

Online Research @ Cardiff

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <http://orca.cf.ac.uk/124636/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Fakoya, Francis A., Emmanouil-Nikoloussi, Elpida, Sharma, Deepak and Moxham, Bernard J. 2017. A core syllabus for the teaching of embryology and teratology to medical students. *Clinical Anatomy* 30 (2) , pp. 159-167. 10.1002/ca.22802 file

Publishers page: <http://dx.doi.org/10.1002/ca.22802> <<http://dx.doi.org/10.1002/ca.22802>>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See <http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



A Core Syllabus for the Teaching of Embryology and Teratology to Medical Students

Francis A. Fakoya¹, Elpida Emmanouil-Nikoloussi²,
Deepak Sharma¹, Bernard J. Moxham^{1,3}

¹St George's University, Grenada, West Indies

²The School of Medicine, European University Cyprus, 6 Diogenous str, 2404 Engomi, P.O.Box 22006, 1516 Nicosia, Cyprus

³Cardiff School of Biosciences, Cardiff University, Museum Avenue, Cardiff, CF10 3AX, Wales, United Kingdom

Running title: Embryology Core Syllabus

KEYWORDS: medical education, embryology, teratology, core syllabus, Delphi panels

Correspondence to: Professor Bernard J Moxham, Cardiff School of Biosciences, Cardiff University, Museum Avenue, Cardiff, CF10 3AX, Wales, United Kingdom

E-mail: moxham@cardiff.ac.uk

Phone: 44 29 20874031

Fax: 44 29 20875964

ABSTRACT

Clinical relevance in the teaching of biomedical sciences within health care courses presupposes that there is internationally agreed core material within the curricula. However, with the exception of a syllabus for neuroanatomy and gross anatomy of the head and neck for medical students, core syllabuses within many of the specialised anatomical sciences have yet to be developed. The International Federation of Associations of Anatomists aims to formulate internationally accepted core syllabuses for all anatomical sciences disciplines initially using Delphi Panels that comprise anatomists, scientists and clinicians who evaluate syllabus content. Here, the suggestions of a Delphi Panel for embryology and teratology are presented prior to their publication on the website of the International Federation of Associations of Anatomists. Hence, to obtain a more definitive syllabus, it is required that anatomical and embryological/teratological societies, as well as individual anatomists, embryologists and clinicians, freely comment upon, elaborate and amend, this draft syllabus. The goal is to set internationally recognized standards and thereby provide guidelines concerning embryological and teratological knowledge when involved with course development.

INTRODUCTION

Without internationally-recognised core syllabuses for the anatomical sciences problems remain relating to the development of medical curricula, the value to be placed on optional (elective) courses (see Moxham and Pais, 2016), a lack of consistency, and reliability and transparency in the higher educational sector dealing with medical education and training. Moreover, there is little to prevent continuing loss of esteem of the anatomical sciences with consequent loss of time devoted to the disciplines. Indeed, Drake *et al.* (2014) have reported that, over the previous 5 years, the range of course hours for embryology within US medical schools declined from 0-68h to 0-30h. Furthermore, some schools had no embryology course, most had no practical classes, the average course only entailed 16h, and the hours devoted to embryology fell by over 70% between 1955 and 2014. Chirculescu and Morris (2008) found that similar events were occurring in the UK. These changes are happening despite the realisation that embryology and teratology is essential for the understanding of prenatal life, of how the organization of the mature human body has developed, and of providing essential information for general medical practice, obstetrics and pediatrics. In addition, the general public, together with political and medical authorities, are becoming increasingly concerned about environmental toxins and how these affect intra-uterine life (*viz.* the recent publicity concerning the Zika virus). In view of these findings and considerations, it seems to us more than ever necessary to develop a core syllabus for embryology and teratology for medical studies.

