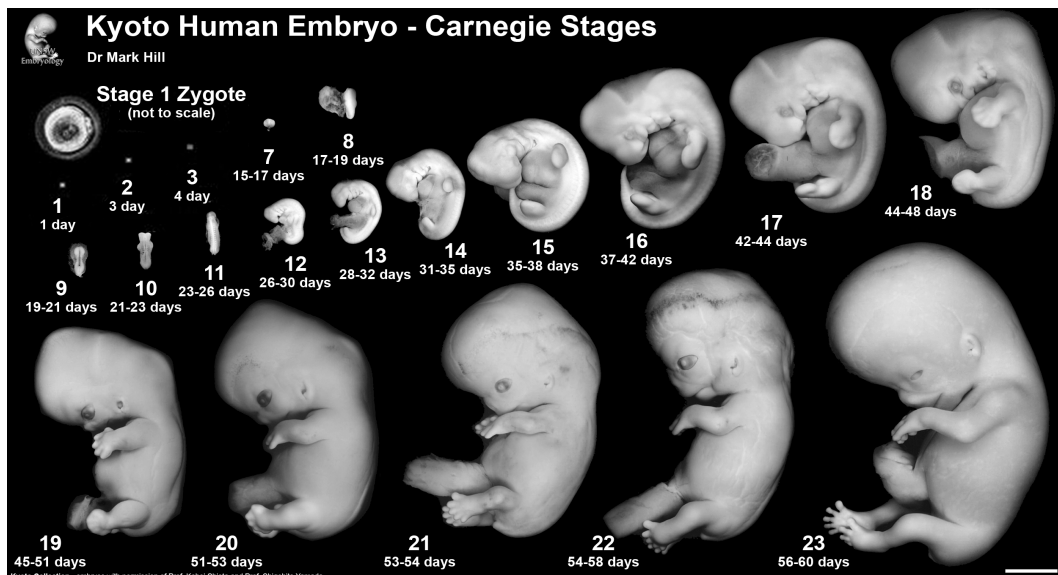


# ANAT 2341

## Embryology



The first 8 weeks of human embryological development.

## COURSE OUTLINE

SEMESTER 2 2018

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[ONLINE TIMETABLE](#)

[OLINE 2018 HOMEPAGE](#)

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Please read this manual/outline in conjunction with the following pages on the [School of Medical Sciences website](#):

- [Advice for Students](#)
- [Learning Resources](#)

(or see "STUDENTS" tab at [medicalsciences.med.unsw.edu.au](http://medicalsciences.med.unsw.edu.au) )

## ANAT2341 Course Information

### OBJECTIVES OF THE COURSE

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Students completing this course will have a broad understanding of human development, and they will be introduced to some animal models of development and to cutting-edge developmental biology research. Furthermore, they will learn how developmental biology is relevant for non-research related professions such as artificial reproductive technology. Experts and researchers from within the field contribute to the current course.

This course will enable students to explore and gain further understanding of embryology both early and systematic through the investigation of development in both humans and animal models. The course includes new applications and techniques to study development and the emerging research and reproductive technologies. This course will enable students to broadly understand abnormalities in development and current applications to medical research. Within the Anatomy program it introduces the developmental origin of organs and tissues as a cornerstone for later study of topics such as Visceral or Functional Anatomy, Neuroanatomy, Cell Biology, Microscopy in Research.

### COURSE CO-ORDINATOR and LECTURERS

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Course Coordinators / Lecturers

- Dr Mark Hill [m.hill@unsw.edu.au](mailto:m.hill@unsw.edu.au)  
Room 221, Wallace Wurth West T: +61 2 9385 2477
- Dr Annemiek Beverdam [A.Beverdam@unsw.edu.au](mailto:A.Beverdam@unsw.edu.au)  
Room 234, Wallace Wurth East T: +61 2 9385 0019

Students wishing to see the course coordinator should make an appointment *via* email as offices are not readily accessible. We will organize to meet you in a convenient location elsewhere in the building.

## **COURSE STRUCTURE and TEACHING STRATEGIES**

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Learning activities occur on the following days, times and locations:

- Lectures:
  - Lecture 1: Monday 12 pm – 1 pm (CLB4);
  - Lecture 2: Tuesday 10 am - 11 am (MathewsThD)
- Practicals: Tuesday 11 am - 1 pm (WW G06/07)

Students are expected to attend all scheduled activities for their full duration (2 hours of face to face lectures per week; 2 hours of practical; and 2 hours of project learning per week).

Students are reminded that UNSW recommends that a 6 units-of-credit course should involve about 150 hours of study and learning activities. The formal learning activities are approximately 60 hours throughout the semester and students are expected (and strongly recommended) to do at least the same number of hours of additional study.

### **Lectures:**

Lectures will provide you with the concepts and theory essential for an understanding of embryology.

### **Practical classes:**

To assist in the development of research and analytical skills practical classes and collaborative learning sessions will be held. These classes allow students to engage in a more interactive form of learning than is possible in the lectures. The skills you will learn in practical classes are relevant to your development as professional scientists.

Many of the practical classes will consist of 3 components:

1. Revision time/group project time
2. Quiz on lecture content of the previous week (part of your ongoing individual assessment)
3. Guest lectures on topic relevant to lecture contents

Three of the practical classes will have a quiz followed by a worksheet or wet lab practical. During the 2 wet lab practicals on 28 August and 2 October students should bring lab coats, safety glasses and fully enclosed shoes.

### **Revision opportunities:**

The embryology course has significant theory content. Therefore, lecture slots have been reserved for course revision in the program. Students will have additional lecture revision time in each of the practical classes. It is highly recommended that students take advantage of these revision opportunities, which are meant to be student-driven. To get the most out of these, please advise lecturers in advance which of the subject matter requires further clarification. This can be done preferentially by posting on Moodle or by email.

