. The administration of soybean before and after treatment in all groups was insignificantly different, but the numbers of atretic follicles in groups 1 and 2 were significantly different. Soybean administration with the ratio of 50:50 has the effect of increasing the percentage in the expression of ZP2 in tertiary follicles ($p = 0.001$) then soybean administration with the ratio of 25:75 has not been able to maintain or increase the formation of ZP2 in tertiary follicles ($p = 0.77$). Soybean administration with a ratio of 50:50 has significantly increased the percentage in the expression of ZP2 in tertiary follicles. This research was conducted after an ethical review by the Health Research Ethics Committee of the Faculty of Medicine, University of Indonesia and after obtaining a certificate of passing an ethical review with protocol number 20-07-0777.

P45 | Age estimation from osteometry parameters of tubular bones of the hand in children and adolescents from Tajikistan

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The intensification of migration processes prompts the development of approaches for age estimation in children and adolescents of various ethnic groups. However, they yield more reliable results when population-related features are taken into account. The study aimed at assessing the possibility of using morphological parameters of tubular bones of the hand for age estimation in Tajik boys and girls aged 6–17 years. The length and width of tubular bones and the width of medullary cavities were measured in a total of 251 X-ray images of the right hand. The X-ray scans were obtained due to medical necessities only. A linear regression analysis was performed to assess the relationship between the morphological parameters of tubular bones of the hand and the age of participants. The quality of regression models was assessed through the coefficient of determination R^2; the significance was assessed using the F test. Only models with statistically significant coefficients of determination were regarded. The results showed that the length of tubular bones of the hand was a better age predictor compared to the diaphysis

width. The model that included the measurements of the phalanges of the thumb, the first, second, and third fingers yielded good results ($R^2 = 0.81$). The model based on the parameters of the phalanges of the thumb and the first finger had nearly the same coefficient of determination. The regression formula that included only the parameters of the phalanges of the thumb and the first finger showed a good prognostic value for boys ($R^2 = 0.8$) while being less reliable for age estimation in girls ($R^2 = 0.72$). If the parameters of phalanges are unavailable, metacarpal bone measurements can be used as age predictors. It can be concluded that morphological parameters of tubular bones of the hand can reliably predict age in Tajik children. The research project was obtained permission from local Ethical Committees of the Academician Pavlov First Saint-Petersburg State Medical University (Saint-Petersburg, Russia). The authors declare that they did not have any conflicts of interest in the planning, implementation, financing and use of the results of this study.

P47 | IGCIP: The Future of Cochlear Implant Programming? Using image guidance CI programming techniques will improve speech performance in CI users compared to current traditional programming techniques

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The cochlear implant (CI) is regarded as one of the most successful neural-prosthesis in the world. However, a percentage of CI users do not experience significant improvement in speech performance benefits. New developments are consistently seen across technological advancements in CI devices and CI surgical techniques, however, less research has been conducted in optimising CI programming. Traditionally, CI programming involves the application of a standard full clinical map, with the assumption that the CI's electrode arrays are in the most optimum anatomical position to transmit signals to the cochlear nerve. A novel technique, known as IGCIP (image-guided cochlear implant programming), considered the use of CT image guidance to identify the anatomical intra-cochlear positions of the electrode arrays. This allows for individualised CI programming approaches, where suboptimally placed electrodes are deactivated from the map, in theory reducing channel interaction between electrodes, resulting in a clearer signal and thus improving speech performance outcomes for CI users. A literature search was conducted of MEDLINE and EMBASE databases from the start of June to the end of September 2020. References of all relevant articles were examined and weekly PubMed searches were conducted for new literature. Thirty articles were retrieved, with additional articles acquired from relevant references (3) and PubMed (2), with 20 meeting the inclusion criteria. Post-exclusion criteria application left 12 studies to be included in the analysis. Seven articles used imaged guidance for CI programming, with five

adopting IGCIP methods and five articles using non-imaged guidance methods. Two main themes emerged from the literature review: *Imaging Techniques vs. Non-Imaging Techniques*. A significant improvement was seen in speech performance outcomes with the IGCIP technique over non-image-guided techniques. Overall, the image-guided techniques proved to be more consistent in results, compared to the high variability observed in the non-image guided. This indicates that image guidance in CI programming results in higher levels of speech improvement than non-image guidance. Through future work, IGCIP could be implemented into a clinical CI programming routine. This study does not require ethical approval as the methodology used consists of reviewing and collating data from publicly available databases.

P48 | The anatomical variance of the anterior ethmoidal Artery, with relevance to endonasal surgery

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The anterior ethmoidal artery is a high-risk structure in the paranasal sinuses, with inadvertent injury potentially leading to blindness or cerebrospinal fluid leak. It is a key structure in certain skull base and sinus surgeries. It is a highly variable structure, in part due to its inter-relations with the many discrete variable structures it closely relates to within the paranasal sinuses and nasal cavity. Awareness of the anterior ethmoidal artery is key to safe surgical practice in endonasal procedures. This study aimed to analyse the relationships of the anterior ethmoidal artery to the adjacent anatomical structures of the nose. This will hopefully help surgeons in identifying the anterior ethmoidal artery and make endonasal surgeries safer. EMBASE, MEDLINE and PubMed were performed in June 2020 and identified articles, of which 17 were considered eligible to be included in this study. The anterior ethmoidal artery was found to have an average diameter and average intranasal length of 0.80 ± 0.24 mm and 5.82 ± 1.41 mm, respectively. The course of the anterior ethmoidal artery was found to vary in its relation to the skull base. It can be adherent to the skull base, suspended within the soft tissue or in a thin bony mesentery below the skull base. The relationship between the anterior ethmoidal artery and the lamellae was investigated in this study to avoid injury to this artery during the dissection of the lamellae in Endoscopic Sinus Surgery. The first lamella is considered the uncinate process, the second is the anterior wall of the ethmoid bulla, the third lamella is the basal lamella of the middle turbinate and divides the anterior and posterior air cells of the ethmoid sinus. The fourth lamella corresponds to the superior turbinate and the fifth is considered the supreme turbinate. The anterior ethmoidal artery was found between the second and the third lamella in 75% of cases, and in the third lamella in 12%. It was concluded that the anterior ethmoidal artery is a key structure in the skull base that is important to find and assess pre-operatively to minimise the risk of serious complications post-operatively in this area.