To date, published core syllabuses for specialist anatomical sciences are infrequent. There have been commendable attempts to develop core syllabuses for gross

anatomy in general (Leonard *et al.*, 1996; Griffioen *et al.*, 1999; McHanwell *et al.*, 2007; Orsbon *et al.*, 2014; Smith *et al.*, 2016a,b and 'specialised' core syllabuses for the anatomical sciences have been published for head and neck anatomy (Tubbs *et al.* 2014; Tubbs and Paulk, 2015) and for neuroanatomy (Moxham *et al.*, 2015). For embryology, but not teratology,, Leonard *et al.* (2000) have presented a syllabus for embryology in the medical curriculum. However, this syllabus did not use a Delphi Panel for its formulation and has remained a document that has not been modified since publication. Using methodologies approved by the International Federation of Associations of Anatomists (IFAA) (Moxham *et al.*, 2014), and previously used to devise the initial stages of the core syllabuses for head and neck anatomy and neuroanatomy mentioned above, we here present the findings of a Delphi Panel set up by the IFAA to provide the first stage in the development of an embryology and teratology core syllabus for medicine.

METHODS

The IFAA has agreed the guiding principles for the development of their core syllabuses and these have been already published and thoroughly discussed (Moxham *et al.*, 2014). Briefly, the process is divided into three stages .

Stage 1

An expert Delphi Panel is constructed consisting of between 20 and 30 persons from different countries. This panel provides a detailed list of topics within their remit (i.e. eschewing a 'broad brush' approach). The panel for embryology and teratology for the medical course consisted of 24 members (7 from USA; 2 from Greece; 2 from Italy; 2 from the Czech Republic; 2 from Nigeria; 2 from Nigeria; 2 from UK and

Ireland, 1 from Israel; 1 from the West Indies; 1 from Germany; 1 from Austria; 1 from Canada). The age ranged from 41 to 70 plus years. all were engaged in embryological/teratological research, over 80% claiming that they devoted more than 40% of their time to research. 66% of the panelists were clinically qualified. One panelist was a writer of an embryology textbook and another has written a textbook within which is a substantial amount of craniofacial embryology. All of the panelists were teachers with substantial or considerable teaching experience, although few were educationalists involved in pedagogic research. Over 80% were academics (clinical or scientific) employed by universities, the remainder being employed by clinics. 40% of those with clinical duties claimed to devote more than 20% of their time to their clinical practice. All panelists stated that the teaching of embryology and teratology to medical students is important or very important.

The coordinators of the panel provided a 'cockshy' list of topics for the panel to consider. This list was amended following comments from some members of the panel. Subsequently, panel members had to evaluate each item/topic in the list according to whether it should be regarded as 'essential', 'important', 'acceptable' or 'not required' status". Table 1 provides an example of the form used by the Delphi Panel for embryology and teratology. A blank section was available within the form for comments from the panel members.

Taking the responses from the Delphi Panel, each item was now categorized so that the essential, recommended, just acceptable, and not required elements are brought together. To accomplish this, and for the sake of consistency with other core syllabuses published through the IFAA, a general rule was followed. Where more

than 60% of the responding panelists considered an item as being essential, this was categorized as being 'core'. Where between 30% and 59% of the responding panelists classified an item as being essential, the topic was designated as being 'recommended'. Classification of 'just acceptable' or 'not required' came when the responding panelists only recorded essential designations between 20% and 29% and less than 20% respectively. This is the stage at which the findings of the Delphi Panel are presented to a more wide-ranging audience through this article and on the IFAA website. Stages 2 and 3 of the development of the core syllabus for embryology and teratology do not involve the Delphi Panel but relies upon comments from learned societies and from individual embryologists and medical clinicians across the world. Further review and modification of the core syllabus will then take place on a regular and continuous basis by the IFAA's Federative International Programme for Anatomical Education (FIPAE) to establish the IFAA core syllabus.

FINDINGS

Below are summarized the results from the responses of the 'Delphi Panel' for embryology and teratology for different topic areas. Note that for consistency of development of this initial syllabus, where a topic is classified as 'recommended' but just approaches 'core' (i.e. being classified as being 'essential' by almost 60% of responding Delphi panelists), it is moved into the 'core' category if associated topics related to teratology and/or congenital malformations are recorded as being 'essential/core'.