## COURSE PROGRAM (draft program, subject to changes)

[https://embryology.med.unsw.edu.au/embryology/index.php/ANAT2341\\_Course\\_Timetable\\_2018](https://embryology.med.unsw.edu.au/embryology/index.php/ANAT2341_Course_Timetable_2018)

Week	Date	Lecture 1 Mon 12-1 pm (CLB4)	Lecture 2 Tue 10-11 am (Matthews ThD)	Laboratory Tue 3-5 pm (WW G06/07)
1	23-Jul	1 Embryology Introduction - by course coordinators Mark and Annemiek	2 Fertilization - by Mark	
2	30-Jul	3 Week 1/2 development - by Annemiek	4 Week 3 development - by Mark	1 Preimplantation and early implantation lab - worksheets
3	6-Aug	5 Endoderm development - by Mark	6 Ectoderm development - by Annemiek	2 Robert Gilchrest (UNSW) - The Reproductive Technology Revolution
4	13-Aug	7 Mesoderm development - by Annemiek	8 Research technologies in developmental biology - by Annemiek	2 Mark Hill (UNSW) – Group Projects
5	20-Aug	9 Revision - by Mark and Annemiek	10 Placental development - by Mark	4 Fabien deLarue (UNSW) - GM manipulation of mouse embryos
6	27-Aug	11 Neural crest development - by Mark	12 Renal development - by Mark	5 Gastrulation, early somitogenesis and neurulation lab - early chicken eggs
7	3-Sep	13 Genital development - by Annemiek	14 Endocrine development - by Mark	6 Kirsty Walters – female reproductive tract development
8	10-Sep	15 Musculoskeletal development - by Mark	16 Integumentary development - by Annemiek	7 Annemiek Beverdam – Skin regeneration research
9	17-Sep	17 Revision - by Annemiek	18 Head development - by Annemiek	8 Sally Dunwoodie: vertebral development research
<b>24 Sep - 1 Oct</b>		<b>Mid-semester break</b>		
10	1-Oct	- Public holiday	19 Limb development - by Annemiek	9 Organogenesis Lab - with mouse and chicken mid-gestation embryos
11	8-Oct	20 Heart development - by Mark	21 Stem cells - by Annemiek	10 Vashe Chandrakanthan (UNSW) - Cardiac development and iMS research
12	15-Oct	22 Respiratory development - by Mark	23 Sensory development - by Mark	11 Group projects
13	22-Oct	24 Fetal development - by Mark	25 Birth and revision - by Mark	12 Stem cell lab - Stem Cell Journal Club

## **APPROACH TO LEARNING AND TEACHING**

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The learning and teaching philosophy underpinning this course is centred on student learning and aims to create an environment which interests and challenges students. The teaching is designed to be engaging and relevant to prepare students for future careers. Although the primary source of information for this course is the lecture material, effective learning can be enhanced through self-directed use of other resources such as textbooks and Web based sources, and attendance of the revision classes. Your practical classes will be research related to the lectures and it is essential to prepare for practical classes before attendance. It is up to you to ensure you perform well in each part of the course; preparing for classes; completing assignments; studying for exams and seeking assistance to clarify your understanding.

## **TEXTBOOKS AND OTHER RESOURCES**

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These resources will take the form of textbooks, journal articles or web-based resources. Links to resources will be provided in the online Wiki and Moodle. There are two embryology textbooks, either of which can be used for this course, both are online accessible through UNSW Library.

1. Moore, K.L., Persaud, T.V.N. & Torchia, M.G. (2015). The developing human: clinically oriented embryology (10th ed.). Philadelphia: Saunders.
2. Schoenwolf, G.C., Bleyl, S.B., Brauer, P.R., Francis-West, P.H. & Philippa H. (2015). Larsen's human embryology (5th ed.). New York; Edinburgh: Churchill Livingstone.

More details are available from the links below.

- Science group projects
- Working online
- Course Moodle page

## **STUDENT LEARNING OUTCOMES**

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ANAT2341 will develop those attributes that the Faculty of Science has identified as important for a Science Graduate to attain. These include; skills, qualities, understanding and attitudes that promote lifelong learning that students should acquire during their university experience.

Graduate Attributes

- A. Research, inquiry and analytical thinking abilities
- B. The capability and motivation for intellectual development
- C. Ethical, social and professional understanding
- D. Effective communication
- E. Teamwork, collaborative and management skills
- F. Information Literacy – the skills to locate, evaluate and use relevant information.

## ASSESSMENT PROCEDURES

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- |  |            |
|--|------------|
| • Individual assessment (ongoing through semester) | <b>30%</b> |
| ○ Quizzes (10%)                                    |            |
| ○ Journal club (20%)                               |            |
| • Group project assessment (through semester)      | <b>20%</b> |
| ○ Online group project                             |            |
| • End of session examination (2 hours duration)    | <b>50%</b> |

A penalty will apply for late submissions of assessment tasks (10% per day).

## COURSE EVALUATION AND DEVELOPMENT

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Each year feedback is sought from students about the course and continual improvements are made based on this feedback. The new “[myExperience](#)” process of UNSW linked through Moodle or student email is the way in which student feedback is evaluated and significant changes to the course will be communicated to subsequent cohorts of students. Furthermore, at the end of the course, we will also ask your feedback on specific aspects of the course in an independent and anonymous Survey Monkey survey.

Based on the feedback received; course content, structure and assessment are continuously updated and revised. In addition, specialised researchers have been introduced to provide current topics in this field.

## LECTURE and PRACTICAL OUTLINES

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The course timetable is available online and shows references to the relevant textbook chapters for each lecture. Both textbooks are available online through the UNSW Library or as hardcopies.

Practical classes are linked from the online timetable and relate to either the weekly lecture content, specialised research topics or student assessment work.

[ANAT2341 Online Timetable](#)

## PRACTICAL CLASSES

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The practical class is an opportunity for students to develop graduate attribute C by behaving in an ethical, socially responsible and professional manner within the practical class. Additional safety information will be provided for classes at research locations other than Wallace Wurth G08, see attached HS Guidelines for this room.

Students must take due care with biological and hazardous material. They should wear lab coats, safety glasses and fully enclosed shoes. They have to make sure all equipment is left clean and functional. In the interests of safety, special attention should be paid to any precautionary measures recommended in the notes. If any accidents or incidents occur, they should be reported immediately to the demonstrator in charge of the class who will record the incident and recommend what further action is required.

For more details see [Advice for Students-Practical Classes](#)

## Preimplantation and early implantation lab – 31 July

In this practical class, we will rotate along 1 of 4 work stations and complete the worksheets below. Both Annemiek and Mark will be available for help and you can also consult your lecture notes and the internet.

