DB3804

Development of Organ Systems

Course Handbook 2016-17
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Cover image:
Confocal micrograph of fluorescently labelled HeLa cells.
Nuclei are labelled in blue, tubulin in green and actin fibres in red.

Courtesy of:
Kevin Mackenzie
Microscopy and Histology Core Facility
Institute of Medical Sciences
University of Aberdeen
http://www.abdn.ac.uk/ims/microscopy-histology
Course Summary

Once the basic processes of fertilisation, gastrulation and axis determination have been achieved, how is the body actually built? What drives the organisation of apparently uniform populations of cells into different three-dimensional tissues and organs? What genes are involved, and how do cells interact to tell each other what to do? This course starts to answer those questions, concentrating on well-studied model systems. We take a tour of the vertebrate body, studying the origin and development of the major organs and tissues, to see how morphogenesis, the creation of form, is initiated and taken to completion. Much of our detailed knowledge of gene regulation and cell-cell interaction during the development of the body plan comes from invertebrate systems, and we will cover two of the most iconic, vulval development in C elegans, and the imaginal discs of Drosophila.

Course Aims & Learning Outcomes

1. This course enables you to achieve a broad understanding of how the functional organs of the body are built.
2. We will put into practice the study of model systems and genetics in order to comprehend the creation of three-dimensional form – morphogenesis.
3. Lectures will depict how processes such as cell proliferation, adhesion and motility contribute to organ formation.
4. The course will act as an introduction to the relationship between developmental biology and cancer, and between developmental biology and evolution.
5. The links between developmental embryology, stem cells and regeneration will be emphasised.

Course Teaching Staff

Course Co-ordinator(s):
Professor Martin Collinson (m.collinson@abdn.ac.uk)

Other Staff:
• Prof Stefan Hoppler (SPH)
• Dr Neil Vargesson (NV)

Assessments & Examinations

Students are expected to attend all lectures, laboratory classes, and tutorials, and to complete all class exercises by stated deadlines. The minimum performance acceptable is attendance at 75% of the lectures, seminars, practical classes, and presentation of all set course work, written and oral.

Students can self-certify absences of up to six days from compulsory classes by completing the downloadable form via MyAberdeen.

Assessment is derived from coursework (30%) and a written examination (70%). The continuous assessment (CA) component is based on a laboratory-based practical class (15%) and a written essay (15%).
Written Examination: 70% of the total assessment is based on one 90 minute written paper. Students have to answer two questions, one from section A and 1 from section B.

**Deadline day for the written essay will be Monday 27th March 2017, and for the practical write-up will be Monday 24th April 2017.**

Common grading scale (CGS) grade: The overall performance of the student is expressed as a grade awarded on the common spine marking scale. The degree examination is held in May, with the re-sit examination in June/July.

**Class Representatives**

We value students’ opinions in regard to enhancing the quality of teaching and its delivery; therefore in conjunction with the Students’ Association we support the Class Representative system.

In the School of Medicine, Medical Sciences and Nutrition we operate a system of course representatives, who are elected from within each course. Any student registered within a course that wishes to represent a given group of students can stand for election as a class representative. You will be informed when the elections for class representative will take place.

**What will it involve?**
It will involve speaking to your fellow students about the course you represent. This can include any comments that they may have. You will attend a Staff-Student Liaison Committee and you should represent the views and concerns of the students within this meeting. As a representative you will also be able to contribute to the agenda. You will then feedback to the students after this meeting with any actions that are being taken.

**Training**
Training for class representatives will be run by the Students Association. Training will take place within each half-session. For more information about the Class representative system visit [www.ausa.org.uk](http://www.ausa.org.uk) or email the VP Education & Employability [vped@abdn.ac.uk](mailto:vped@abdn.ac.uk). Class representatives are also eligible to undertake the STAR (Students Taking Active Roles) Award with further information about this co-curricular award being available at: [www.abdn.ac.uk/careers](http://www.abdn.ac.uk/careers).

**Problems with Coursework**

If students have difficulties with any part of the course that they cannot cope with alone they should notify the course coordinator immediately. If the problem relates to the subject matter general advice would be to contact the member of staff who is teaching that part of the course. Students with registered disabilities should contact Mrs Jenna Reynolds ([j.reynolds@abdn.ac.uk](mailto:j.reynolds@abdn.ac.uk)) in the School Office (based in the IMS, Foresterhill), or Mrs Sheila Jones ([s.jones@abdn.ac.uk](mailto:s.jones@abdn.ac.uk)) in the Old Aberdeen office associated with the teaching.
laboratories, to ensure that the appropriate facilities have been made available. Otherwise, you are strongly encouraged to contact any of the following as you see appropriate:

- Course student representatives
- Course co-ordinator
- Convenor of the Medical Sciences Staff/Student Liaison Committee (Prof Gordon McEwan)
- Personal Tutor
- Medical Sciences Disabilities Co-ordinator (Dr Derryck Shewan)

All staff are based at Foresterhill and we strongly encourage the use of email or telephone the Medical Sciences Office. You may have a wasted journey travelling to Foresterhill only to find staff unavailable.