P49 | Medical students view on the methods of teaching anatomy in a new Subsahara medical school

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Relatively little has been written on methods of teaching Anatomy in a new medical school in sub-Saharan Africa, although there are a number of initiatives in support of the quality of medical education to improve the quality and quantity of medical graduates. This study assessed medical students' perception of the type of medical curriculum implemented and the methods of teaching Anatomy. A 5-point Likert scale questionnaire was designed to address the Methods of teaching Anatomy, as adopted by the Department of Anatomy, Edo University, Iyamho, Edo State, Nigeria, which was completed by ninety-four 200 L and 300 L medical students exposed to the curriculum and Anatomy teaching methods. Our findings showed that 97.9% of medical students were aware of the type of curriculum, but 77.7% know that it is an integrated medical curriculum. However, 36.2% knows that horizontal integration was implemented in Basic Medical courses. About 68.1% agrees that Anatomy is important in medical training, 59.6% agrees that horizontal integration improves anatomy knowledge, while 61.7% agrees that clinical correlation of anatomy prepares them for Anatomy clinical application. Students preference pattern for methods of teaching Anatomy differs 33% for Traditional Lecture room teaching, 57.4% for use of Powerpoint, 53.2% for Museum teaching, 54.2% for the combination of a classroom and Cadaver dissection (CD), 50% for use of Technology-enhanced teaching (the Anatomage) and 61.7% for the combination of classroom + CD + tutorials. About 55.3% agrees that time allocated for CD was adequate and 65.6% agrees that it improves their Anatomy knowledge via peer learning, 64.5% agreed it deepen their understanding of Anatomy. Although CD is good, 45.7% disagree it should not be replaced with lectures while 45.7% disagree with it being replaced with prosection and 37.2% against replacement with virtual dissection using Anatomage. On-time adequacy implemented in methods of teachings and regions of anatomy taught, responds agreed as follows: CD (60.6%), anatomical models (58.5%), gross lectures (63.8%), histology lectures (63.8%), embryology (61.7%) and histology practical (69.1%), whereas the use of Anatomage is 48.9%. An integrated medical curriculum is good. Horizontal integration of the Anatomy course model improves Anatomy understanding and knowledge in addition to combined methods of teaching Anatomy in a new sub-Saharan medical. The ethics committee approves this study and informed concern of respondents was sort before the administration of the questionnaire.

P50 | Uterine transplant in women with Mayer–Rokitansky–Küster–Hauser Syndrome: A review of the surgical anatomy and vascular considerations for donors and recipients

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The successful live births from uterus transplants offer hope of gestational motherhood to women with Mayer-Rotikansky-Kuster-Hauser syndrome. The first uterus transplant, performed in 2000, failed for anatomical reasons, namely the lack of support of the uterus leading to kinking of the vessels and ultimately thrombosis. By 2018, the UK received approval to perform 10 deceased and 5 living uterus transplants and have since published their inclusion and exclusion criteria for donors and recipients. The aim of this paper is to critically analyse the published cases of uterine transplant in Mayer-Rotikansky-Kuster-Hauser syndrome patients to determine key anatomical and vascular considerations prior to the UK trial. A literature search of MEDLINE and EMBASE was performed from 2002 until present and the references of included studies were searched for relevant articles. Overall, 173 articles were identified and 32 met the inclusion criteria. After application of the exclusion criteria, 17 articles were included in this review. Ten articles were primary papers with 7 follow-up papers. A total of 32 cases were included resulting in 23 patients menstruating, nine pregnancies with three miscarriages and six live births. Anatomically, deceased donors are advantageous as longer vascular pedicles can be retrieved and the ovarian arteries can be harvested from young donors without ethical concerns. The changes in English and Scottish law regarding organ donation mean that the UK team may have increased access deceased donors. The choice of vessels to use for venous drainage remains the most controversial topic and is dependent on donor age and menopausal status, anatomical variation and surgical technique. The ovarian veins have the least risk of venous congestion resulting in graft removal and was associated with fewer donor complications; however, in young donors, this may lead to surgically induced menopause. As the UK criteria states donors must be premenopausal, this is not an option in the UK unless the inclusion criteria is expanded. Uterus transplant is still in its early stages but despite previous setbacks, advances in medical technology and publishing of both successes and setbacks worldwide will allow for the development of a protocol with minimum complications and maximum live births.

P51 | Use case for rare human foetus museum specimens in online anatomy education: Preparation 296 curated by Jacob Henle sometime between 1844-1852

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Old and rare museum specimens provide a potentially useful source of learning assets for anatomy education due to advances in medical imaging and online collaborative platforms. The purpose of this study is to describe a use case in anatomical education with extended reality (XR) visualisations of dicephalic parapagus full-term conjoined twins that were curated by Dr Jacob Henle sometime between 1844 and 1852. The cadaver (Preparation 296) is located in the Department of Anatomy and Cell Biology at the University of Heidelberg and was CT/MR imaged at Das Radiologische Zentrum Heidelberg. Analysis of system development was undertaken to create diagnostic characteristics for an online presentation to medical students. A workflow was utilised comprising image capture, segmentation and visualisation. A radiology report was created and posted with MR/CT volumes for presentation to medical students as an XR learning module introducing first-year medical students to the human body plan. Critical developmental defects in Preparation 296 were identified including duplicated supradiaphragmatic structures and osteological features. Subdiaphragmatically, the gut was continuous on the right but terminated at the distal oesophagus on the left. One large liver occupied the abdomen with one large spleen located on the left. Observations suggest zygote fission ceased near the yolk sac during midgut formation, but with the secondary fusion of midline upper extremities and ribs. Collaborative review and discussion of the XR models were undertaken to initiate discussion amongst the students concerning human body plan, mechanisms of conjoined twinning, historical figures in medicine and psychosocial health issues including biological individuation and anatomical normalisation. The workflow presented here enables XR visualisations of a rare anatomical museum specimen with non-intrusive observations using advanced biomedical imaging. Visualisations can be used in an educational module introducing body plans with online display beneficial for remote learning as well facilitating knowledge acquisition beyond human anatomy and embryology. IRB exemption was applied (University of Heidelberg) based on the rationale that the identity of the twins could not be ascertained since personally identifiable information does not exist.