### **Station 1: preimplantation** (microscopy and models)

Identify and draw the 4 pre-implantation stages of mouse embryos you see under the light microscope.

Name the key anatomical features of the embryos of these 4 stages.

Where in the female reproductive tract does fertilization take place?

What are the polar bodies, and up to how many are formed per embryo?

What is the zona pellucida? What does it do?

At what stage is the embryo ready for implantation?



## Preimplantation and early implantation lab – 31 July

### **Station 2: early implantation** (worksheet and models)

#### Implantation:

Name the two tissues that make up a blastocyst.

1:

2:

The embryonic tissue of the blastocyst gives rise to two other structures. Which?

1:

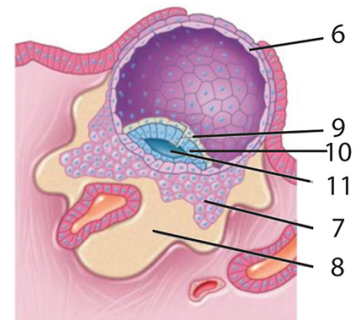
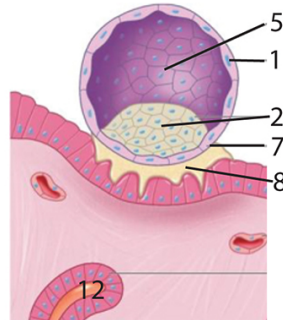
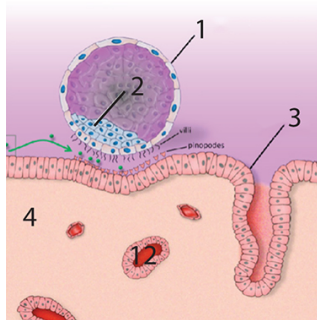
2:

The non-embryonic tissue of the blastocyst gives rise to which two other tissues?

1:

2:

Name all the numbered structures below.



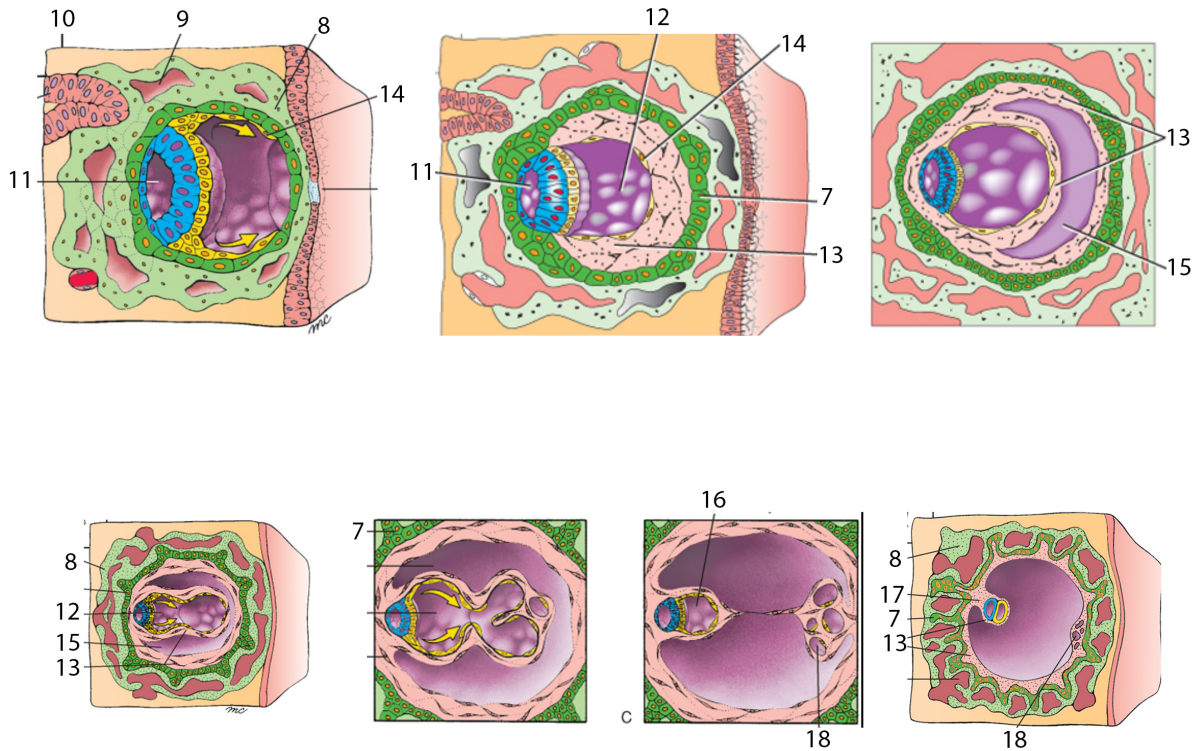
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12

What are the functions of the 4 embryonic cell types?

- 1
- 2
- 3
- 4

## Preimplantation and early implantation lab – 31 July

### Station 3: Embryonic cavities: worksheet and models



Name structures and identify all embryonic cavities. Compare with models at the table.