If a course has been completed and students are no longer on campus (i.e. work from second semester during the summer vacation), coursework will be kept until the end of Freshers’ Week, during the new academic year. After that point, unclaimed student work will be securely destroyed.

**Course Reading List**

**Recommended Reading**

Essential Developmental Biology by JMW Slack (Blackwells, 3rd Edition, 2013) will be the main textbook used for the course.

The following textbooks will also be useful textbooks for some aspects of the course:


**Lecture Synopsis**

**Lecture 1. Introduction to Course – Professor Martin Collinson**

This lecture introduces the course and starts to describe the size of the problem – how many tissue types are there, and how are they interrelated. Many of our organs are of epithelial origin, and one of the early developmental events defines a subset of the embryonic epithelium that will become neural. We need connective tissues – e.g. ligaments, tendon and bone to hold things together, and muscle to move it all around. Last but not least, none of this works without a circulatory system – with blood. This lecture will introduce the haematopoietic system and explain what you need to do for the essay assignment.

**Lecture 2. Nervous System 1: The differential adhesion hypothesis – Professor Martin Collinson**
How do cells from different tissues separate during development and then stay separate afterwards. Cell surface adhesion properties are fundamental, and the theory and practical evidence for the basis of cell mixing and segregation are explored.

Lecture 3. Nervous System 2: Anterior-posterior patterning – Professor Martin Collinson

Starting with the classic experiments that showed the genetic basis of compartment formation and anterior-posterior patterning in Drosophila, we move onto the experimental evidence for similar mechanisms in vertebrates. We look at how Hox genes drive patterning of the vertebrate hindbrain. (Lecture shared with BM3803 Integrative Neuroscience)

Lecture 4. Nervous System 3: Dorso-ventral patterning – Professor Martin Collinson

In the CNS, motor output is via the mid-ventral neurones in the neural tube and sensory input comes in dorsally where it must be picked up and transmitted by many types of interneuron. This lecture looks at how dorsalising signals including BMPs tussle with ventralising signals such as Shh to pattern the vertebrate neural tube in the dorso-ventral axis. (Lecture shared with BM3803 Integrative Neuroscience)

Lecture 5. Nervous System 4: Placodes and neural crest – Professor Martin Collinson

While the neural plate represents the beginnings of our brain and spinal cord, it is a feature of vertebrate development that many of the sensory organs – e.g. eyes, ears, nasal epithelia – that form our interface with the outside world have their origins as specialised thickened epithelial plates (placodes). Development of these placodes was a significant event in evolution of the vertebrate body plan, and we will examine examples of tissues, such as the eye lens, which arise from placodes. But placodes don’t do the job alone, they are largely induced by, and interact with underlying tissues, and we need to explore the concept of induction. Moreover, there is a contribution to sensory organ development from a population of cells that delaminate from the roof of the neural tube – the neural crest. The origins and fate of the neural crest will be discussed in this and future lectures.

Lecture 6. Pattern formation: How the Zebra got its stripes – Professor Martin Collinson

How can we understand the formation of complex patterns in organs and tissues from basic principles? It is possible to use very simple mathematical models to predict the biology that underlies body patterning – this lecture will briefly explore some of these models.

Lecture 7. Drosophila imaginal disc development – Professor Martin Collinson

Flies are really two animals in one: during metamorphosis, the larval structures are replaced by adult organs that unfold from specialised sheets of epithelium, the imaginal discs that were tucked away under the body wall during embryogenesis. There are different imaginal discs for each set of legs, the wings and halteres, the eyes and antennae mouthparts and genitals. Using specific examples, the genetic control of specification and patterning (anterior-posterior and dorso-ventral) of imaginal discs will be described. Apart from being interesting
in their own right for our understanding of cell-cell interactions, they also act as classical models for the discovery of fundamental signalling pathways that we will and have come across time and time again during vertebrate organogenesis.

Lecture 8. Hippo signalling in skeletal muscle development – Professor Martin Collinson

This lecture introduces the Hippo signalling pathway – not well studied until recently, this pathway has fundamental roles in control of organ size and tissue integrity, for example by controlling stem cell activity and cell proliferation. The pathway is deregulated in many cancers and interacts with the Wnt signalling pathway.

The development and maintenance of skeletal muscle is fundamental to normal health, and the degeneration of skeletal muscle underlies many human diseases, as well as being a cause of morbidity in aging. Central to long term maintenance of skeletal muscles are the satellite cells – this lecture explains their origin and roles in muscle regeneration and repair. The Hippo signalling pathway is central.