General principles and topics before fertilization:

A medical student should have core knowledge of:

1. The ovarian and menstrual cycles
2. Hormonal events at ovulation
3. General principles underpinning teratogenesis
4. Classifications of congenital malformations
5. Genetic versus environmental (and multifactorial) causes of congenital malformations
6. Estimation of embryonic age

Topics recommended for teaching (but not 'core') include:

1. Gross anatomy of the female and male reproductive organs (although these topics can be taught in gross anatomy classes)
2. Histology of the female and male reproductive organs (although these topics can be taught in histology classes)
3. Cell division, especially meiosis (although this topic can be taught with genetics)
4. Comparisons between female and male gametes
5. Spermeogenesis, sperm transport, maturation of sperms
6. Anatomical and physiological aspects of sex (although some panellists state that these topics can be taught with Obstetrics and Gynaecology)
7. Historical perspective on teratology
8. Mechanisms of teratology
9. Epidemiology of congenital malformations
10. Types and classes of teratogens
11. Effects of teratogens (death; abortion/miscarriage; malformation; IUGR)
12. Counselling for teratogen exposure (although this topic might be dealt with in the clinic)

Not 'core' or recommended for teaching are:

1. Primordial germ cells
2. Genetic imprinting

3. X inactivation
4. Contraception (to be taught with Obstetrics and Gynaecology)
5. Reproductive toxicity
6. High risk pregnancies (to be taught with Obstetrics)
7. Birth defects surveillance and monitoring, including birth defects registries, legislation, global health aspects (to be taught in the clinic)
8. Cultural perspectives and socioeconomic aspects of teratology
9. Experimental teratology, including animal models, in-vitro systems, embryo culture
10. Procedures for assessing foetal status (to be taught in the clinic)

N.B. The highlights of events during life in utero was regarded as 'core' from week 0 to week 8 but only recommended for week 9 to week 38. Furthermore, knowledge of the expected date of parturition was core but not stages of labour, and the umbilical cord, the placenta and foetal membranes after birth.

Fertilization:

A medical student should have a good knowledge of:

1. Phases of fertilization and cleavage of zygote
2. Formation of the blastocyst
3. Formation of the amniotic cavity, embryonic disc, umbilical vesicle
4. Development of chorionic sac
5. Implantation of the blastocyst

Multiple pregnancy (twins etc) is recommended but was not assessed as being 'core'

The following topics were found to be neither 'core' nor recommended for teaching:

1. Infertility and assisted reproduction (topics to be taught by Obstetrics and Gynaecology)
2. Molecular events in the zygote
3. Experimental studies in the early embryo

4. Embryonic stem cells

Gastrulation and folding of the embryo:

A medical student should have a good knowledge of:

1. The epiblast and hypoblast and primitive streak
2. The trilaminar embryonic disc
3. Migration of epiblast cells and formation of germ layers
4. Medial-lateral subdivisions of the mesoderm
5. Germ layer derivatives
6. The notochord
7. Head and Tail folds of the embryo
8. Lateral folds of the embryo

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Buccopharyngeal and cloaca membranes
2. Germ layer theory as dogma
3. Convergent extension of notochordal plate
4. Paths of migration of mesoderm

The following topics were found to be neither 'core' nor recommended for teaching:

1. Molecular basis for forming left-right axis
2. Fate mapping of the epiblast
3. The nodal flow model for gastrulation
4. Formation of the tail bud
5. Molecular and genetic events during gastrulation

Neurulation and development of the nervous system:

A medical student should have a good knowledge of:

1. Neural plate and neural tube formation
2. Neuropores and their closure
3. Neural crest formation
4. Properties of neural crest
5. Topographical distribution of neural crest and their fate
6. Spinal cord development, the basal and alar plates
7. Development of the spinal ganglia
8. Positional changes of the spinal cord
9. Myelination of nerve fibres
10. Brain flexures
11. Hindbrain development – fate of myelencephalon
12. Hindbrain development – fate of ventral metencephalon
13. Hindbrain development – fate of dorsal metencephalon
14. Development of the midbrain (mesencephalon)
15. Development of the forebrain (prosencephalon)
16. Development of the diencephalon
17. Development of the telencephalon (including cerebral hemispheres)
18. Development of the cerebral cortex
19. Formation of the internal capsule and cerebral commissures
20. Development of the choroid plexuses and CSF
21. Origin of the peripheral nervous system (PNS)
22. Role of the neural crest in PNS development
23. Development of spinal nerves and ganglia
24. Segmentation and the development of the PNS

25. Development of the autonomic nervous system
26. Development of cranial nerves
27. Spina bifida
28. Myeloschisis (rachischisis posterior)
29. Anencephaly
30. Iniencephaly
31. Encephalocele

The following items/topics were, at this initial stage in the development of the embryology syllabus, considered to be recommended for teaching but not 'core':