P52 | A stereological study of the pigmented retinal epithelium in the wobbler mouse model of motor neuron disease

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The Wobbler mouse is used as a model for the investigation of human inherited motor neuron diseases including amyotrophic lateral sclerosis (ALS). In this presentation, we use stereological methods to document changes in the anatomy of the Pigmented Retinal Epithelium in this mutant. The retinal pigmented epithelium (RPE) is key in maintaining the health of the retina. Previous studies had reported disturbances in the anatomy of the eye in the MND mouse model. In the present study, transmission electron microscopy and stereological methods were used to quantify aspects of the ultrastructure of the RPE. A systematic sampling regime was combined with stereological methods to provide estimates of melanosomes, mitochondria, apical and basal cell membranes in Normal and Wobbler mice. There was a significant decrease in the cell, total mitochondrial and total melanosome volumes in the Wobbler group. There was also a significant decrease in basal membrane surface area. The data suggest that the RPE in normal mice seem to be far more efficient than the Wobbler. This may explain earlier reported disturbances in the choroid vasculature where there was evidence of an increased length, density and a corresponding decrease in radial diffusion in the Wobbler mice. This study may shed light on the pathological mechanisms encountered in a variety of chorioretinal diseases. This study also highlights the importance of a whole-body approach when using animal models to investigate complex diseases such as MNDs. This study had appropriate ethics committee approval.

P53 | Evidence from *ex vivo* culture for tissue stiffness as the driver in palate elevation in the mouse

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The mammalian palate serves as the essential physical and functional barrier between the oral and the nasal cavities, assisting in speech, eating and breathing. It is also one of the commonest locations for human birth defects, with the incidence of cleft lip and/or palate at 1:700 live births worldwide. These dysmorphias of the palate may arise at any stage of palatogenesis, from the initial ventral outgrowth of the paired so-called palatal shelves (PS), via their elevation above the tongue to their eventual fusion horizontally at the midline. Of these stages, elevation is most poorly understood, with no universally agreed-upon mechanism by which it occurs. It is purported that elevation is driven by a force internal to the PS and that there is a heterogeneity to the process, with the anterior 'flipping-up' like a drawbridge, and the posterior actively remodelling around the tongue. To investigate palate elevation, we used an established head tissue explant rolling-culture system and documented the PS tissue movements *ex vivo*. Unexpectedly, measurements of growth and elevation and fate mapping with DiI suggested that in the absence of the tongue, there is no distinct elevation event, contrary to what has been previously described in the literature. Our early

data suggest that the palatal shelves autonomously try to grow medially but, being elastically deformable, are normally ventrally deflected and laterally compressed by the tongue during outgrowth. Therefore, we propose that the supposed heterogeneity in elevation along with the anteroposterior axis is entirely due to mechanical differences arising from the anteroposterior differences in the geometry of shelf-tongue apposition: the anterior flipping-up is the relief of elastic deflection and posterior remodelling is the relief of elastic compression. In both cases, movement of the shelves over the tongue is enabled by increased space in the oral cavity *in vivo*. Future approaches to testing this hypothesis, including stiffness mapping and computational modelling approaches, are discussed. All work with animals was compliant with UK Home Office regulations and King's College London Ethics Committee approval.

P54 | Woodruff's area in humans as the source of posterior epistaxis – Insights into an anatomical misconception

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Most anatomists would recognise Kiesselbach's plexus as the source of anterior epistaxis. Conversely, posterior epistaxis is a much less common occurrence (5-10% of cases) than the anterior form via Kiesselbach's plexus and its vascular location has been subject to debate. Woodruff's plexus is routinely cited as the source of posterior epistaxis, however, there is significant inconsistency as to the morphology and nature of this vascular network, some papers identifying it as arterial and others as venous. Consequently, we aimed to evaluate relevant literature and establish a consensus as to the anatomy of Woodruff's plexus. A systematic search was conducted on major databases using a combination of keywords relating to Woodruff's plexus. Using the PRISMA framework, a total of 41 papers met the inclusion criteria. Woodruff's original paper from 1949 described the plexus as a venous structure and made the assumption that it is responsible for posterior epistaxis based on clinical correlations. Since then, only 2 anatomical dissection studies have been conducted, both of which demonstrated the plexus to be venous. Despite these findings, 56.1% of papers document the plexus as arterial describing a heterogeneity of vessels, without referencing any anatomical publication. Various authors identify a combination of the sphenopalatine artery, ascending pharyngeal artery, posterior nasal artery or maxillary artery branches as the components of the plexus. Clinical studies on idiopathic posterior epistaxis have also revealed that bleeding from this area occurs only in up to 8% of cases, thus its significance is exaggerated in this pathology. In conclusion, a significant discrepancy can be found in the literature with regards to this plexus and it is difficult to point to the exact historical source of the confusion. We hypothesise that the sphenopalatine artery is defined as the main vascular source as the surgical ligation of this artery is so

efficient in managing complex cases of epistaxis; thus, the disparity might have arisen from clinical correlations. Rather than a plexus, we propose the term of Woodruff's area, as the source of posterior epistaxis, covering the region supplied by the posterior sphenopalatine branches as well as the plexus described by Woodruff.

P55 | Evaluation of Craniometric landmarks to investigate novel discriminant functions for sex estimation of the human skull

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Sex estimation is a key stage in constructing a biological profile for recovered human remains. Traditionally, the pelvis has been commonly used to estimate sex. However, due to its relative fragility and inconsistent recovery, an alternative sex estimation method is often required. Numerous studies have now demonstrated that the skull is sexually dimorphic and has the potential to be used in estimating sex. Therefore, this study aims to create a novel and validated process to estimate sex with the potential for application for fragmented human remains in a forensic context. A dataset of twenty-two cranial inter-landmark distances (ILD) from 22 skulls (11 male and 11 female) of Southeast Asian origin was used in this study. Univariate and multivariate analyses were performed on the data using SPSS version 24, with ILDs divided into anterosuperior, anterolateral and posterolateral regions. Inter- and intra-observer errors were also investigated between three observers. Results indicated that the anterosuperior cranial region is a region of particular interest for sex estimation as three of the most sexually dimorphic ILDs were from the anterosuperior cranial region. Five Fisher's discriminant functions were produced which had an original/cross-validation accuracy of 1. The accuracies of these discriminant function equations ranged from 77.3% to 86.4%. The results suggest that the anterosuperior cranial region has the potential to be used in developing novel sex estimation methodologies. This research utilised historic human skulls from The Anatomical Museum, Teviot Place, Edinburgh, which are permitted for use in research under existing departmental guidance and documentation.

