

## Vertical Integration Group (VIG)—Genetics Final Report

To: The Medical Education Committee (MEC)

Committee Members:

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This task force has been charged with the review of current course work relating to all aspects of genetics and with making suggestions as to the integration of these topics across the curriculum. We have met on several occasions and have actively communicated through a website that was set up by Dr. Sobieraj to review and exchange materials. In addition to reviewing the current curriculum in the basic sciences and clinical clerkships, the Chair has made contact with several directors of genetics education at other medical schools to determine how and whether genetics is integrated in their curriculum.

Discussions were held and information was gathered from Harvard University, University of Alabama, and University of Vermont in reference to their genetics curricula. Harvard University and the University of Alabama do not have integrated curricula. The University of Vermont has started an integrated curriculum that is taught by systems during their first year introductory course. In their second year they have a course entitled “Generations” that include discussions of genetic concepts and content from preconception to old age. In addition they have a bridge curricula for two weeks during their third year that involve small groups that include genetics lectures.

As you know, the BUSM curriculum has been revised to integrate students learning around clinical concepts and content, reduce scheduled contact time, particularly lectures, and increase small group and independent learning as well as emphasizing professionalism/humanism. The BUSM Mission and Goals document contains several genetic content areas in which the graduate needs to demonstrate proficiency. Although some horizontal integration of the basic science of genetics exists, there are no proposals at present for integration into the four year curriculum of concepts and content in clinical genetics.

### **Our charge as outlined by Dr. Adrienne Rogers was as follows:**

- 1. Review and make recommendations about our four year curriculum relevant to clinical genetics**
- 2. What should our graduating students know and be able to do?**

**3. What do we teach them now?**

**4. What changes might be made in the curriculum content to achieve our goals?**

As we continue in the golden age of genetics we are cognizant that primary care physicians as well as medical and surgical specialists and sub-specialists will have significant exposure to genetics in their daily practice. Given the increased presence of genetics in the practice of our graduating students, we felt that it was important to propose specific “genetic goals” for the graduating BUSM student. We feel that the vertical integration of clinical genetic concepts and content throughout the four year curriculum will best allow the graduating BUSM student to achieve these goals.

**Proposed genetic goals for the graduating BUSM student:**

- A** Graduates should have basic knowledge in human genetics allowing them to read, understand, and interpret the general medical literature.
- B** Graduates should be able to obtain and update a relevant 3 generational family history appropriate to each medical setting.
- C** Graduates should understand the indications for a genetic referral.
- D** Graduates should be able to use genetic testing appropriately and appreciate the ethical, legal and societal issues involved in testing.
- E** Graduates should be able to understand and interpret the clinical relevance of genetic test results.
- F** Graduates should have familiarity with the specific standards of care in medical practice regarding genetic counseling and testing.

In order to ascertain what is taught throughout the four years in genetics at BUSM, we used a combination of the Curriculum Database as well as a manual review of multiple syllabi. A draft report was presented to the PCS (8/7/08) and CCS (9/9/08) and all members were asked to correct, amend, and contribute to the report. All corrections have been made and the feedback has been considered and integrated into this final report. We also reviewed the core competencies as compiled by the National Coalition for Health Professional Education and Genetics (NCHPEG). These core competencies in genetics helped to form a basis for the above genetics goals for our BUSM graduating students.

An extensive literature review only yielded a handful of useful references with regard to Genetics education for medical students. More has been published on Genetics education for primary-care providers and other health professionals. A list of these references is appended to this report. In a 2007 paper in *Academic Medicine*, Thurston et al reviewed the current status of medical genetics instruction in U.S. and Canadian medical schools. They found that all schools adequately covered the knowledge of genetic transmission,