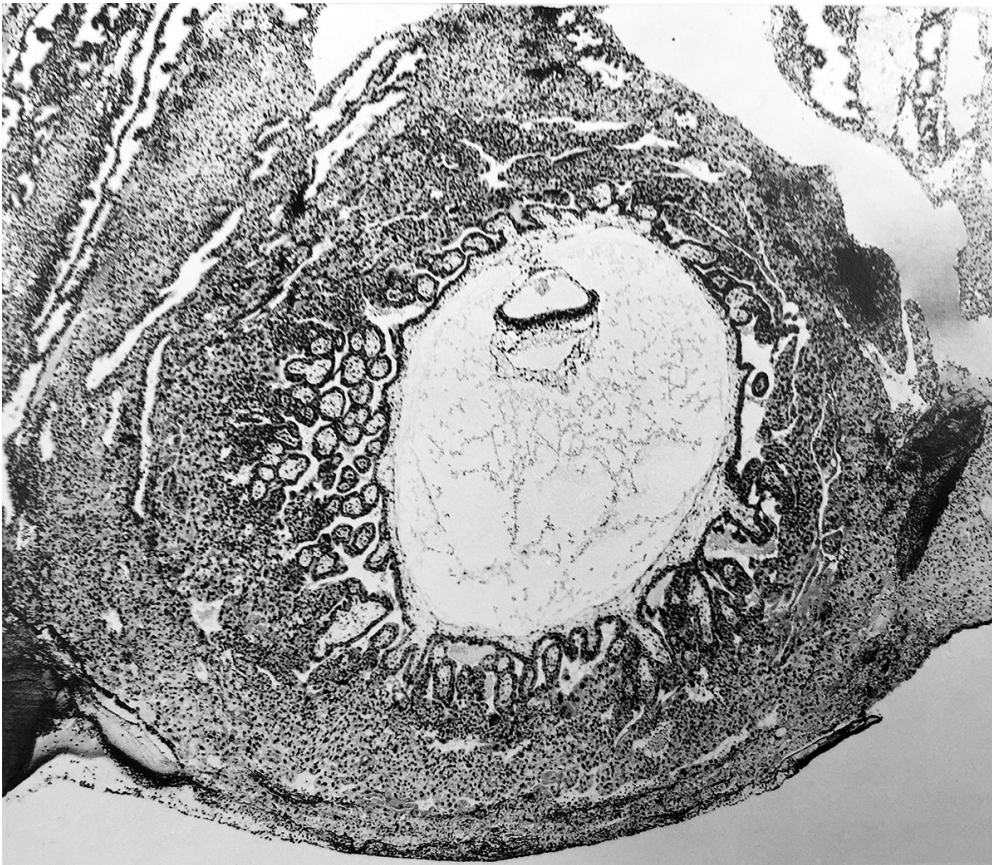
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18



Identify:

Bilaminar embryo  
Epiblast  
Hypoblast  
Heuser's membrane  
Cytotrophoblast  
Extra-embryonic mesoderm  
Primitive yolk sac  
Endometrium  
Uterine gland





Identify:

Bilaminar embryo

Amnion

Definitive yolk sac

Chorion

Connecting stalk

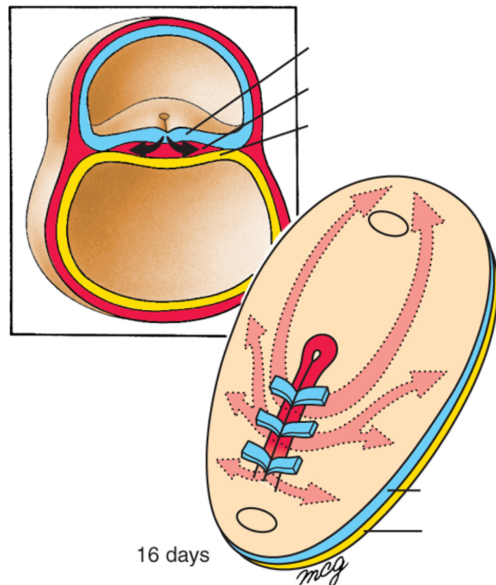
Cytotrophoblast

Endometrium

Placental villi (developing)

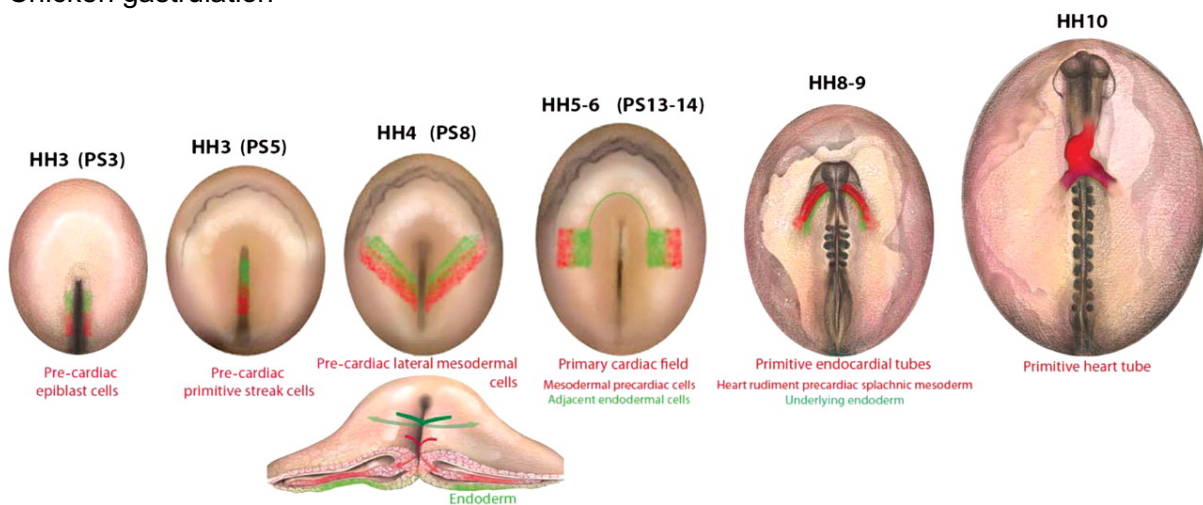
## Preimplantation and early implantation lab – 31 July

### **Station 4: Gastrulation:** worksheet, chicken embryo preps, and models



#### Chicken gastrulation

HH10



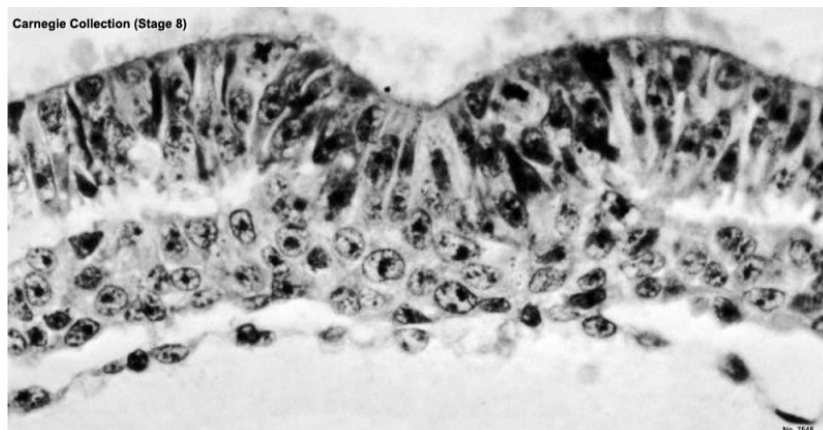
What embryonic tissues are formed at gastrulation?

