Bioengineering & Genetics Homework Problem (Draft)
Genetics & Race

Companies like 23andme and AncestryDNA provide direct to consumer genetic testing that uses single nucleotide polymorphism genotyping to generate reports including the prediction of ancestry.

a) How does Genotyping differ from DNA Sequencing?
b) Starting with the collection of the saliva sample diagram the steps need to analyze a sample for SNPs. Highlight techniques and specific molecular interactions we have discussed in the process.

In order to do ancestral analysis, segments of a person's DNA are compared to a database of DNA from people who are representative of 45 different geographic populations. Probabilities are assigned for the ancestry of each individual segment and then they are taken together to define an overall ancestry composition. 23andme claims that they are able to predict that a piece of DNA comes from a specific reference population with an accuracy of greater than 90% accuracy. The relatively high degree of ancestral geographic predictive ability of this type of DNA analysis can lead consumers to believe that there is a higher degree of genetic similarity within these than across them.

To try to understand the genetic differences both across and within a geographic ancestral population, let's begin by thinking about one specific segment of hypothetical DNA. At this locus within the genome, there are 6 different alleles that have been identified.

c) What would a possible distribution of the prevalence of the individual alleles look like for 3 regions if the presence of the allele was 100% predictive of ancestral population?
d) What would a possible distribution of the prevalence of the individual alleles look like for 3 regions if there was no variation between different geographic populations?

The actual distribution of the potential alleles looks more like the below figure (based on data from Rosenberg 2011). In this graph, we can see variation in allele distribution both within and across populations.

e) How does the above graph support or refute a claim that there is genetic variation between geographic regions? What does it say about genetic variation within a given region?
f) Use the analysis in Rosenberg 2011 to explain how even with the variation of distribution of alleles within a given ancestral region, an individual's ancestral lineage becomes more predictable as the number of different loci increases.

Any two humans share 99.9% of their DNA, which means that 0.1% of human DNA varies between individuals. Studies find that, on average, 4.3% of genetic variability in humans (4.3% of the 0.1% of the variable portion of human DNA) occurs between the continental populations commonly associated with US census racial groups (i.e., Africa, Asia, Pacific Islands, and The Americas, Europe). In contrast, 95.7% of human genetic variation (95.7% of the 0.1% of variable portion of human DNA) occurs between individuals within those same groups (Rosenberg, 2011; Rosenberg et al., 2002). Thus, if we randomly pick two individuals from two different continental groups and compare them with two randomly picked individuals from the same group, we can expect that the former will be 4.3% more different from one another than the latter (Donovan, 2015a). These findings undermine the idea of intraracial uniformity because they show that people of the same group are different in their variable DNA. (Donovan 2019).

g) *[Author note: I need one more question (at least) here to wrap things up a bit. To connect the differences within and across groups with the false assumptions made on the genetic basis of differences between different region groups (often with race used as a proxy).]*

References & Citations

1. Question based on the framework provided by Donovan, B. M., Semmens, R., Keck, P., Brimhall, E., Busch, K. C., Weindling, M., ... & Salazar, B. (2019). Toward a more humane genetics education: Learning about the social and quantitative complexities of human genetic variation research could reduce racial bias in adolescent and adult populations. Science Education, 103(3), 529–560. https://doi.org/ 10.1002/sce.21506 D
2. Rosenberg, N. A. (2011). A population-genetic perspective on the similarities and differences among worldwide human populations. Human Biology, 83(6), 659–684. https://doi.org/10.3378/027.083.0601

Other resources

1. Race: the power of Illusion - https://www.racepowerofanillusion.org/resources/
2. Toolkit: Race, Ethics, and Justice in Genetics - https://docs.google.com/document/d/1PucJEKE4I-joU_aTayxBcCzR5wbodhas7xFlJQ49clM/edit#
3. The biology of Skin Color - https://www.biointeractive.org/classroom-resources/biology-skin-color
4. Beckwith et al Using Dialogues to Explore Genetics, Ancestry, and Race. The American Biology Teacher (2017) 79 (7): 525–537. https://doi.org/10.1525/abt.2017.79.7.525

5. Hales. Signaling Inclusivity in Undergraduate Biology Courses through Deliberate Framing of Genetics Topics Relevant to Gender Identity, Disability, and Race. Life Science Education. (2020) 19 (2). https://doi.org/10.1187/cbe.19-08-0156
6. Hubbard (2017). Teaching Race (Bioculturally) Matters: A Visual Approach for College Biology Courses. The American Biology Teacher (2017) 79 (7): 516–524. https://doi.org/10.1525/abt.2017.79.7.516