Lecture 9. Gut Development and Colorectal Cancer – Professor Stefan Hoppler

As the first and most fundamental example of an endodermal organ, this lecture will study the embryonic origins and development of the gut. Starting as little more than a tube, the gut becomes patterned into different specialised units (e.g. oesophagus, stomach, small intestine, large intestine) along the body’s anterior/posterior axis. Within each region of the gut, the arrangement and function of cells, together with their nervous and vascular supplies, are different. This lecture concentrates in detail on the intestine, which like the skin has a distinct stem cell niche. Colorectal cancer is a major killer in the west, and, complementing lecture 4, this lecture will examine the origins of gut cancers.

Lecture 10. Heart development – Professor Stefan Hoppler

The heart is the first organ to become functional during vertebrate embryonic development, and without it, everything else stops. The embryology of the heart, and the important signalling mechanisms that underlie its formation, will be described, using model systems such as Xenopus where the genes required for heart development have been well studied. The origin of the heart as a simple tube, and its development into a chambered structure will be examined. Heart structure will be compared between different vertebrates.

Lecture 11. Kidney development – Professor Stefan Hoppler

The development of kidneys and the reproductive organs and cells are linked through a common origin in the urogenital ridge. Reproductive development is covered elsewhere (DB3502), and this lecture covers development of the excretory system. The embryonic or primitive ‘kidney’ structures of the pronephros and mesonephros will be described before the development of the metanephros, giving rise to our adult kidneys is covered in depth. The interaction between the metanephric mesenchyme and the ureteric bud has been studied by genetic means in vivo, but can also be set up in culture systems in vitro. The genes required
for this two-way inductive interaction and the subsequent branching patterns that underlie the organisation of the adult kidney will be examined.

Lecture 12. Blood vessel development (in embryology and oncology) – Dr Neil Vargesson

We mentioned above that the heart develops early and without it, development of the rest of the animal cannot proceed. This is true, but the heart is useless without a circulatory system to plumb into. The development of blood vessels will be covered in this lecture, encompassing both their physical formation and the signalling mechanisms that control the branching and growth of arteries, capillaries and veins. All tumours need oxygen and nutrients to grow, and this lecture will cover the processes by which tumours can subvert the patterning of the vasculature to maintain their growth.

Lecture 13. Skin & Hair (Stem cells and cancer) – Professor Stefan Hoppler

The largest organ of our body is the skin. More than just a bag to hold the rest of our organs in, the skin plays fundamental roles in homeostasis and, as will be shown in this lecture is a model system for the specification and role of adult stem cells in maintenance of the body plan. The multiple embryonic origins of skin tissues will be described. Vertebrate skin tends to have appendages – hair, feathers or scales, and the development of these will be described. The adult stem cell niche will be described, using the skin and cornea as an example. This lecture will introduce the concept of cancer as a developmental disease.

Lecture 14. The liver, the lung and the pancreas – Professor Martin Collinson

Budding off from the gut – the set of our most squishy organs that have different but related ontogenies. The development and evolutionary origins of the lung will be examined briefly, with reference to broader issues of the development of the head and neck. The patterning of the gut that leads to budding of the liver and pancreas, and the dual origins of the pancreas will be described. The genetic pathways that lead to development of insulin-producing \( \beta \)-cells in the islets of Langerhans will be described – these are intensively studied by research groups trying to manufacture or regenerate insulin-secreting tissue for the treatment of diabetes.

Practical/Lab/Tutorial Work

Laboratory Work

Cell death analysis – Prof Martin Collinson and Dr Neil Vargesson.

This will be a laboratory-based class which investigates assays of cell death during limb development. For laboratory work it is essential that you should wear appropriate protective clothing, such as examination gloves and laboratory coats. You must also keep an accurate protocol and records of all experiments performed, including numerical analysis of the experimental results and imaging of the morphology of experimental and control embryos. Following the practical, you will each prepare an individual report which should be word
processed in the form of a short scientific paper. This report will form an important component of the continuous assessment. The practical work required in this course might present difficulties to students with special access needs. For such students, alternative arrangements will be made. Any student with special needs should make these known to the Course Co-ordinator when registering for the class, and should then also discuss their needs with the School Disabilities Co-ordinator, to ensure that they have the best possible outcome.

**Written Essay**

**Haematopoiesis – Prof Martin Collinson**

This will be an exercise in library research. Haematopoiesis (the formation of blood) is the classic example of tissue development from stem cells. You should write an essay of up to 3000 words that synthesises what we know about blood stem cells, and the *in vivo* and *in vitro* experimental evidence that underlies our knowledge. Write about the implications and uses of haematopoietic stem cells for the treatment of human disease.