molecular biology, and population genetics, but few integrate genetics into clinical training outside the pediatrics clerkships. They also found that most medical schools use case presentations in their curricula but did not find any that used standardized patients for genetics education. In addition, few discussed the integration of basic science and clinical medicine. What we describe later in our report as “teaching moments” were not widely implemented. The use of standardized patients, case presentations, and integration of basic science and clinical medicine and genetics education supported the AAMC’s report in June 2004. One example of further integration of genetics in medical school curricula is the University of Rochester School of Medicine and Dentistry (Robinson et al 2008). In their paper, they discussed a variety of methods, including problem based learning and the integration of specific clinical examples to explain medical genetic principles. Beyond integrating clinical examples and problems into the first two years, they also have three advanced basic science blocks at the end of the third year. Throughout the four years, they have genetics integrated into lectures, small group discussions, large group patient demonstrations, and problem based learning. In May 2009, Greb et al reported on the retention of medical genetics knowledge and skills by medical students. In their study, not only did third year medical students not retain medical genetics knowledge and skills learned in the first year, but most failed to apply basic genetic concepts to a common and routine clinical problem. This failure of application goes beyond strict memorization, but rather to a deeper understanding, or lack thereof, of basic medical genetics concepts. They concluded that medical schools need to integrate genetics curriculum throughout the continuum of the four years of medical school. Hence, this final report is very timely. The remainder of this report will summarize the current state of genetic teaching within our curriculum and will outline concrete changes with the identification of genetics teaching moments throughout the curriculum.

### **BUSM I/II (pre-clinical)**

There is a significant lack of clinical genetics content in the preclinical curriculum at BUSM. In addition to implementing the suggested teaching moments, formal integration of genetics into the learning objectives of each course/section is necessary. In 2008-09, BUSM II is now taught through a combined Disease and Therapy (DRx) course that effectively replaces the Biology of Disease, Microbiology, Pharmacology, and Pathology courses. Hence, the teaching moments (below) can be incorporated into the appropriate sections of the new course.

#### **Anatomy/Embryology**

##### Current

- Genetics content essentially absent
- No significant discussion of the etiology of congenital malformations, particularly in the context of the embryology unit

##### Teaching moments

- Discuss simultaneous development of organ systems establishing clinical links for the students (e.g. kidney and ear malformations)

- Introduce role of teratogens interrupting normal formation of organ systems (eg Valproate and neural tube defects)
- Introduce multiple examples of congenital malformations when discussing normal structures (e.g. cleft palate, omphalocele, hemi-vertebrae, horseshoe kidney)

## **Biochemistry**

### Current

- Good detail about the molecular biology of the gene with examples when particular processes go awry such as in mismatch repair in colon cancer, excision repair in skin cancer, loss of tumor suppressor genes in adenomas and carcinomas, oncogenes, apoptosis and cell cycle regulators in a variety of cancers.
- Molecular biology of the gene clinical correlations including skin cancer, retinoblastoma, breast cancer, Li Fraumeni syndrome, Rhabdomyosarcoma, colorectal cancer, GIST, sickle cell anemia.
- Enzymatic examples of Inborn Errors of Metabolism are given and there is a clinical correlation on hereditary porphyrias.
- Discussion of genetic disorders that reflect important biochemical/cell biology principles e.g. disorders of organelles such as Tay-Sachs disease and Gaucher disease, transport and trafficking disorders such as familial hypercholesterolemia.

### Teaching moments

- Add more clinical correlation and specifically discuss genetic disorders that reflect important biochemical/cell biology principles (e.g. disorders of organelles such as peroxisomes, mitochondria; more transport and trafficking disorders)
- Introduce newborn screening methodologies and clinical information concerning major detectable Inborn Errors of Metabolism
- In Molecular Biology of the Gene block, give additional examples of genetic disorders that occur when particular processes go awry (e.g. chromatin packaging disorders)

## **Biology of Disease**

### Current

- This was a very arduous course to review and required both Curriculum Database survey and a review of slides from many lectures
- Twelve out of an approximate 463 learning objectives have some genetic content
- There is very cursory coverage of genetics in several of the sections while it is essentially absent in other sections