In the images above, locate node, primitive streak, somites, neural folds, spinal cord, brain vesicles.

Draw the chicken embryos, and mark the embryonic structures: primitive streak, node, neural plate, neural folds, cardiac mesoderm, somites,

Indicate the anteroposterior orientation of the embryos

## Preimplantation and early implantation lab – 31 July



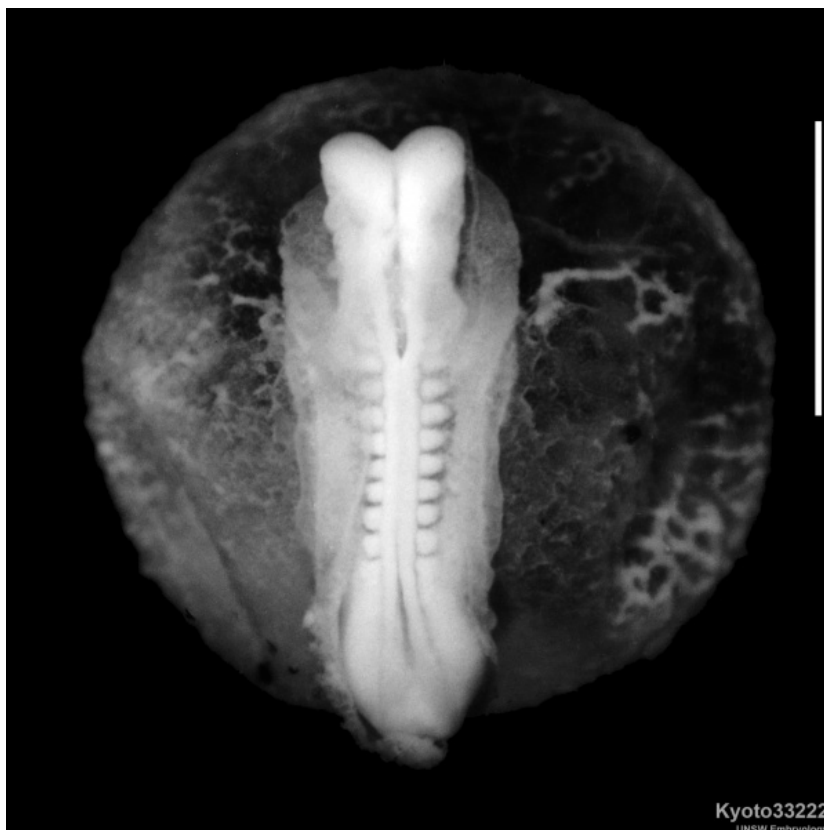
Identify:

Epiblast

Primitive Streak

Endoderm

Mesoderm



Identify:

Neural folds

Neural groove

Posterior neuropore

Somites

Where is the anterior region?



Identify:

- Yolk sac
- Embryo
- Heart tube
- Indicate the cranial region





The chicken (*Gallus gallus*) embryo is an excellent model for the study of early vertebrate embryogenesis and later organogenesis. The embryo is encased within a hardened eggshell which provides a natural incubator or culture dish. Through a hole in the eggshell, the embryo can be visualized and easily manipulated with microsurgical tools or gene constructs, then allowed to continue development *in ovo* to determine the consequence of the experimental manipulation.

Fertilized chicken eggs are readily available anywhere in the world and the equipment needed is minimal – a humidified incubator (39°C, no CO<sub>2</sub> required), a dissecting microscope, microsurgical tools that can be prepared in the lab or purchased, and either a hand-held mouth pipette or a manufactured micromanipulator and picospritzer.

Fertilized eggs can be held at between 13-16°C for up to 1 week prior to incubation. They are incubated at 38°C-39°C to the desired stage in a humidified incubator with the eggs placed on their side (horizontal). For long-term post-operative survival, it is best that the eggs be left in the incubator until experimental manipulation. However, eggs can be removed from the incubator and held at room temperature to slow development.

For staging of chicken embryos:

[https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger\\_Hamilton\\_Stages](https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger_Hamilton_Stages)

### SAFE WORKING PROCEDURES AND ANIMAL ETHICS

#### Risks Associated with Practical

Eggs have the potential to be contaminated with the bacteria [Salmonella](#). Wear gloves throughout and students should always wash their hands before leaving the lab.

Dissection implements are sharp, so students should take care not to cut themselves or other students.



## Gastrulation, early somitogenesis and neurulation lab – 28 August

Students should wear a lab coat, gloves and enclosed shoes to protect themselves from egg splatter.

### Animal Ethics Compliance

The procedures used in this practicum are in compliance with the UNSW Animal Care and Ethics Committee and the National Health and Medical Research Council 'Australian code of practice (8<sup>th</sup> edition, 2013).

## EXPERIMENTAL PROCEDURES

### Opening of the egg

1. Eggs were incubated for several days at 38.5°C to generate embryos that undergo organogenesis.
2. Each student pair should have one egg and an egg holder, a pair of blunt forceps and a pair of scissors, 3 petridishes, PBS, disposable pipet, syringe and 23G needle, Indian ink solution, dissection microscope.
3. Put the egg into the holder with the blunt end up (pointed end down).
4. Use the pointy end of the scissors to tap a hole in the top of the egg into the air chamber, be very careful not to push the scissors too far into the egg.
5. Use the forceps to pick bits of shell out. Do not remove egg shell beyond the air chamber. You will see the air chamber and the vitelline membrane.
6. Carefully remove the vitelline membrane at the top.
7. If you do not see the embryo (a ring of blood vessels should be visible) then gently swirl the egg so that it floats up to the top of the yolk. If this doesn't work you will need to take another egg if available.
8. Use the forceps to break off pieces of shell down to the yolk so that the embryo (visible as a ring of blood vessels) is exposed and the rim of the shell is just above the surface of the egg white or albumen.
9. You may be able to see the heart beating without magnification. If not, then put the egg under the dissection microscope.