P56 | Bilateral variation of median nerve in the arm – A case report

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The median nerve is formed by the union of medial root and lateral root from the corresponding cords of the brachial plexus in the axilla. Anatomical variations in the median nerve are very crucial for the various surgical and anaesthetic treatment modalities. This case report presents the variation in the formation of the median nerve which was noticed bilaterally in a 28-year-old male cadaver during routine anatomical dissection for undergraduate medical students. The median nerve was formed by the union of the medial root of the medial cord and lateral root of the lateral cord of the brachial plexus in the middle one-third of the arm. A muscular slip was found extending from the medial border of the long head of the biceps brachii to the long head of the triceps brachii concealing the neurovascular bundle. Upon further dissection, it was observed that the lateral root of the median nerve innervated the biceps brachii, brachialis and gave off the lateral cutaneous nerve of the forearm and then joined the medial root of the median nerve to form the median nerve in the arm. While tracing the musculocutaneous nerve, it was absent and the coracobrachialis was innervated by a small muscular branch directly from the lateral cord of the brachial plexus in the axilla. The knowledge of variations of the median nerve is of paramount importance in various therapeutic modalities in the axilla and arm, such as axillary nerve blocks during upper limb surgeries. The cadaver was donated to the institution for the purpose of teaching and research. The research was done according to the Declaration of Helsinki and the consent was obtained during body donation for the purpose of education and research.

P57 | Sex estimation using 3D scapula models based on geometric morphometric method for forensic identification in the Malaysian population

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In the forensic field, sex estimation of the scapula has been extensively reported by traditional morphometric methods, but only few literatures had reported its application using geometric morphometrics. While sex estimation from scapula is very crucial, geometric morphometrics offers a new powerful tool for shape analysis for sex estimation. The aim of the study was to determine the sexual dimorphism of 3D scapula models using geometric morphometrics and its classification accuracy. In this study, 248 females and 222 males (n = 470) scapula models were sampled. Twelve three-dimensional landmarks were recorded using the Stratovan Checkpoint software. In the analysis, collected landmarks were translated, scaled, and rotated by generalised Procrustes analysis to generate Procrustes coordinates. The Procrustes coordinates were used in the principal component analysis (PCA) to explore the variation patterns, followed by discriminant function analysis (DFA) for sex prediction accuracy. Procrustes component (PC) scores generated from PCA were used in multivariate analysis of variance. A p-value of < 0.05 was considered

as significant. Results revealed a significant scapula shape difference between males and females ($p < 0.05$). Principal component analysis revealed 29 PCs with PC1–PC6 exhibiting more than 5% variation. By DFA, a total of 80.3% cross-validated groups were correctly classified, which represented 83.1% females and 77.2% males. Based on the finding, the scapula shape of the Malaysian population are sexually dimorphic with encouraging classification accuracy. Thus, sex estimation based on scapula shape may be beneficial in the forensic identification of skeletal remains. Ethics approval was granted by the Medical Ethics Committee, Faculty of Medicine, UKMMC (Code No: UKM PPI/111/8/JEP-2018-004).

P58 | A histological and immunohistochemical exploration of diabetic wound healing using Indian traditional medicines in adult albino Wistar rats

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Diabetic wounds have a negative impact on the healthcare economy of a country, especially the developing countries where resources are poor and funding is limited. Different approaches are adopted in its treatment. The use of traditional medicines is one amongst them and has drawn global attention. *Ayurveda* and Indian folk medicine have used honey (H), ghee (G), *Glycyrrhiza glabra* (GG) and *Nerium indicum* (NI) effectively for treating normal wounds. However, the involvement of these traditional medicines in treating diabetic wounds is less explored. The present study attempts to explore the same. The study was conducted on healthy adult albino Wistar rats. H, G, GG and NI were used singly and in combination (H + G and combination of all test materials) topically to treat the excision and incision wounds created in the streptozotocin-induced diabetic rats. At two different time intervals (days 8 and 16 for excision and days 6 and 11 for incision wounds), the tissues were procured for histological and immunohistochemical (IHC) analyses. H&E was used to identify the rate of wound healing, epithelialisation, regrowth of hair follicles and Masson's trichrome stain for vascularity, inflammatory responses, fibre composition and distribution. The wound tissues were also processed to identify the inflammatory cytokine-interleukins, i.e. IL1-β and myofibroblast activity using the IHC-horseradish peroxidase method. The findings were quantified using Image analyzer software. The results showed rapid epithelialisation, early wound closure, increased vascularity, systematic rearrangement of collagen in the wounds treated with the traditional medicines in hyperglycemic conditions. In addition, we also found the complementary activity of IL-1 beta and myofibroblasts which are crucial for better wound healing. Amongst all the treated groups, H and GG showed the best results. Traditional medicines, therefore, play a vital role in treating diabetic wounds. The study thus renders an increased value to the efficacy of the traditional Indian medicines. Additionally, the derivations from the study may aid in further evaluation of various other intricate mechanisms which may lead to the development of new therapeutic approaches to the treatment of medically challenging wounds. The experiments were carried out after approval from the Institutional Animal Ethics Committee (IAEC/KMC/49/2013).

P60 | Symptom distribution in carpal tunnel syndrome: A systematic review

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Carpal tunnel syndrome (CTS) is considered the most common entrapment neuropathy. In CTS, the median nerve is compressed giving symptoms in the wrist and hand. Even though electrodiagnostic tests are the gold standard for diagnosing CTS, usually the diagnosis is based on clinical assessment. This means that, for clinicians, symptoms outside the median nerve innervation area exclude a CTS diagnosis. However, evidence shows that there is no correlation between electrodiagnostic tests and diagnosis based on median nerve distribution. Consequently, the aim of this systematic review is to investigate symptom distribution in patients with CTS in order to improve the specificity of clinical diagnosis. A systematic review was conducted using PubMed and Scopus during May of 2021. Cross-sectional studies that describe the distribution of symptoms in patients with CTS were considered eligible for this systematic review. Some additional inclusion criteria were studies in the English language that were published in the last decade. Included studies were analysed using AXIS critical appraisal tool. This review adheres to the Preferred Reporting Items for Systematic Review (PRISMA). Two reviewers conducted literature screening and a total of five studies were included (sample size = 1,151). The results show an increased frequency of extra-median symptom distribution. Also, there are indications of different distribution between painful and non-painful symptoms. The presence of extra-median symptoms can be explained in terms of sensitisation or anatomical variation. It is of clinical importance that the diagnosis of CTS should not be excluded based on the presence of an atypical distribution of symptoms. A limitation of the studies is the heterogeneity in symptom reporting and categorisation. Further research should investigate if extra-median symptoms are correlated with a longer duration of CTS.