1. Development of the spinal meninges
2. Specification of precursor cells of the PNS
3. Plasticity of the PNS
4. Arnold-Chiari malformation
5. Disorders of structures derived from the mediobasal prosencephalon
6. Migration disorders
7. Destructive lesions of foetal brain
8. Porencephaly
9. Hydranencephaly
10. Hydrocephalus
11. Dandy-Walker malformations
12. Intracranial non-neoplastic cysts
13. Arachnoid cyst
14. Neuroepithelial cyst

The following topics were found to be neither 'core' nor recommended for teaching:

1. Molecular events during neurulation

2. Molecular events during development of the neural crest
3. Axonal guidance in the PNS

Somites and other embryonic development:

A medical student should have a good knowledge of:

1. Definition and location of somites
2. Division of somites into sclerotomes and dermomyotomes and their fates
3. Development of intraembryonic coelom
4. Early development of cardiovascular system (vasculogenesis and angiogenesis)

The following topics were found to be neither 'core' nor recommended for teaching:

1. Numbering of somites

The placenta, amnion and associated structures, embryonic body cavity:

A medical student should have a good knowledge of:

1. Development of the placenta
2. Placental circulation
3. Placenta as a barrier and exchange of substances
4. Hormonal synthesis by the placenta
5. Intraembryonic coelom
6. Mesenteries
7. Division of the embryonic body cavity

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. The decidua

2. The amniochorionic membrane
3. Significance of amniotic fluid production and its resorption

The following topics were found to be neither 'core' nor recommended for teaching:

1. The foetomaternal junction
2. The intervillous space
3. Development of the umbilical cord
4. Composition of amniotic fluid
5. The umbilical vesicle and its significance
6. The formation and fate of the allantois

Development of the gut:

A medical student should have a good knowledge of:

1. Body folding and the development of the gut
2. Development of the duodenum
3. Development of the liver and biliary apparatus
4. Development of the pancreas (but NOT signalling events)
5. The cloaca and hindgut development
6. The ano-rectal canal and ano-rectal malformations
7. The urogenital sinus
8. The urorectal septum
9. Genital tubercle, urethral plate and urogenital folds

N.B. The pharyngeal arches are considered with craniofacial development

The following items/topics were considered to be recommended for teaching but not 'core':

1. The stomodeum and buccopharyngeal membrane

2. Development of the oesophagus and congenital defects
3. Formation and rotation of the stomach
4. Development of the spleen
5. Primary intestinal loop and rotation of the midgut
6. Caecum and appendix development
7. Role of the neural crest in gut development
8. The anal pit and anal membrane
9. Atresia of the intestines
10. Malrotation of the intestines
11. Remnants of the omphalomesenteric duct
12. Duplicatures within the GI tract
13. Defects of the abdominal wall
14. Omphaloceles and gastroschisis

The following topics were found to be neither 'core' nor recommended for teaching:

1. Molecular events during gut development
2. Development of the dorsal and ventral mesenteries
3. Development of the greater omentum and lesser sac
4. Hepatoblast specification and fate
5. Development of the outer wall of the gut and its innervation
6. Cytodifferentiation of endodermal epithelium and formation of gut lumens
7. Congenital malformations of the stomach and of the intestines (other than atresia and malrotations)
8. The limb-body wall complex
9. Pentalogy of Cantrell

Development of the Diaphragm and the Respiratory System:

A medical student should have a good knowledge of:

1. The septum transversum
2. Origin of respiratory system from the foregut
3. The respiratory diverticulum
4. Development of the bronchial tree, trachea and lungs
5. Bronchiopulmonary segments
6. Maturation of the lungs

N.B. The development of the nasal cavities is considered with craniofacial development

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. In relation to development of the diaphragm, the pleuroperitoneal membranes
2. Congenital malformation of the diaphragm and the respiratory tract

The following topics were found to be neither 'core' nor recommended for teaching:

1. In relation to development of the diaphragm, the dorsal mesentery of the oesophagus
2. In relation to development of the diaphragm, muscular ingrowth from the lateral body walls
3. Positional changes of the diaphragm
4. Development of the innervation of the diaphragm
5. Molecular events during the development of the respiratory tract

Development of the Urinary and Genital Systems:

With no consensus, few topics were considered to be 'core' for these systems at this stage in the development of the core embryology and teratology syllabus for the medical curriculum. The exceptions were:

1. Positional changes of the developing kidneys, including variations in shape and position

2. Development of the suprarenal glands
3. Development of the gonads
4. Development of the external genitalia
5. Descent of the testes and ovaries

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Role of the intermediate mesoderm (nephrotome)
2. Formation of the mesonephros
3. Development of ureteric buds and metanephric blastema of the metanephros
4. Changes in the blood supply of the developing kidneys
5. Development of the urinary bladder, including congenital malformations
6. Relationship between the development of the urinary and genital systems
7. Sex determination
8. Development of the prostate
9. Renal agenesis
10. Renal cystic disease and infantile and adult polycystic kidneys. Also autosomal dominant polycystic kidney disease in the foetus and infant
11. Renal dysplasia
12. Congenital tubular renal dysgenesis
13. Hypospadias
14. Somatosexual disorders (but not with normal karyotype)
15. Pseudohermaphroditism masculinus
16. Testicular feminization syndrome, female XY
17. Congenital adrenal hyperplasia
18. Congenital malformations of the female genitalia (but not of the vulva)

19. Congenital malformations of the internal genitalia and in association with malformations of the urinary system
20. Congenital malformations of the male genitalia
21. Cryptorchidism
22. Congenital tumours of the urinary and genital systems
23. Sacrococcygeal teratoma

The following topics were found to be neither 'core' nor recommended for teaching:

1. Formation of the pronephros
2. The urogenital ridge
3. Signalling events during ureteric bud formation
4. Development of nephrons from the metanephros
5. Formation of ducts and tubules, renal pelvis and calyces from the metanephros
6. Signalling events associated with development of the metanephros
7. Genes involved in the nephric lineage
8. Development of the urethra and urinary tract
9. Cellular and molecular events during development of the gonads
10. Role of Amh in male genital development
11. Testis Leydig cells
12. Development of female and male genital ducts
13. Molecular events during development of the external genitalia
14. Development of the inguinal canals
15. Lower urinary tract obstruction
16. Posterior urethral valves
17. Androgen insensitivity syndrome

18. Pseudohermaphroditism feminus

19. Sith-Lemli-Opitz syndrome

Development of Cardiovascular System (including the Lymphatic System):

A medical student should have a good knowledge of:

1. Primitive heart tubes, regionalisation and folding
2. Septum primum, foramen primum, and congenital defects
3. Septum secundum, foramen secundum, and congenital defects
4. Foramen ovale
5. Development of the ventricular septum and congenital defects
6. Truncus arteriosus and anomalies of the great arteries
7. Foetal circulation and events at birth

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Sinus venosus
2. Endocardial cushions (but NOT myocardialisation)
3. Development of the lymphatic system – spleen and tonsils
4. Double-outlet right ventricle
5. Valve development and defects
6. Fallot's tetralogy
7. Malformations of the aortic arch system
8. Development of the veins and malformations of the venous system
9. Anomalies of the site and position of the heart
10. Dr George syndrome

The following topics were found to be neither 'core' nor recommended for teaching:

1. Fate of the vitelline and umbilical arteries
2. Cardiac progenitor cells
3. Primary heart field and molecular and signalling events
4. Regional specification of the cardiogenic mesoderm
5. Growth factors associated with development of the heart tube
6. Mechanisms of looping and folding of heart tube
7. Mesenteries of the developing heart
8. Secondary heart fields
9. The atrioventricular sulcus of the developing heart
10. Formation of the transverse pericardial sinus
11. Heart remodelling associated with differentiation of the systemic and pulmonary circulations
12. Circulation through the primordial heart
13. Inflow remodelling ensuring system blood goes to the right atrium
14. Gene expression during development of the heart chambers
15. The septum spurium
16. The sinus venarum and crista terminalis
17. Development of the trabeculated and non-trabeculated parts of atrium
18. Spina vestibule
19. Realignment of the heart with atrial septum development
20. Neural crest and outflow separation
21. Development of the conducting system of the heart
22. Development of the epicardium
23. Development of the coronary vasculature
24. Jugular lymph sacs

25. Cisterna chyli and other lymph sacs
26. Development of the lymph nodes
27. Development of the thoracic duct
28. Generation of the lymphatic vessels
29. Molecular events associated with development of the lymphatic system

