**Improving diversity in genomics/microbiome research: designing and testing an experiential education approach**

**I. Specific Educational Aims:**
a) To encourage collaborative, interdisciplinary, hands-on genomics research that partners with an understudied community.
b) To highlight existing gaps in inclusivity of genomics research, and to engage students in an active scientific project that promotes diversity and inclusion in microbiome research.
c) To mobilize students from varied ethnic, cultural and educational backgrounds to develop tools/resources that engage non-college educated, lay community members from historically understudied communities in understanding their microbiomes.

**II. Project Rationale:** Biomedical sciences, in general, and human microbiome studies, in particular have focused on a subset of individuals, predominantly those living in high income settings (Turnbaugh et al., 2007). This unfortunate pattern has repeated itself in scientific research in several occasions. For instance, for a long period of time a vast majority of research on model animals utilized only males. Also, there has been vast underrepresentation of minority populations in nearly all published genomics research. It is imperative we broaden efforts to sample and test understudied populations to understand if these patterns hold. To do so, researchers at Stanford University are collaborating with the H3Africa Genomics consortium to study of the human microbiome of the African continent. This will help to establish the level of generalizability of current findings in human microbiome.

**III. Approach:** Learning about the human microbiome, its research and applications in the classroom often emphasizes theoretical concepts that may be hard to connect to everyday experience. Hands-on research projects help make that connection. Project-based science allows students to apply classroom learning in non-academic settings where they engage with problems of everyday importance and local relevance, ask and refine questions, develop and revise study designs, and engage deeply with results. This process not only allows students to choose science activities that match their career interests and definitions of science (Bouillion 2001, p.887). When students find education to be empowering and transformative, they are likely to embrace and further investigate what they are learning (Bouillion 2001). Additionally, the National Research Council states that "partnerships between science-rich institutions and local communities show great promise for structuring inclusive science learning across settings, especially when partnerships are rooted in ongoing input from community partners" (Freire 2000**).** This collaborative strategy engenders a sense of agency in the research experience, for both students and community members, and the development of principled social relationships.

In this project, we will incorporate a hands-on diversity and inclusion project into GENE208, a spring quarter, 3-unit graduate course that is taken by Stanford undergraduates, graduate students, professional students and post-doctoral fellows. The course will be given for the third time in Spring 2018 and is co-taught by Profs. Falkow, Bhatt, KC Huang, and Sonnenburg. In this project, students will leverage stool samples collected under an IRB-approved protocol by the Bhatt lab in collaboration with colleagues at the University of Witwatersrand (Johannesburg, South Africa) and the INDEPTH consortium. The specific approach is outlined below:

**1) Microbiome wet-lab:** Students will perform hands-on extraction of DNA and sequencing library preparation in the Bhatt lab. Samples will then be sequenced and data will be provided to the students.
**2) Hands-on computational work:** Students will be set up with a compute cluster account at Stanford and will go through a practical set of exercises to perform taxonomic and functional analysis of the data.
**3) Design-inspired lay educational resource development:** They will then work with members of the community engagement team at Stanford to develop methods to report results back to community participants in the two field sites in Agincourt and Soweto, South Africa.

**4) Developing a survey tool:** Patient engagement experts will be engaged to develop an evaluation of the efficacy of these materials in communicating basic and advanced scientific concepts.
**5) Testing the impact of the lay educational resource:** A post-doctoral fellow in the Bhatt lab with experience in community engagement and microbiome research will design all aspects of the project with mentorship from Ami Bhatt (Genetics, Medicine), Lisa Goldman-Rosas (Population Health Sciences, Community engagement), and others.

**IV. Timeline and plan for implementation:**

| **Activity** | **Oct – Dec 2017** | **Jan – Mar 2018** | **Apr – Jul 2018** |
|---|---|---|---|
| Complete collection of stool samples from South Africa and transport to Stanford | X | | |
| Post-doctoral fellow guides curriculum development for GENE208 hands-on project | X | X | |
| Develop pre- and post-study evaluation tool for assessing student's self-assessed understanding of and prioritization of diversity in research | X | X | |
| Deliver curriculum (lecture based) | | | X |
| Deliver curriculum (hands-on) – wet lab portion in April over two course periods; sequencing returned in mid-May; sequencing analysis over three course periods in May – June. | | | X |
| Develop microbiome "reports" for community participants | | | X |
| Test impact of the community participant microbiome reports (July 2018 – K. Andrade to travel to South Africa) | | | X |

**V. Anticipated work product:**
We will generate a curriculum for hands-on microbiome research that will encourage students to personally engage in improving diversity of representation in genomics results. The curriculum will be formally evaluated for its ability to achieve its stated objectives and a manuscript will be prepared describing the curriculum and its performance. Furthermore, a community-oriented, lay "microbiome report" format will be generated and tested.

**VI. Evaluation plan:**
We will evaluate the success of this project based on two criteria:
1) The ability to improve student understanding and prioritization of diversity in biosciences research based on exposure to a hands-on curriculum. We will use a pre- and post- intervention survey, which will be developed for this purpose.
2) The ability to engage community participants in genomics research regarding their stool microbiome.
We will judge the project to be a success if we are able to improve student appreciation of the importance of diverse representation within research samples/subjects and we are able to deliver and test the efficacy of a community-oriented educational document.

**VII. Dissemination of results:**
We will disseminate these results both on a publically accessible website as well a manuscript that describes the educational intervention and results. The actual DNA sequencing results that are generated will be included in the larger analysis of an ongoing H3Africa/Stanford collaboration that will focus on identifying associations between the extremes of body mass index and the microbiome.

If funded, this project will support lifelong learning by connecting the classroom with real-life experience and promoting a sense of agency among student as they recognize themselves as important actors in the scientific process. This is particularly important for students of underrepresented backgrounds, who often struggle with feeling that science is incompatible with their lives and of their communities (O'Fallon 2002, Jackson 1982).

**VIII. Budget and Justification:**

| | Item | Justification | Amount |
|---|---|---|---|
| Compensation | | | |
| | 0.1FTE Post-doctoral fellowship salary (Karen Andrade, PhD) | Post-doctoral fellow's time to develop curriculum for Spring quarter Microbiome course (guided by mentors from the Population Health Sciences Group, Community engagement group at the School of Medicine, Genetics, and Medicine) | $7,040 |
| | | **Total compensation:** | **$7,040** |
| Non-compensation | | | |
| | Access to advanced computer graphics software (such as Adobe Illustrator) through purchase of a CMGM license | For course participants to design and produce materials for community engagement (for dissemination and testing in 2 South African field sites) | $1,000 |
| | Round-trip travel for post-doctoral fellow to South Africa | Funds for round-trip economy airfare, hotel and meals for post-doctoral fellow to South Africa to disseminate project results and test efficacy of communication methods developed by the course participants | $2,900 |
| | Taxi/bus vouchers and lunch for 40 study subjects x $25 | Funds to support lunch and ground travel (bus/taxi) costs for South African study subjects to participate in evaluation of the test educational materials | $1,000 |
| | Library preparation and sequencing costs for 40 samples | Molecular biology supplies for DNA extraction, sequencing library preparation ($100/sample) and multiplexed shotgun DNA sequencing ($200/sample) for 20 samples. | $6,000 |
| | Compute storage and fair-share compute use costs | Access to a dedicated node in the Sherlock compute cluster for class participants for hands-on microbiome data analysis | $2,000 |
| | | **Total non-compensation:** | **$12,960** |
| | | **Total request:** | **$20,000** |

**References:**

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