P61 | Rolando's long path from enteroid processes to the gyri and sulci of the human brain

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Gyri were represented haphazardly as coils since the time of Erasistratus, who stated that they were comparable to the intestinal loops, which are mobile. Luigi Rolando was the first to challenge this, stating in 1829 that gyri have specific shapes and positions. In 1804, Luigi Rolando left his native Turin for Sardinia having been appointed as a Chairman of Medicine in the University of Sassari. Due to an outbreak of yellow fever in the harbour of Livorno, he took refuge in Florence where he met the old Felice Fontana who had been the founder of La Specola Museum. He became friends with Paolo Mascagni, the Chairman of the Anatomy School of the Hospital of S. Maria Nuova and chief anatomist of La Specola. He had access to both institutions, practising anatomy and learning the arts of engraving and ceroplastics. In the meantime, at La Specola, the chief modeller Clemente Susini was collaborating with the Sardinian anatomist F. A. Boi was working as a dissector in Mascagni's lab. Boi had been ordered by Carlo Felice, viceroy of Sardinia, to commission to Susini a collection of waxes for his museum in Cagliari. Thus, Rolando saw the models of Susini-Boi as several waxes were completed, including the one contained in box XIII, dated 1803. In this model, there is a correct representation of the gyri with the pre- and post-central ones and the intervening sulcus. Further evidence of Rolando's knowledge of model XIII results from the wax moulds of the superior part of two brains that are exhibited in Sassari Anatomical Museum since his stay (1807–1814) there. They show gyri patterns similar to those of the 1803 wax. Casts may have been made in Sassari by Rolando himself from the very human brains he studied in his 1809 essay. In the preface of the same essay, Rolando wrote that the shortness of the text and the scarcity of human specimens did not allow him to describe the brain external parts. This confirms it took Rolando a quarter of a century and a good deal of experiments to convince himself of the gyri regular arrangement.

P62 | The importance of peer mentoring in gross anatomy laboratory: An approach for improving medical education in Puerto Rico

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Peer mentoring involves employing skilled students to tutor novice students in a collaborative learning experience. In 2018, the Anatomy Department of the School of Medicine at Universidad Central del Caribe (UCC) in Puerto Rico, started a project focused on peer tutoring as an academic support to students using valuable resources – other students. The programme employs second- and third-year medical students to tutor first-year medical students. This format has been used in the anatomy laboratory courses in the United States and Europe as well. The goal of the present study is to evaluate a peer-mentoring program conducted over two academic years with medical students at UCC. With this project, both mentors and mentees acquire multiple benefits including: (1) improve dissecting performance, (2) research reporting anatomical variations particularly to students interested in a surgical field, (3) tutors review their knowledge of anatomy for USMLE examinations and (4) improve teaching and communication skills necessary for clinical years. To evaluate the effectiveness of this mentoring programme, we used the academic performance of mentees for each examination given during the course and compared with during other academic years, where students did not receive such mentorship. Quantitative data containing mentees final course grades for academic years 2018–2020 confirmed the fact that peer mentoring provides a positive tendency and richly benefit both groups. Furthermore, peer teaching is a viable option that satisfies the demands of modern curricula using small groups. This format stimulates learning within courses that have large numbers of students and low faculty-to-student ratios. These findings support the hypothesis that second- and third-year medical students are a worthwhile educational resource. Further projections will include a descriptive, cross-sectional and retrospective survey assessing all medical students in their second year of the medical school's curriculum who participated in peer tutoring. All procedures performed in this study does not contain human participants in accordance with the ethical standards of the institution.

P63 | Assessing the impact of human body dissection on the first-year undergraduate medical students at BPKIHS

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The first contact with the dissection hall is an unforgettable and important step in medical education. The present study aimed to assess the stress experienced just after 1 week of first dissection (IES1) and compare it with impact after 12 weeks (IES2) of the first experience by using the Impact Event Scale (IES) on first-year medical students of B.P. Koirala Institute of Health Sciences (BPKIHS). Questionnaires for Impact Event Scale (IES) were administered to 100 students attending the cadaveric dissection at the Department of Human Anatomy, BPKIHS after obtaining Intuitional ethical clearance and informed consent from the students. It has 15 items having four response options VIZ, 'not at all', 'rarely', 'sometimes' and 'often' and

were scored 0, 1, 3 and 5, respectively. The questionnaire provides an overall scale, sub-scales of intrusion and avoidance. The sub-scale scores of 0–8 as a minor reaction, 9–19 as a moderate reaction and a score of 20 or above as a clinically important reaction. The cut-off overall score of 30 on IES indicates a traumatic stress reaction. The IES was administered on two separate occasions between December 2018 and March 2019. All statistical procedures will be performed on SPSS, version 11.5. Since the data were not in a normal distribution, non-parametric tests were applied to find the significant level. The results were considered significant at $p < 0.05$. The percentage of students having a clinically important reaction (a score of 20 or above) after 1 week of first cadaveric dissection in both sub-scales of Intrusion and Avoidance were 2% and 6%, respectively, but was found to be reduced to 1% each after 12 weeks. The overall scores indicating traumatic stress reaction was found to be reduced to 2% from 8%. In the present study, the mean rank differences between IES1 and IES2 scores are found to be highly statistically significant ($p < 0.001$). The bivariate correlation analysis between IES 1 and IES 2 was found to have a positive correlation with a statistically significant level ($r_s=0.252$; $p < 0.001$). These results suggest that the initial stress associated with human dissection dissipates relatively rapidly.