### Teaching moments

- This course represents the major opportunity to discuss the genetics of each major organ system/disease
- Fuller integration of genetic information including pathophysiology, existence of susceptibility genes/polymorphisms, existence of carrier screening and diagnostic tests, along with therapeutic approaches need to be inserted in every section of this course
- Introduce web-based assignments using Clinical Genetic databases (eg OMIM, GeneTests) for several BOD sections (to prepare students for clinical years web-based assignments)

- Examples of teaching points will be provided to the course director of BOD divided per section (16 printed pages of Excel spreadsheet)

## **Endocrinology**

### Current

- Examples are given of genetic disorders such as Turner syndrome and Klinefelter syndrome as well as other disorders of sexual dysfunction and a mention of genetic factors contributing to diabetes
- No significant clinical information is given even about the relatively common genetic endocrine mediated disorders

### Teaching moments

- Augment learning objectives that already cover genetic diseases to require students be familiar with the effects of certain genetic mutations on endocrine function and human development
- Coordinate what is taught in this course with Medical Genetics and Biology of Disease
- Include a discussion of genetic factors in thyroid and parathyroid disorders and in calcium metabolism

## **Essentials of Public Health**

### Current

- Currently split between the fall of BUSM I and the spring of BUSM II.
- The block in the first year includes primarily medical ethics and human rights.
- Within the medical ethics block, the main concept introduced here is the principle of autonomy, which is of particular significance with reference to non-directive genetic counseling. The idea of liberty limiting principles may have some application with reference to doctor-patient privilege and sharing genetic results within families
- The human rights section includes discussion of freedom from discrimination, which includes genetic discrimination. Similarly, right to privacy has implications for genetic test results. Finally, health inequalities have particular importance in a field where the tests can be quite costly and insurance or patents/exclusive licensing of genetic tests limits access

### Teaching moments

- In the patient autonomy block introduce non-directive genetic counseling and discussion of the sharing of genetic results within families
- Similarly, in the reproductive rights block address confidentiality and genetic testing results that may influence both the patient and their family
- Introduce insurance discrimination, genetic patents and inequalities to access in genetic testing

## **Medical Genetics**

### Current

- A mostly basic science course with numerous clinical examples. Because of the ubiquitous nature of genetics in medicine, a single course cannot cover all clinically relevant applications of genetic principles, which leaves opportunity for

courses later in the curriculum to refer to genetic concepts from the BUSM I course.

- There is significant room for clinical correlation as well as case based learning in courses following the introduction of genetics in the spring of BUSM I. The Genetics course itself has numerous discussion-based cases as well as on-line cases.
- There appears to be a disconnect between what is learned in Genetics in the first year and how to apply the information in the clinical years so reference to these concepts throughout the curriculum is key.

#### Teaching moments

- Continue to inculcate clinical genetics within each of the basic science genetics lectures with clinical examples and details so that the students can readily apply the information in the clinical years
- Develop joint cases with the Biochemistry and Cell Biology course with part I introduced in the fall, focusing on biochemical and cell biological principles, and part II introduced in the spring, focusing on genetic issues
- Increase teaching by Clinical faculty

### **Histology**

#### Current

- Concepts of meiosis and mitosis and unequal crossing over introduced
- DNA dynamics in spermatogenesis/oogenesis discussed. However, no clinical correlations provided

#### Teaching moments

- In the chromosomal rearrangements and numerical abnormalities section include clinical details of common chromosomal aneuploidies and deletion syndromes in coordination with the Medical Genetic course
- Coordinate the introductory material in the Medical Genetics course where mitosis and meiosis are revisited with the histology course spermatogenesis/oogenesis as well as DNA dynamics

### **Human Behavior/Medicine**

#### Current

- The human sexuality lecture introduces Androgen Insensitivity syndrome and congenital adrenal hyperplasia
- There is no formal mention of genetics in terms of the death and dying topic
- No mention of genetic counseling