### Early stage somitogenesis embryos

1. Draw Indian Ink solution (if available) up into a 1 ml syringe fitted with a 23G syringe needle.
2. Open an egg as described above. Once the shell has been removed down to the level of the yolk and the vitelline membrane has been removed, slide the syringe needle under the

## Gastrulation, early somitogenesis and neurulation lab – 28 August

3. embryo. It is easiest to insert the syringe needle vertically at the edge of the egg initially and then rotate the needle until it is almost horizontal using the edge of the egg shell as a support. The tip of the needle should end up just below the embryo in the centre of the egg.
4. Slowly inject the Indian ink solution to reveal the embryo and view under a dissecting microscope.
5. Identify the HH stage and the diverse embryonic structures. See last page or link below.  
[https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger\\_Hamilton\\_Stages](https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger_Hamilton_Stages)
6. Draw your embryo, indicate the Hamburger & Hamilton (HH) developmental stages using the guide on course manual pages 22-24, and annotate the embryonic structures that you have identified.
7. Hand your drawing in at the end of the prac.

### Observation of developmental stages

Move around the class to study the embryonic chicken stages of your colleagues. Identify the following structures:

- Amniotic sac
- Hensen's node
- Neural groove and folds
- Head ectoderm
- Somites
- Brain vesicles
- Cardiogenic mesoderm
- Heart and vasculature

### Tidying up after the prac

- Please discard egg waste and disposable consumables into the yellow bins (not the paper bins).
- Dispose of Syringes and needles in sharps bins
- Wash forceps and scissors with water, and wipe with ethanol, place in provided containers on the sink.
- Clean surfaces (microscope stages, benches) with water and ethanol, and wipe dry.

### SAFE WORKING PROCEDURES AND ANIMAL ETHICS

#### Risks Associated with Practical

Eggs have the potential to be contaminated with Salmonella. Wear gloves throughout and students should wash their hands before leaving the lab.

Dissection implements are sharp, so students should take care not to cut themselves or other students.

Students should wear a labcoat, gloves and enclosed shoes to protect themselves from egg splatter.

#### Animal Ethics Compliance

The procedures used in this practicum are in compliance with the UNSW Animal Care and Ethics Committee and the National Health and Medical Research Council “Australian code of practice” (8<sup>th</sup> edition, 2013).

### EXPERIMENTAL PROCEDURES

#### Opening of the egg

8. Eggs were incubated for several days at 38.5°C to generate embryos that undergo organogenesis.
9. Each student pair should have one egg and an egg holder, a pair of blunt forceps and a pair of scissors, 3 petri dishes, PBS, disposable pipet, syringe and 23G needle, Indian ink solution, dissection microscope.
10. Put the egg into the holder with the blunt end up (pointed end down).
11. Use the pointy end of the scissors to tap a hole in the top of the egg into the air chamber, be very careful not to push the scissors too far into the egg.
12. Use the forceps to pick bits of shell out. Do not remove egg shell beyond the air chamber. You will see the air chamber and the vitelline membrane.
13. Carefully remove the vitelline membrane at the top.
14. If you do not see the embryo (a ring of blood vessels should be visible) then gently swirl the egg so that it floats up to the top of the yolk. If this doesn't work you will need to take another egg if available.

## Organogenesis lab – 2 October

15. Use the forceps to break off pieces of shell down to the yolk so that the embryo (visible as a ring of blood vessels) is exposed and the rim of the shell is just above the surface of the egg white or albumen.
16. You may be able to see the heart beating without magnification. If not, then put the egg under the dissection microscope.

### Organogenesis embryos

1. Carefully tear a hole in the vitelline membrane.
2. Very carefully tilt egg contents in a large petri dish, holding the egg very close to the dish.
3. Find and dissect the embryo, transfer it to a clean petri dish and cover it with PBS.
4. Study embryo under a dissection microscope, determine Hamburger & Hamilton (HH) developmental stages using the guide on course manual pages 22-24, and identify the embryonic structures.
5. Draw your embryo, indicate the developmental stage (HH, pages 22-24), and annotate the embryonic structures that you have identified.
6. Hand your drawing in at the end of the prac

### Observation of developmental stages

Move around the class to study the embryonic chicken stages of your colleagues. Identify the following structures:

- Somites
- Brain vesicles
- Heart and vasculature
- Optic vesicles
- Branchial arches
- Nasal placodes
- Nasal pits and nasal processes
- Otic vesicle
- Limb buds
- Autopod, stylopod and zeugopod
- Handplate and fingers

### **E. Mouse and chicken embryogenesis**

There will be one demonstration station with dissection and light microscopes where you can investigate mouse embryos from E7.5 (late gastrula) until late organogenesis (E15.5), skeletal preparations of mouse foetuses, and mounted and stained early stage chicken embryos.

Identify the following structures:

- Amniotic sac
- Hensen's node
- Neural groove and folds
- Head ectoderm
- Somites
- Brain vesicles
- Cardiogenic mesoderm
- Heart and vasculature
- Optic vesicles
- Branchial arches
- Nasal placodes
- Nasal pits and nasal processes
- Otic vesicle
- Limb buds
- Autopod, stylopod and zeugopod
- Handplate and fingers

Note that mouse foetuses mainly consist of cartilage (blue), and only some skeletal elements are ossified (red) including the calvaria.

### **F. Tidying up after the prac**

- Please discard egg waste and disposable consumables into the yellow bins (not the paper bins).
- Dispose of Syringes and needles in sharps bins
- Wash forceps and scissors with water, and wipe with ethanol, place in provided containers on the sink.
- Clean surfaces (microscope stages, benches) with water and ethanol, and wipe dry.