P64 | Geometric morphometric analysis of Os coxae computed tomographic scans in adult Malaysians for sex estimation

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Sex estimation is an essential element for the identification of unknown human skeletal remains in forensic investigation. This study examined variations in size and shape of os coxae in different sexes of adult Malaysians. Cross-validated classification accuracy rates for sexing using os coxae size and shape were also determined. A total of 402 (201 males and 201 females) multislice computed tomographic scans were retrieved from the Universiti Kebangsaan Malaysia Medical Centre. Twenty-five anatomical landmarks were applied in Checkpoint to capture os coxae size and shape. Landmark data were analysed in MorphoJ using Procrustes-based geometric morphometric (GMM) analyses, including principal component analysis (PCA) and Procrustes analysis of variance. Independent t test, analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) were performed to determine the differences between groups. Discriminant function analyses were performed to classify individuals into specific groups and to determine cross-validated classification accuracy. The first five principal components accounted for 49.5% shape variations in os coxae, with the PC1 accounting for the highest percentage of shape variation (17.9%). The male and female os coxae shapes were clearly separated along the PC1 axis of the PCA scatterplot. Male individuals were mainly scattered towards the positive end of the PC1 axis, whereby the female individuals were towards the negative end. Wireframes and morphed models of male and female os coxae showed comparative changes at the iliac crest, posterior iliac spine, greater sciatic notch, obturator foramen, ischiopubic ramus, pubic symphysis and acetabulum. Statistical analyses revealed that the size and shape of os coxae were significantly different amongst males and females. Male os coxae were significantly larger than the females. Individuals were correctly classified into specific sex groups with accuracy rates of 67.4% and 97.5% using the os coxae size and shape, respectively. These findings indicated that Procrustes-based GMM methods using os coxae shape may be useful for sex estimation, particularly in the forensic context in Malaysia. However, os coxae size was a poor indicator for sex estimation. The ethics approval was granted by the Research and Ethics Committee of Universiti Kebangsaan Malaysia (Research Ethics No: UKM PPI/111/8/JEP-2018-006).

P65 | Human accessory olfactory neurons are oestrogen targets

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Recently, we found evidence for an accessory olfactory system in humans. In the present study, we aimed to investigate morphological features of accessory chemosensory human cells in more detail. We studied post-mortem preparations of nasal septa and tissue samples of olfactory bulbs and brains from adult subjects of both genders without an apparent history of intranasal surgery. Samples were obtained during the routine autopsy. The immunohistochemical method was employed for detection of olfactory marker protein (OMP), sex hormone-binding globulin (SHBG) and oestrogen receptor alpha (ERα). Cells expressing OMP, a protein known to occur in sensory neurons of sensory epithelium, were seen disseminated within the mucosa of the lower nasal cavity, independently from a persistent vomeronasal duct. OMP positive projections could be traced through the lamina cribrosa merging into the olfactory nerve. These projections showed particularly thick myelinisation. In consecutive vibratome sections, they could be traced to the medial amygdaloid nuclei. Immunofluorescence for sex hormone-binding globulin (SHBG) was observed in sensory cilia and oestrogen receptor alpha (ERα) was found in sensory dendrites and in nuclei of OMP positive cells. We assume that human accessory olfactory neurons are oestrogen targets. These cells project to portions of the limbic system. Our morphological observations may be linked to the known effects of steroidal pheromones in man.

This study was approved by the ethics committee of Jena University Hospital, protocol no. 4230-10/14.

P66 | Team-based learning for gross anatomy education in undergraduate medical students: A systematic review

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Gross anatomy education is experiencing a pedagogical shift to include more student-centred active teaching methods. A variety of active methods exist, including a novel approach called team-based learning (TBL). In TBL, a series of exercises are completed by multiple 'teams' of students simultaneously. Consequently, the educational advantages of small group learning are gained, whilst the practicality of large group teaching is retained. Learning is enhanced by linking factual anatomical content to clinical scenarios, enabling students to apply anatomy clinically, promoting a better understanding. This systematic review aims to determine the efficacy of TBL in gross anatomy education. A pre-defined search strategy used seven electronic databases: MEDLINE, Embase, ERIC, CINAHL, PsycINFO, Web of Science and ProQuest Dissertations & Theses. Additional sources searched included Google Scholar, reference lists of systematic reviews on TBL in health profession's education and reference lists of included studies. Articles were screened against eligibility criteria. All included studies underwent data collection and quality appraisal using the MERSQI. The results were analysed using qualitative narrative synthesis. The initial search identified 334 articles, of which 10 were included after screening. Considerable heterogeneity existed in TBL implementation, especially in the application exercise phase. There was a unanimous consensus across all included studies that TBL was associated with positive student satisfaction, especially a perception of enhanced knowledge. Knowledge was addressed by four studies and the findings were inconclusive due to limited literature and methodological limitations. However, the results of the narrative analysis are encouraging, as they show TBL to be as effective as alternative teaching methods. Interestingly, TBL enhanced the performance of poorly performing students with reduced failure rates, possibly by cultivating a skill of self-regulated learning, permitting students to identify areas of the curriculum they understand least and act accordingly. TBL is a relatively new method in the literature. The results of this systematic review demonstrate good potential for TBL. Further research is recommended, especially on knowledge acquisition, to strengthen findings. In practice, TBL can be a good supplement to cadaveric dissection, as part of an integrated curriculum.

Ethical approval was not required for this systematic review.

P67 | Human cerebellum: White matter branching patterns

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The cerebellar white matter exhibits a sophisticated tree-like branched appearance, also known as 'arbour vitae cerebelli'. In this study, we aimed to investigate patterns of white matter branching in the human cerebellum. The study was carried out on cadaveric specimens: 230 cerebella (136 male and 94 female); age range of 20–99 years. Cerebella were obtained during forensic autopsies. Midsagittal sections of the cerebella were investigated. We have described eight main branches of cerebellar white matter and revealed three types of their branching. The first branch forms cerebellar lobule I (lingula), second – lobule II (lobulus centralis I), third – lobule III (lobulus centralis II), fourth – lobules IV–V (culmen), fifth branch – lobules VI–VII (declive, folium and tuber), sixth – lobule VIII (pyramis), seventh – lobule IX (uvula) and eighth – lobule X (nodulus). We found that the third branch was present only in 76 studied cerebella (33%). The branches of cerebellar white matter had three different patterns of branching. The first to third and eighth branches had a single trunk of white matter without secondary branches or with a small secondary branch situated near the visible surface of the cerebellum. We described this pattern of branching as 'simple'. The fourth branch had a common trunk divided into two secondary branches forming the lobules IV and V. Each secondary branch was divided into two tertiary branches, which were dichotomously divided into branches of following generations. We described this pattern of branching as 'dichotomous'. Fifth to seventh branches had similar patterns of branching. The main trunks of these branches were Y-like divided into two or three main branches. Each of the main branches had a variable number of secondary branches (1–3) but had no dichotomous pattern of further branching. We described this pattern of branching as 'Y-like'. Thus, the tree-like architecture of cerebellar white matter determines the structural complexity of the human cerebellum and exhibits significant individual variability. The study was conducted in compliance with the current legislation in Ukraine and was approved by the Commission on Ethics and Bioethics of Kharkiv National Medical University.