Students are asked to make themselves familiar with the information on key institutional policies which been made available within MyAberdeen (https://abdn.blackboard.com/bbcswebdav/institution/Policies). These policies are relevant to all students and will be useful to you throughout your studies. They contain important information and address issues such as what to do if you are absent, how to raise an appeal or a complaint and how seriously the University takes your feedback.

These institutional policies should be read in conjunction with this programme and/or course handbook, in which School and College specific policies are detailed. Further information can be found on the [University’s Infohub webpage](https://abdn.blackboard.com/bbcswebdav/institution/Policies) or by visiting the Infohub.

The information included in the institutional area for 2016/17 includes the following:

- Absence
- Academic Appeals & Complaints
- Assessment (Common Grading Scale)
- Codes of Practice on Student Discipline (Academic and Non-Academic)
- Class Certificates
- Recording of Lectures
- Exam Results
- Transcripts
- MyAberdeen
- TurnitinUK
- Feedback
- Communication
• Aberdeen Graduate Attributes
• The Co-Curriculum
## Medical Sciences Common Grading Scale

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<tr>
<th>Grade</th>
<th>Grade Point</th>
<th>% Mark</th>
<th>Category</th>
<th>Honours Class</th>
<th>Description</th>
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</table>
| A1    | 22          | 90-100 | Excellent      | First         | • Outstanding ability and critical thought  
|       |             |        |                |               | • Evidence of extensive reading  
|       |             |        |                |               | • Superior understanding  
|       |             |        |                |               | • The best performance that can be expected from a student at this level     |
| A2    | 21          | 85-89  |                |               |                                                                             |
| A3    | 20          | 80-84  |                |               |                                                                             |
| A4    | 19          | 75-79  |                |               |                                                                             |
| A5    | 18          | 70-74  |                |               |                                                                             |
| B1    | 17          | 67-69  | Very Good      | Upper Second  | • Able to argue logically and organise answers well  
|       |             |        |                |               | • Shows a thorough grasp of concepts  
|       |             |        |                |               | • Good use of examples to illustrate points and justify arguments  
|       |             |        |                |               | • Evidence of reading and wide appreciation of subject                      |
| B2    | 16          | 64-66  |                |               |                                                                             |
| B3    | 15          | 60-63  |                |               |                                                                             |
| C1    | 14          | 57-59  | Good           | Lower Second  | • Repetition of lecture notes without evidence of further appreciation of subject  
|       |             |        |                |               | • Lacking illustrative examples and originality  
|       |             |        |                |               | • Basic level of understanding                                               |
| C2    | 13          | 54-56  |                |               |                                                                             |
| C3    | 12          | 50-53  |                |               |                                                                             |
| D1    | 11          | 47-49  | Pass           | Third         | • Limited ability to argue logically and organise answers  
|       |             |        |                |               | • Failure to develop or illustrate points  
|       |             |        |                |               | • The minimum level of performance required for a student to be awarded a pass |
| D2    | 10          | 44-46  |                |               |                                                                             |
| D3    | 9           | 40-43  |                |               |                                                                             |
| E1    | 8           | 37-39  | Fail           | Fail          | • Weak presentation  
|       |             |        |                |               | • Tendency to irrelevance  
|       |             |        |                |               | • Some attempt at an answer but seriously lacking in content and/or ability to organise thoughts |
| E2    | 7           | 34-36  |                |               |                                                                             |
| E3    | 6           | 30-33  |                |               |                                                                             |
| F1    | 5           | 26-29  | Clear Fail     | Not used for Honours | • Contains major errors or misconceptions  
<p>|       |             |        |                |               | • Poor presentation                                                        |
| F2    | 4           | 21-25  |                |               |                                                                             |
| F3    | 3           | 16-20  |                |               |                                                                             |
| G1    | 2           | 11-15  | Clear Fail/Abysmal | -         | • Token or no submission                                                  |
| G2    | 1           | 1-10   |                |               |                                                                             |
| G3    | 0           | 0      |                |               |                                                                             |</p>
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<th>Place</th>
<th>Subject</th>
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<tr>
<td>Mon 27 Feb</td>
<td>10:00-11:00</td>
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<td>1) Introduction to course</td>
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<td>JMC</td>
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<td>2) Nervous system 1: Differential Adhesion Hypothesis</td>
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<td>09:00-10:00</td>
<td>LT3</td>
<td>4) Nervous system 3: Dorso-ventral patterning</td>
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<td>5) Nervous system 4: Placodes and Neural Crest</td>
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<td>6) Pattern Formation: How the zebra got its stripes</td>
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<td>8) Hippo Signalling and Skeletal Muscle Development</td>
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<td>Private Study/ Write up</td>
<td>Study</td>
<td>JMC</td>
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</tbody>
</table>

**Staff**

- Professor Martin Collinson (JMC), (Course Coordinator)
- Prof Stefan Hoppler (SPH)
- Dr Neil Vargesson (NV)