Development of the Skeletal System and the Limbs:

A medical student should have a good knowledge of:

1. Long bone development
2. Early stages of limb development – limb buds
3. Limb digit formation

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Overview of bone histogenesis
2. General aspects of development of the vertebral column
3. Development of ribs and sternum
4. Development of skull
5. Development of skeletal muscle and muscle progenitors and their migration
6. Development of smooth muscle
7. Limb bud patterning
8. Epithelial-mesenchymal interaction and limb development
9. Morphogenesis of the limb bud

The following topics were found to be neither 'core' nor recommended for teaching:

1. Overview of cartilage histogenesis
2. Overview of muscle development
3. Overview of development of joints

4. Molecular events and development of the skeletal system
5. Cartilaginous and bony stages of vertebral development
6. Development of the intervertebral discs
7. Genes and signalling events during development of the skeletal system
8. Development of cardiac muscle
9. Growth of the limb in all axes
10. Development of the innervation and blood supply of the limbs
11. Regulation of limb morphogenesis
12. Developmental anomalies of the skeleton

Craniofacial Development:

A medical student should have a good knowledge of:

1. Components of a pharyngeal arch
2. Skeletal, muscular, and cranial nerve derivatives of the pharyngeal arches
3. Derivatives of the pharyngeal pouches
4. Derivatives from the pharyngeal clefts
5. Development of the thyroid gland
6. Development of salivary glands
7. The facial processes around the stomodeum and their fusion – clefts of the lip
8. The naso-optic furrow
9. The stomodeum and buccopharyngeal membrane
10. The primary palate
11. The development of the secondary palate through re-orientation of the palatal shelves (including molecular and cellular mechanisms) – palatal clefts
12. The existence of facial ectodermal placodes
13. The development of the optic sulcus, vesicle and cup

14. The development of the lens from the lens placode
15. Development of the choroid, sclera, ciliary body, and iris of the eye
16. Development of the aqueous chamber of the eye
17. Development of the cornea, optic nerve and eyelids
18. The otic placode and vesicle and development (early and late) of the internal ear
19. The primary epithelial band, vestibular band, and dental lamina
20. The bud, cap and bell stages of tooth development
21. The enamel organ, dental papilla and follicle of the tooth germ

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Role of retinoic acid in craniofacial development
2. Role of neural crest in development of the pharyngeal arches
3. The ultimobranchial body
4. Pharyngeal membranes
5. Lateral and median lingual buds, hypopharyngeal eminence and copula and tongue development
6. Development of the innervation of the tongue
7. Ectodermal-mesenchymal interactions during facial development
8. The nasal placodes and development of the nasal pits
9. The naso-oral membrane and primary nasal septum
10. Development of the paranasal sinuses
11. The common oro-nasal chamber
12. Mechanisms of fusion of the re-orientated palatal shelves
13. Histogenic events during palatogenesis
14. Development of the eye field

15. Molecular events and eye development
16. Development of the lacrimal glands
17. Patterning during development of the internal ear
18. Development of middle ear and the ossicles
19. Development of the external ear
20. Ectodermal-mesenchymal interactions during tooth development
21. The enamel knot (a signalling centre)
22. Amelogenesis (excluding enamel maturation) and dentinogenesis
23. Development of the tooth root from the epithelial root sheath (excluding cementogenesis and periodontal ligament)
24. Timing of tooth eruption

The following topics were found to be neither 'core' nor recommended for teaching:

1. Derivatives of the pharyngeal arch arteries
2. Development of the lingual papillae and taste buds
3. The nasal fin
4. Gene expression during internal ear development
5. Formation of the innervation and sensory cells of the internal ear
6. Morphogenic influences on the development of tooth types
7. Role of neural crest in tooth development
8. Cell signalling during tooth development
9. The reduced enamel epithelium and the gubernaculum
10. The process of tooth eruption and the mechanisms responsible for generating the forces of eruption
11. The resorption and shedding of deciduous teeth
12. Embryonic stem cells within the adult periodontal ligament and dental pulp

Skin development:

A medical student should have a good knowledge of:

1. Development of the epidermis and glands of the skin

The following items/topics were, at this stage, considered to be recommended for teaching but not 'core':