P68 | Ghrelin upregulates *Pax6* expression in dissociated cortical neurons of newborn rats in an *in vitro* model of ischaemic stroke

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Recovery from stroke, a medical condition of impeded blood supply to the brain and oxygen shortage (hypoxia), harnesses a variety of developmentally related processes, which may include neurogenesis. In the healthy brain, adult neurogenesis is believed to be restricted to the subventricular zone and the dentate gyrus. However, there are some reports showing that in the process of recovery from stroke, neurogenesis can also occur in the cortex. A key player in

neurogenesis is the transcription factor *Pax6*. Unlike the neurogenic niches, where hypoxia increases *Pax6* expression, the levels in the neocortex are downregulated. This raises the question of whether decreased neocortical expression of *Pax6* hampers recovery upon re-oxygenation. To answer this question, we used the hormone ghrelin (Ghr), which is well known to act neuroprotective against oxidative stress via its receptor GHSR1a, to see if the neuropeptide could influence neurogenesis, and thus, to benefit recovery from hypoxia. We studied whether Ghr would upregulate *Pax6* in hypoxic neurons. To this aim, dissociated cortical neurons isolated from the brains of newborn rats were exposed to hypoxia (pO_2 ~ 25 mmHg) for 6 hours and then re-oxygenated in medium with or without (controls) recombinant Ghr for 24 hours. Following fixation, the cultures were immunostained for *Pax6*, GHSR1a, Ki67 (proliferation marker), and NeuN and doublecortin (markers for late phases of neuronal proliferation). Hypoxia downregulated *Pax6* expression in contrast to normoxia. The Ghr-treated cultures showed higher *Pax6* expression than controls. Moreover, Ghr treatment resulted in an increased number of proliferating cells double-positive for *Pax6* and doublecortin, as well as an increased number of mitotic neurons positive for Ki67 and NeuN. Furthermore, Ghr triggered internalisation and nuclear translocation of its receptor GHSR1a in neurons, which could be a possible mechanism for ghrelin-mediated activation of various transcription factors, including *Pax6*. Since *Pax6* stimulates proliferation, neurogenesis and differentiation, its elevated levels due to Ghr stimulation could ameliorate recovery after hypoxia. Our findings highlight the therapeutic potential of Ghr for the treatment of stroke patients.

All animal experiments were conducted according to the Dutch law and approved by the Dutch committee on animal use and conform to the guidelines set by the European Union.

P70 | Publication bias and small-study effect in anatomical studies

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Evidence-based anatomy was established in 2014 with the aim to systematically collect and analyse the data retrieved from anatomical studies to generate new findings. Evidence-based anatomical studies are usually published as meta-analyses, which seeks to amplify statistical power by aggregating weighted information from multiple studies. In meta-analyses, researchers are not in control of the retrieved data, as a result, the outcome of pooled analysis could be mediated by biases such as publication bias and small-study effect. Publication bias occurs when the outcome of an experiment influences the decision whether to publish or not publish a study, whereby studies with favourable or positive findings are more likely to get published, especially in smaller studies where the outcomes are typically inflated. This phenomenon is known as the small-study

effect. While these effects have been investigated across subfields in medicine, they have not been investigated in the anatomy literature. In the present study, we retrospectively analysed previously published dichotomous meta-analyses published in anatomy journals to identify the presence of publication bias and small-study effect. The presence of these biases was investigated using funnel plots, correlation coefficients and statistical analysis. We found that a significant portion of anatomical studies was moderated by publication bias and a small-study effect. As a result, the outcomes of some studies are misinterpreted, particularly in the case of fabella and median artery. We found that the seemingly increase in the prevalence of fabella and median artery was in fact moderated by the small-study effect. In other words, the effect sizes in these two studies were negatively correlated with study size, and because of a continuous decline in study size over the years, it gave the impression that the prevalence of these two structures is increasing over time. Finally, we also propose a number of measures to detect and counterbalance these biases, which will be helpful for anatomists when conducting or reading evidence-based anatomical studies.

P71 | Deciphering the role of pyramidal neuron identity in assembling inhibitory interneuron inputs in mice

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The complexity of cortical circuits arises from the morphologically and molecularly distinct cell types that are represented across all cortical layers and proven to have unique input and output connections. Such exquisitely crafted neural networks are dependent upon the precise wiring between glutamatergic pyramidal neurons and inhibitory GABAergic interneurons providing subtype-specific inputs to subclasses of pyramidal cells defined by their areal, laminar, and long-range projection targets. While previous studies have identified basic connection motifs between interneurons and pyramidal cells, it remains unknown whether pyramidal neurons orchestrate the spatial organisation of cortical interneurons. In addition, little is known about the role of pyramidal neuron identity in instructing the assembly of inhibitory brain circuits. Here, we applied a new method termed 'intersectional monosynaptic tracing' that combines rabies virus and intersectional reporter mice to label interneuron subtypes (parvalbumin, somatostatin, and vasoactive intestinal peptide) sending inputs to pyramidal cells. To test whether pyramidal neuron identity is a critical determinant for the input organisation of interneurons, we generated layer 5 pyramidal neuron-like cells by knocking-out Satb2, a transcription factor necessary for the acquisition of layer 2/3 identity, in layer 2/3 pyramidal cells using the CRISPR/Cas9 system. Selective targeting of layer-specific PNs was achieved by in utero electroporation (IUE) at embryonic day E15.5 in

PV-Cre mice and monosynaptic rabies virus tracing was done at P21. Animals were killed by transcardial perfusion under terminal anaesthesia with ketamine-xylazine. We found that layer 2/3 pyramidal neurons receive both local and translaminar inputs from parvalbumin interneurons, whereas layer 5 pyramidal neurons predominantly receive local inputs from parvalbumin interneurons suggesting that distinct pyramidal cell subtypes uniquely recruit cortical interneurons. Following the fate conversion of layer 2/3 pyramidal neuron identity to layer 5-like cells, however; we observed a spatial rearrangement of parvalbumin interneuron inputs to ectopically created layer 5 pyramidal cells in layer 2/3. In particular, the genetic manipulation of the fate of pyramidal neuron identity significantly reduced translaminar inputs from layer 5 parvalbumin interneurons. These results suggest that layer 2/3 pyramidal cells provide molecular cues that are necessary for receiving translaminar synaptic inputs from layer 5 parvalbumin interneurons. Using intersectional monosynaptic tracing, we have started to discover the spatial organisation of interneuron subtypes providing GABAergic inhibition to pyramidal neurons and further unravel the wiring principles of cortical circuits serving as the structural basis for cortical function.