## STAGING CHICK EMBRYOS - HAMBURGER HAMILTON STAGES

(Full tables available: <http://www.ncbi.nlm.nih.gov/pubmed/1304820>)

HH Stage	Time and Features
2	6-7 hr: Initial primitive streak, 0.3-0.5 mm long
3	12-13 hr: Intermediate primitive streak
4	18-19 hr: Definitive primitive streak, $\pm 1.88$ mm long
5	19-22 hr: Head process (notochord)
6	23-25 hr: Head fold
7	23-26 hr: 1 somite; neural folds
7 to 8-	ca. 23-26 hr: 1-3 somites; coelom
8	26-29 hr: 4 somites; blood islands
9	29-33 hr: 7 somites; primary optic vesicles
9+ to 10-	ca. 33 hr: 8-9 somites; anterior amniotic fold
10	33-38 hr: 10 somites; 3 primary brain vesicles
11	40-45 hr: 13 somites; 5 neuromeres of hindbrain
12	45-49 hr: 16 somites; telencephalon
13	48-52 hr: 19 somites; atrioventricular canal
13+ to 14-	ca. 50-52 hr: 20-21 somites; tail bud
14	50-53 hr: 22 somites; trunk flexure; visceral arches I and II, clefts 1 and 2
14+ to 15-	ca. 50-54 hr: 23 somites; premandibular head cavities
15	50-55 hr: 24-27 somites; visceral arch III, cleft 3
16	51-56 hr: 26-28 somites; wing bud; posterior amniotic fold
17	52-64 hr: 29-32 somites; leg bud; epiphysis
18	65-69 hr: 30-36 somites extending beyond level of leg bud; allantois
19	68-72 hr: 37-40 somites extending into tail; maxillary process
20	70-72 hr: 40-43 somites; rotation completed; eye pigment faint grey
21	3.5 da: 43-44 somites; pharyngeal arch IV, pharyngeal cleft 4; eye pigment faint
22	3.5 da: Somites extend to tip of tail; eye pigmentation distinct
23	3.5-4 da: Dorsal contour from hindbrain to tail is a curved line
24	4 da: Toe plate in leg-bud distinct; 4th pharyngeal cleft reduced to small pit
25	4.5 da: Elbow and knee joints; 3rd & 4th pharyngeal clefts reduced to small pits
26	4.5-5 da: 1st 3 toes; 3rd and 4th pharyngeal clefts no longer visible
27	5 da: Beak just barely recognisable
28	5.5 da: 3 digits, 4 toes; beak outgrowth distinct in profile
29	6 da: Rudiment of 5th toe; beak more prominent; no egg tooth
30	6.5 da: Feather germs; scleral papillae; egg tooth
31	7 da: Web between 1st and 2nd digits; feather germs dorsally continuous from brachial to lumbosacral level
32	7.5 da: Anterior tip of mandible has reached beak
33	7.5-8.0 da: Web on radial margin of wing and 1st digit

34	8 da: Nictitating membrane
35	8 - 9 da: Phalanges in toes
36	10 da: Length of 3rd toe from tip to middle of metatarsal joint = $5.4 \pm 0.3$ mm; length of beak from anterior angle of nostril to tip of bill = 2.5 mm; primordium of comb; labial groove; uropygial gland
37	11 da: Length of 3rd toe = $7.4 \pm 0.3$ mm; length of beak = 3.0 mm
38	12 da: Length of 3rd toe = $8.4 \pm 0.3$ mm; length of beak = 3.1 mm
39	13 da: Length of 3rd toe = $9.8 \pm 0.3$ mm; length of beak = 3.5 mm
40	14 da: Length of beak = 4.0 mm; length of 3rd toe = $12.7 \pm 0.5$ mm
41	15 da: Length of beak from anterior angle of nostril to tip of upper bill = 4.5 mm; length of 3rd toe = $14.9 \pm 0.8$ mm
42	16 da: Length of beak = 4.8 mm; length of 3rd toe = $16.7 \pm 0.8$ mm
43	17 da: Length of beak = 5.0 mm; length of 3rd toe = $18.6 \pm 0.8$ mm
44	18 da: Length of beak = 5.7 mm; length of 3rd toe = $20.4 \pm 0.8$ mm
45	19-20 da: Yolk sac half enclosed in body cavity; chorio-allantoic membrane contains less blood and is "sticky" in living embryo
46	20-21 da: Newly-hatched chick