1. Development of dermis and hair
2. Development of nails
3. Development of mammary glands

DISCUSSION

The IFAA, in commissioning the development of core syllabuses for the anatomical sciences through its international educational programme (FIPAE), is committed to producing detailed syllabuses rather than adopt a 'broad brush' approach. There is however an awareness that any attempt to dictate what should, or should not, be taught by a team of experts, however distinguished, is doomed to failure. However, the principle agreed by the IFAA is that a core syllabus must be flexible and 'fluid' such that it is amenable to regular review and change as comments are received from interested parties, whether academic, scientific or clinical. Following the publication of the IFAA procedures for the development of core syllabuses (Moxham *et al.*, 2014), Berman (2014) criticised the procedures by questioning the international basis of the enterprise. Two responses to this criticism should be levelled. First, no national or local authority has the monopoly on wisdom or on the correct course of action to take for developing medical curricula. Second, on a political note, nationally or locally-derived syllabuses can always be accused of being developed by special interests that are self-serving; an accusation that is more difficult to make when the scale is international and all universities and medical

authorities wish to measure themselves according to international standards. A further criticism was that it is not possible to formulate a core syllabus 'democratically'. Taken to its logical conclusion, this argument is tantamount to suggesting that 'experts' have a right to dictate what is taught or not taught or, worse still, have the syllabus written inflexibly (i.e. in 'tablets of stone'). The IFAA's approach recognises the importance of the initial input of 'experts' to the formulation of a core syllabus but believes that there must be regular updating from the whole community of stakeholders (including anatomists, neuroscientists, clinicians, students and those politico-educational forces that often drive curricular change). Moreover, syllabuses must evolve over time as new material comes along and as old material ceases to be academically or clinically relevant. In this regard, a core syllabus has implications for the belief that medical education should be made more clinically relevant. This of course presupposes that there is a clear understanding of what can be considered core material within the medical syllabus.

However, the findings of the Delphi Panel are just the initial stage in the formulation of the core syllabus for the teaching of embryology and teratology to medical students. Indeed, even at this point the authors would welcome comments that will be passed to FIPAE for their consideration as the syllabus goes to the second phase of evaluation. It is during this second phase that the IFAA will compare its syllabus with that published in 2000 by Leonard *et al.* who did not employ Delphi processes and regular updates. Indeed, such a comparison will be instructive of how a syllabus can develop, as well as providing hints as to how the status of embryology in the medical curriculum might have changed in the past 16 years. In particular, more emphasis on teratology might be expected.

It should be borne in mind that using Delphi processes just as a survey methodology can lack rigor if this is the only stage employed in attempting to obtain consensus. However, it is often in the lack of consensus following a Delphi analysis that the interesting questions arise as the reasons for that failure to agree on a question or series of questions are explored. In the present survey, consensus across the panel was clearly evident for most, but not all, topics. Indeed, we were surprised at the exclusion of certain topics from the lists of core topics. In particular, the omission of much of the development of the skeletal system and the urinary and reproductive systems was unexpected. Furthermore, we did not expect embryonic stem cells and of issues relating to clinical reproductive biology (e.g. IVF) to be considered non-core. This matter can be related to the findings of a survey of the attitudes of European medical students to the clinical relevance of embryology assessed quantitatively using Thurstone and Chave analyses (Moxham et al., 2016). Although overall the attitudes were not unfavourable, they were not particularly favourable and much less favourable than for gross anatomy. It was concluded that the medical students needed to be made more aware at the start of their courses of the scientific and clinical importance of embryology and teratology and that one way of enthusing and motivating them was to highlight some of the controversial and ethical issues faced by society that relate to these disciplines. Consequently, discussions on such topics as embryonic stem cells, modern techniques for fertility treatment, cloning, and environmental (teratogenic) influences on the developing embryo and foetus can help motivate the students.

Finally, it must be asked: what is the purpose of a core syllabus? This question we raised in our paper on the core syllabus for neuroanatomy and our answer remains unaltered – “While recognising that it may be hard to obtain universal agreement on the details, a core syllabus should provides the minimum level of knowledge expected of a recently-qualified medical graduate in order to carry out many clinical procedures safely and effectively (thus to ensure that students are not overloaded with facts). The aim is to set standards not impose them. Thus, the core syllabus does NOT dictate WHEN or HOW the syllabus is delivered..... It certainly does not mean that ONLY core material should be taught and examined for the strength of a university system is that there are different schools of thought. However, it cannot be right that truly core material that represent international norms is not covered in a university’s/medical school’s curriculum” (Moxham *et al.*, 2015).