P73 | The creation of an integrated instructional display for embryology incorporating 3D modelling, digital light processing 3D printing and augmented reality

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Even though the subject of human embryology and the development of organ systems involves the understanding of a large amount of detail regarding the sequential addition and changes to the various structures; the gradual reduction in the time and resources dedicated to instructing medical and paramedical students in this subject have led to a corresponding decrease in educational resources. This includes, but not limited to, an adequate number and accessibility to true-to-life models, the present-day shift towards 2D illustrations of embryological structures or at best 3D virtual illustrations, leaving students having to resort to the oft-limited availability of moulded models for a more psychomotor-based approach to learning in this subject. To ameliorate this issue presented in both instructors and learners alike, we embarked on a pilot project to convert raw embryological data obtained from the open-sourced 3D Atlas of Human Embryology of the Academic Medical Center (AMC-Amsterdam, Netherlands) into 3D models of the different stages of the development of the nervous system; and subsequently use 3D sculpting and Digital Light Processing (DLP-SLA) 3D printing to produce true-to-life, enlarged 3D printed models for use in the instruction of the "Development of the Nervous System". Furthermore, the models

were further placed onto a display that includes accompanying legends and captions, QR codes that allows for the student and instructors to view the 3D models on other platforms and to download the corresponding .STL files for printing on their own systems; along with augmented reality (AR) image markers that allow the viewer to visualize the models on their hand-held smartphone/tablets in real-time. Thus, this platform developed in this project resulted in the greater equality in accessibility and hands-on learning for the learner at their own pace, allowing for the instructor to further modify the models to better cater to their needs as well as produce reproducible models at scale, whilst incorporating newer, engaging technologies for more interactive learning in this subject.

The study only involved the usage of image database of existing embryological specimens freely available for academic use from the Academic Medical Center (AMC-Amsterdam, Netherlands) licensed under the Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) license by Creative Commons. This project, thus, did not involve the use of cadaveric or live specimens as outlined in the abstract.

P74 | Comparison of neuromuscular junction pathology in four mouse models of spinal muscular atrophy indicates distinct patterns of selective vulnerability

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In spinal muscular atrophy (SMA), a childhood motor neuron disease, breakdown of neuromuscular junctions (NMJs) occurs early in disease. Importantly, in both patients and mouse models, not all motor units are equally vulnerable, with some being lost early in disease while others remain intact. This selective vulnerability is an excellent tool to investigate factors which affect motor neuron vulnerability. Previous studies have profiled these patterns of vulnerability in a range of different mouse models of SMA, however, analysis of the similarities and differences between these models is lacking. Here, we have conducted an extensive analysis of levels of NMJ pathology in a range of muscles in the $Smn^{2B/-}$ mouse model of SMA, and subsequently compared selective vulnerability patterns to three other mouse models. In the $Smn^{2B/-}$ mice, we found an increased vulnerability in muscles innervated by spinal nerves from the cervical and thoracic regions compared to those receiving innervation from lumbar and cranial regions. We subsequently combined previously published data on selectively vulnerable muscles from three other mouse models with our data from the $Smn^{2B/-}$ mice. This revealed that whilst neuromuscular junction loss and selective vulnerability was a prominent feature in all mouse models, each model displays a distinct vulnerability pattern. Further work is required to decipher

the basis for these differences in selective vulnerability. This work also has important implications for using selective vulnerability as a tool to study mechanisms of motor neuron vulnerability. All procedures were performed in accordance with regulations set out by the UK Home Office and institutional guidelines from the University of Edinburgh.

P75 | Radiological evaluation of congenital anomalies of anterior and posterior arch of atlas in Omani subjects

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sThe atlas vertebra (C1) is known to show congenital anomalies in its anterior and posterior arches. Anomalies of C1 may increase the risk of developing myelopathy, anterior rachischisis and early cervical degenerative disc disease. These anomalies are also associated with atlantoaxial joint instability which necessitates the treatment with a cervical collar or surgery. The knowledge about the occurrence and existing variants of arch anomalies is clinically important in the current practice of surgery and radiology. Hence, the present study was aimed to determine the prevalence and various existing variations of C1 arch congenital anomalies in Omani subjects. This study was carried out by reviewing the cervical spine computed tomography (CT) scans of all the patients who had been visited the Radiology Department, Sultan Qaboos University Hospital. Patients' data were collected retrospectively from the 'TRACKCARE' system at SQUH from January 2016 till December 2017. After applying inclusion criteria, a total of 663 subjects aged ≥18 years were included in the present study. The types of arch anomalies of C1 were recorded based on Currarino's classification. The characteristic CT appearance of C1 was used to differentiate the anomalies from fractures. The anomalies are identified by smooth and well-corticated margins without any associated soft tissue swelling. Descriptive statistics and Chi-squared tests were employed to analyse the data. Overall, the prevalence of C1 arch anomalies was 4.37% with 4.07% of isolated posterior arch anomalies, 0.3% of combined anterior and posterior arch anomalies. Type A and B posterior arch defects were accounted for 86.2% and 6.9% of all observed anomalies. Combined anterior and posterior arch anomalies were noted in 6.9% of all anomalies. Atlantooccipital assimilation was noted in one case of total study subjects. The prevalence rate of C1 arch anomalies is relatively high in Omani subjects. The baseline data of C1 arch anomalies reported in the present study has a great impact on clinical practice, due to the fact that studying and evaluating the types of congenital anomalies helps in their accurate diagnosis and early intervention. The study was approved by the Medical Research Ethics Committee, College of Medicine, SQUH (REF. NO. SQU-EC/181/18).