#### Teaching moments

- As child development is discussed, add a discussion of genetic factors involved in delayed development including criteria for referral for a clinical genetics evaluation
- Introduce the concept of genetic counseling and its role in the stages of grieving in the context of a genetic diagnosis

## **Immunology**

### Current

- Good discussion of genetic phenomena including somatic hypermutation and VDJ rearrangement
- Case discussions are included for X-linked hyper IgM syndrome and leukocyte adhesion deficiency
- Immunodeficiency topic that is covered is also relevant to genetics

### Teaching moments

- Expand the genetic aspects of autoimmunity
- Expand the immunodeficiency topic to include genetic pathogenesis and gene therapy strategies (e.g. WAS, SCID)
- Discuss genetic susceptibilities to various infections (e.g. HIV; complement disorders)

## **Introduction to Clinical Medicine/Integrated Problems**

### Current

- Several cases have the potential for active discussion involving genetic etiology in IP course

### Teaching moments

- In each case expect an active discussion involving the genetic etiology, along with diagnostic testing and therapies if available
- On a case by case basis, discuss the indications for a genetic referral
- Emphasize the collection and importance of a three generational family history in each case discussed

## **Microbiology**

### Current

- There is a discussion of host factors that might limit antibiotic choice
- There is no significant discussion of genetic issues

### Teaching moments

- Discuss the genetic differences in drug metabolism in the principles of antibiotic therapy
- Reiterate the concept of differences in susceptibility and severity to infections due to specific genetic factors (e.g. TB and HIV)
- Discuss interpretation of genetic testing in reference to infectious disease
- Integrate genetics into discussion of the “integrated case discussions”

## **Pharmacology**

### Current

- There is one lecture on pharmacokinetics that mentions genotype-phenotype correlation
- There are a smattering of references to metabolism related to genetic issues such as slow acetylators
- There is no specific lecture on pharmacogenomics

### Teaching moments

- Introduce role of genetic factors or genetic mechanisms influencing pharmacological responses
- Integrate pharmacogenomic information into appropriate lectures on drug classes (specifically discussing what is currently available; eg polymorphism testing for Warfarin)
- Discuss potential for personalized medicine based on genomic data

### **Pathology**

#### Current

- More significant teaching is present in regard to important genetic concepts including inheritance patterns, genotype/phenotype relationships, cancer genetics, chromosomal anomalies, immunodeficiency, susceptibilities, and metabolic disorders

#### Teaching moments

- Link the discussed genetics concepts to clinical scenarios to enhance learning
- Discuss what is currently available in terms of cancer genetic testing and targeted therapies (during Hematology lectures)
- Review identification of genetic disease and link it to referral for genetic counseling (especially during molecular pathways on neoplasia, early identification/screening for colon cancer, and cytogenetics)

### **Physiology**

#### Current

- There is some discussion of genetics in the physiology of specific types of human disease, but again no significant clinical correlation

#### Teaching moments

- Coordinate what is taught between faculty members who give lectures on similar aspects of genetic diseases in the Medical Genetics course
- Discuss specific genetic diseases included in the differential diagnosis of specific symptoms that are mentioned (eg anemia, cardiac arrhythmias)
- Provide more significant clinical correlation and discuss the potential for genetic abnormality within each physiologic system

### **Psychiatry II course**

#### Current

- Genetics is not part of their learning objectives
- Genetics is mentioned as a risk factor for various diseases including alcohol abuse, bipolar disorder, and schizophrenia
- There is no significant detail provided in reference to the importance of genetics in Psychiatry

#### Teaching moments

- Provide a discussion of some genetic disorders in which mental illness is prominent (e.g. Velocardiofacial syndrome, X chromosome aneuploidy)
- Include genetics as part of their learning objectives

- Discuss the psychiatric co-morbidity that may accompany genetic disorders

### **BUSM III/IV (Clinical)**

There is no formal genetics curriculum in Medicine, Emergency Medicine, Geriatrics, or Radiology Clerkships. Genetics is mentioned in some cases covered in Surgery, Psychiatry, and the Neurology Clerkship. There is some genetic content in the Family Medicine learning objectives with some case discussions. Pediatrics and Obstetrics have the most genetics content with lectures, cases, web based learning, and genetics embedded in their learning objectives.