ACKNOWLEDGEMENT

The authors wish to thank all members of the Delphi Panel who, working under the principles of anonymity and confidentiality, assisted in the formulation of the first stage of development of the IFAA core syllabus for embryology and teratology.

REFERENCES

Berman AC. 2014. Anatomy of curriculum: Digging to the core. *Anat Sci Educ* 7: 326-328

Chirculescu ARM, Morris JF. (2008). The curriculum in anatomy for medical students: UK and Irish responses to the ASGBI questionnaire. *J Anat* 213: 348

Drake RL., McBride JM., Pawlina W. 2014. An update on the status of anatomical sciences education in United States medical schools. *Anat Sci Educ* 7: 321-325

Griffioen FMM, Drukker J, Hoogland PVJM, Godschalk M. 1999. General plan anatomy objectives of the teaching of anatomy/embryology in medical curricula in the Netherlands. *Eur J Morphol* 37: 228-325

Leonard RJ, Acland RD, Agur A, Blevins CE, Cahill DR, Collins JD, Dalley AF II, Dolph J, Hagedoorn JP, Hoos PC, Jones DG, Mathers LH, McFee R, Mennin SP, Negulesco JA, Nelson ML, Olson TR, Page DW, Pawlina W, Petterborg LJ, Price JM, Spielman JE, Younoszai R. 1996. A clinical anatomy curriculum for the medical student in the 21st century: Gross Anatomy. *Clin Anat* 9: 71-99

Leonard RJ, Hoos PC, Agur A, Gilroy AM, Lozanoff S, Nelson ML, Newman LM, Petterborg LJ, Rosenheimer J. 2000. A clinical anatomy curriculum for the medical student in the 21st century: developmental anatomy. *Clin Anat* 13: 17-35

McHanwell S, Atkinson M, Davies DC, Dyball R, Morris J, Ockleford C, Parkin I, Standing S, Whiten S, Wilton J. 2007. A core syllabus in anatomy – adding common sense to need to know. *Eur J Anat* 11: S3-S18

Moxham BJ, Plaisant O, Smith CF, Pawlina W, McHanwell S. 2014. An approach toward the development of core syllabuses for the anatomical sciences. *Anat Sci Educ* 7: 302-311

Moxham BJ, McHanwell S, Plaisant O, Pais D. 2015. A core syllabus for the teaching of neuroanatomy to medical students. *Clin Anat* 28: 706-716

Moxham BJ, Emmanouil-Nikoloussi E, Standley H, Brenner E, Plaisant O, Brichova H, Pais D, Stabile I, Borg J, Chirculescu A. 2016. The attitudes of medical students in Europe toward the clinical importance of embryology. *Clin Anat* 29: 144-150

Moxham BJ, Pais D. 2016. How optional should regional anatomy be in a medical course? An opinion piece. *Clin Anat* 29: 702-710

Orsbon CP, Kaiser RS, Ross CE. 2014. Physician opinions about an anatomy core curriculum: A case for medical imaging and vertical integration. *Anat Sci Educ* 7: 251-261

Smith CF, Finn GM, Stewart J, McHanwell S. 2016a. Anatomical Society core regional anatomy syllabus for undergraduate medicine: the Delphi process. *J Anat* 228: 2-14

Smith CF, Finn GM, Stewart J, Atkinson MA, Davies DC, Dyball R, Morris J, Ockleford C, Parkin I, Standring S, Whiten S, Wilton J, McHanwell S. 2016b. The Anatomical Society core regional anatomy syllabus for undergraduate medicine. *J Anat* 228: 15-23

Thurstone LL, Chave EJ. 1951. The Measurement of Attitude; A Psychophysical Method and Some Experiments with a Scale for Measuring Attitude Toward the Church. Chicago, Ill.: University of Chicago Press.

Tubbs RS, Sorenson EP, Sharma A, Benninger B, Norton N, Loukas M, Moxham BJ. 2014. The development of a core syllabus for the teaching of head and neck anatomy to medical students. Clin Anat 27: 321-330

Tubbs RS, Paulk PB. 2015. Essential anatomy of the head and neck: The complete Delphi panel list. Clin Anat 28: 423