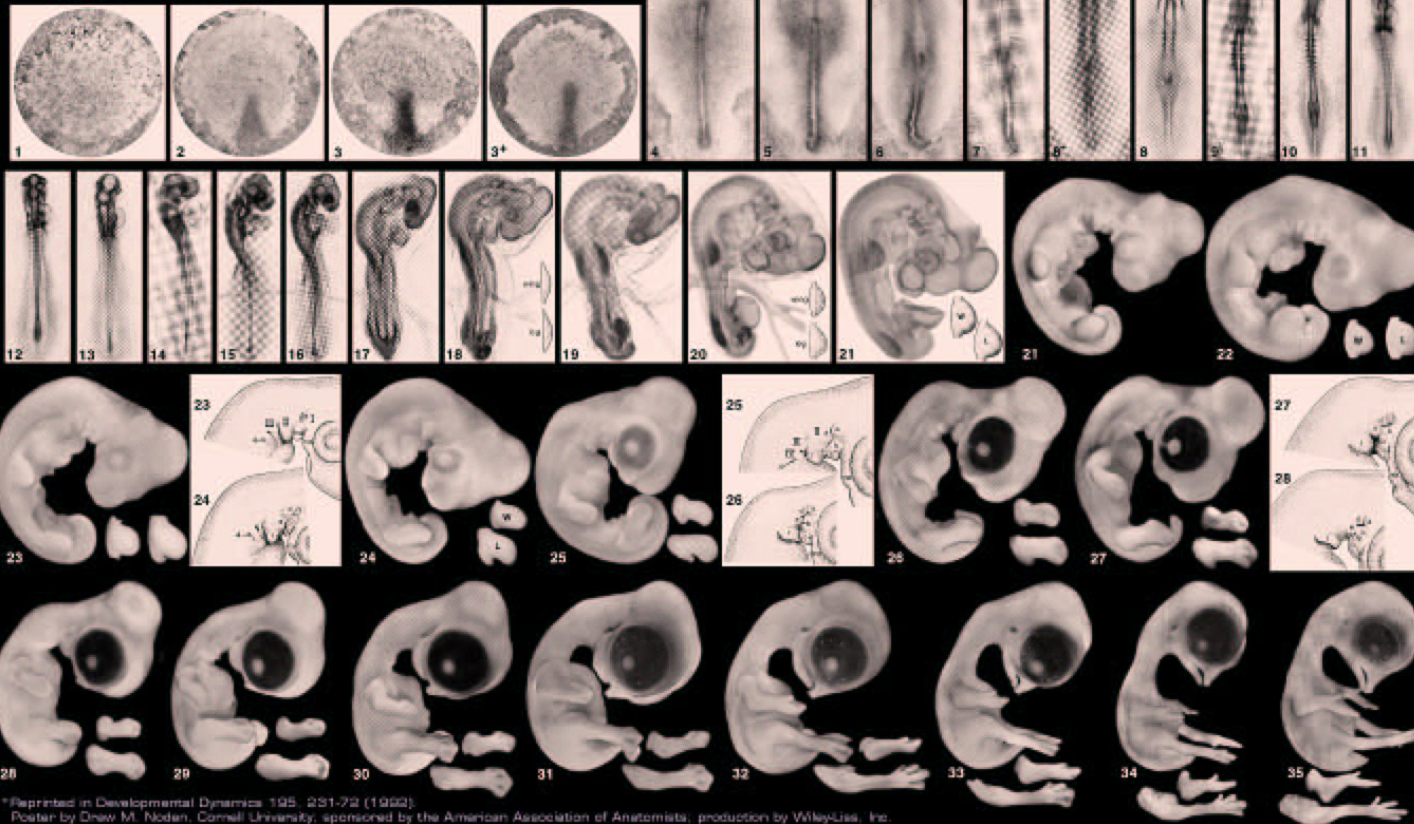


## STAGING CHICK EMBRYOS - HAMBURGER HAMILTON STAGES

# In Memory of Viktor Hamburger: 1900-2001

## NORMAL STAGES OF CHICK EMBRYONIC DEVELOPMENT

Hamburger V., Hamilton H.L. 1951.  
A series of normal stages in the development of the chick embryo. *J Morph* 88: 49-92.



The stage series of normal chick embryonic development is one of the most frequently cited and enduring biomedical articles ever published, and set the standards for numerous species-specific stage series that have followed. The compiler of this paper, Viktor Hamburger, died in June, 2001, just a few weeks prior to his 101st birthday. In recognition of the tremendous importance of this stage series to countless research and teaching laboratories around the world, and in tribute to Prof. Hamburger's many contributions to developmental biology spanning seven decades, the editors and publisher of *Developmental Dynamics* commissioned the poster that accompanies this issue. Stages 1-35 (incubation days 0 through 50) were scanned from the original 1951 publication. Embryos have been retouched and cropped for this poster format, and digitally enhanced to better highlight key features of each stage. Sketches of early head and branchial (pharyngeal) arch development are also included; keys for these are in the original publication.

\*Reprinted in *Developmental Dynamics* 195: 231-72 (1992).

Poster by Drew M. Noden, Cornell University, sponsored by the American Association of Anatomists; production by Wiley-Liss, Inc.

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## HEALTH & SAFETY GUIDELINES

Generic safety rules for UNSW can be found at: [SAFETY.UNSW.EDU.AU](http://SAFETY.UNSW.EDU.AU) and for the School of Medical Sciences at [MEDICALSCIENCES.MED.UNSW.EDU.AU/STAFF/HEALTH-SAFETY](http://MEDICALSCIENCES.MED.UNSW.EDU.AU/STAFF/HEALTH-SAFETY)  
Additional safety information will be provided for classes at other locations.

ScienceTeaching Laboratory

Student Risk Assessment



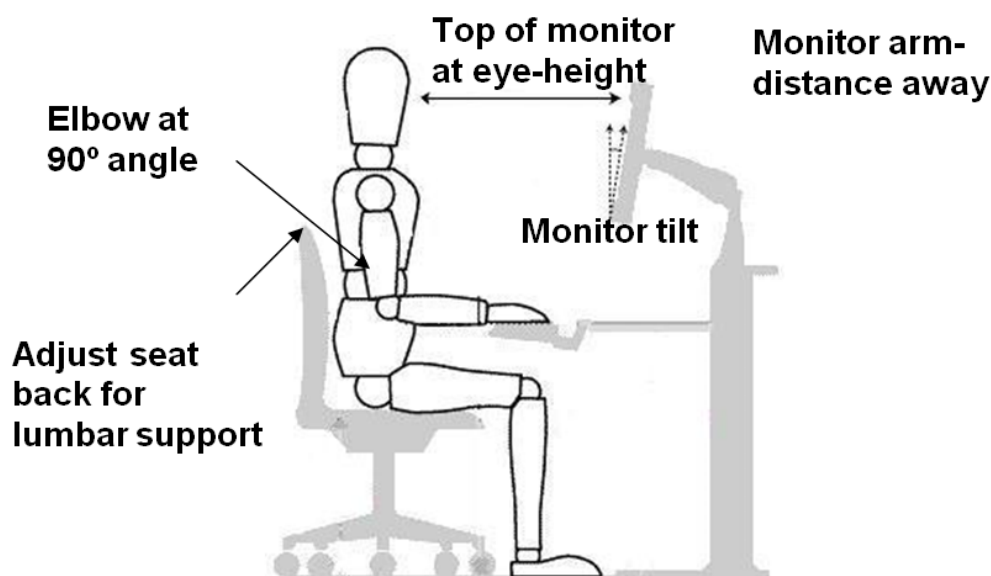
**UNSW**  
SYDNEY

ANAT2341

Wallace Wurth East G6-7  
Semester 2, 2018.

### Workstation set-up

Ergonomics	Musculoskeletal pain.	Correct workstation set-up.
Electrical	Shock/fire	Check electrical equipment in good condition before use. All electrical equipment tested and tagged.



### Personal Protective Equipment

Not necessary in these practicals. (specimens are fully sealed)

### Emergency Procedures

In the event of an alarm, follow the instructions of the demonstrator. The initial sound is advising you to prepare for evacuation and during this time start packing up your things. The second sound gives instruction to leave. The Wallace Wurth assembly point is the lawn in front of the Chancellery. In the event of an injury, inform the demonstrator. First aiders contact details and Kit locations are on display by the lifts.

### Clean up and waste disposal

No apparatus or chemicals used in these practicals.

### Declaration

I have read and understand the safety requirements for these practical classes and I will observe these requirements.

Student Number:..... Signature:..... Date:.....