Although many opportunities exist, there is a lack of formal clinical genetics curricula within any of the clinical clerkships except for Pediatrics and Obstetrics. Combined with the apparent lack of clinical genetic content in the preclinical years, our BUSM graduates are currently not adequately prepared in genetics to best care for patients.

A major recommendation includes the establishment and expansion of web-based teaching (with cases) throughout all of the clerkships. Although online modules may take time away from students' other work, it was felt that well-constructed online modules might be an efficient way to add teaching on genetics. Specifically for Clinical Genetics, this could best be accomplished by creating a website that holds all clinical modules and links to useful genetic websites. The completion of a certain number of modules per clerkship would be a suggested requirement. In terms of resources, each clerkship director would need formal assistance (from medical genetics specialists) to design and implement the appropriate web-based cases. It was noted by the CCS that genetics is ever-changing, and the modules would have to be updated constantly. Our general feeling is that the basic modules created would not need significant modification, but could be reviewed, changed, and added to every few years. Examples of sample modules appear below:

#### Emergency Medicine

- Early stroke (Factor V mutation)
- Fever of unknown origin (Familial Mediterranean Fever)
- Multiple fractures (OI)

#### Family Medicine

- Factor V and Prothrombin testing
- Genetic issues in prenatal testing
- Testing of children

#### Geriatrics

- Fragile X tremor ataxia syndrome
- Warfarin susceptibility testing

## Medicine

- Coronary artery disease
- Hemochromatosis
- Hypertension
- Thromboembolism

## Neurology

- Charcot-Marie-Tooth disease
- Early Alzheimer's
- Huntington disease

## Obstetrics

- 1<sup>st</sup> and 2<sup>nd</sup> trimester maternal serum screening
- Endometrial cancer
- Infertility
- Preconception counseling
- Ultrasound abnormalities

## Pediatrics

- Developmental delay
- Fragile X
- Hyperbilirubinemia
- Multiple congenital anomalies

## Psychiatry

- Pregnant patient on teratogenic psychiatric medications
- Velo-Cardio-Facial syndrome and schizophrenia

## Surgery

- Breast cancer
- Congenital hearing loss (ENT)
- Colon cancer
- Omphalocele associations (Pedi Surg)

## Radiology

- Agenesis of the corpus callosum
- Skeletal dysplasia
- Vertebral anomalies

Two additional teaching modules are also recommended, the first in Pediatrics (congenital anomalies) and the second in Obstetrics (family history).

For Pediatrics, the new module would integrate learning basic dysmorphology in the Nursery rotation (taught by the trained Nursery staff). This module would emphasize the

characterization of major and minor anomalies with examples, perhaps with a checklist of 10 minor dysmorphic features (eg clinodactyly, syndactyly, etc).

In Obstetrics, a formal review and teaching of how to take and interpret a three generational family history would be taught by antenatal Genetic Counselors.

Two additional suggestions to maximize the clinical genetic impact on the BUSM curriculum would be to introduce a clinical genetics OSCI and a day in the 4<sup>th</sup> year during which students can learn what are the basic standards of care regarding genetics throughout the specialties and primary care. This “standard of care day” could be expanded to include other specialties. There needs to be a recognition by our graduates of the evolving standards of care especially in terms of the fast moving subject of genetics.

In light of the new curriculum at BUSM with changes in design and delivery of courses and a new timeline for teaching and learning across the four years, we have made concrete suggestions to vertically integrate genetics in an attempt to have our graduates achieve the aforementioned genetic goals and best care for patients.

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