Breast Cancer in the Age of Personalized Medicine: An Inquiry Module for Undergraduates

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ABSTRACT
Rapid and relatively inexpensive sequencing of the human genomes combined with remarkable progress from genome-wide association studies inspired a new era of human genetics and personalized medicine. The potential for genetics and genomics to provide novel paradigms for preventing, diagnosing, and treating human disease in the clinical setting is imminent. Therefore, training undergraduates to apply and evaluate scientific and ethical issues of personalized genomic medicine is necessary for the development of an informed citizenry and well-trained future clinicians. We designed a semester-long experimental proof-of-principle inquiry module thematically centered on the concept of personalized medicine. The module was implemented in the context of an upper-division majors molecular biology course using a cooperative learning approach. Students analyzed the transcriptome of biopsied human breast cancer tissue using DNA microarrays and compared the molecular profile to clinical pathological data. They were given the challenge of determining a molecular diagnosis and prognosis for the patient. Students correlated the MammaPrint gene list, developed as a diagnostic tool to predict the risk of breast cancer metastasis using the expression of 70 genes, to underlying mechanisms of tumor cell progression and metastasis (Tian, 2010) and created a predictive model for tumor progression using a system biology framework. Using their gene expression profile and biomarkers for tumor progression, students successfully and reproducibly subtyped breast tumors as ER+/- and/or HER2+/- and BRCA1-2 +/- . In addition, students reproducibly correlated the expression of key tumorigenesis genes (TP53, RB1, MYC, JUN, et al) based on pathological data. Surveys designed to measure the extent to which the module facilitated student’s understanding of personalized medicine and pathological data.  Students successfully and reproducibly created a predictive model for tumor progression using a system biology framework. Using their gene expression profile and biomarkers for tumor progression, students successfully and reproducibly subtyped breast tumors as ER+/- and/or HER2+/- and BRCA1-2 +/- . In addition, students reproducibly correlated the expression of key tumorigenesis genes (TP53, RB1, MYC, JUN, et al) based on pathological data.

QUESTION
Are upper division students and graduating majors prepared to critically evaluate the complex interaction between scientific research, society, and ethics surrounding personalized medicine?

COURSE BACKGROUND
BIO378: Molecular Biology
Enrolls juniors and senior majors, Biology and Biochemistry/Molecular Biology, Premed
Prerequisites: Genetics and Organic Chemistry

COURSE DESIGN & ELEMENTS
Lab challenge: breast cancer subtyping
Clinical Pathological Data
Stage 2, LuminB, 5x1.5x1.5 cm, no metastasis
Sample from human patient
Subtype tumor based on gene expression profile
Role play: determine genomic diagnosis, prognosis; recommend personalized treatment

Weeks 1-9 Objective: Develop technical proficiency in genomics experimentation and molecular techniques
Eberwine Method

Weeks 10-13 Objective: Statistical Analysis and Modeling
1. Tumor Subtype and Diagnosis
2. MammaPrint Prognostic Signature

Weeks 14-16: Synthesis and connection to society
Promises of personalized medicine: hope or hype?
1. Scientific Poster Session (see examples)
2. Role Play - Oral Presentation
Random selection of target audience from general public to scientific
Kindergarten Students
Parents
Best Friend (mom with breast cancer)
Cast of Jersey Shore
Susan G. Komen Race for the Cure Participants
Thesis Committee
Program Officer
Producers of Oprah Show
Pharmaceutical Executives

3. Emperor of All Maladies and faith integration discussion – how do the values of a society shape how cancer treatment is pursued?

COURSE ASSESSMENT
Significant learning gains in the following:
1 = no progress; 5 = exceptional progress

Objective | Score
---|---
Gaining factual knowledge | 4.5
Learning fundamental principles | 4.5
Applying course material to improve thinking, problem solving and decision-making | 4.6
Developing skills and competencies needed by professionals in field | 4.8
Working with others in a team | 4.5
Analyzing and critically evaluating ideas, arguments, and points of view | 4.4
Learning more by asking questions | 4.5
Developing creative capacities | 4.3
Overall Experience | 4.7

FUTURE DIRECTIONS
Next Generation Sequencing