When Will We All Be Black, And What Will We Look Like?

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Abstract

Because one is defined as black if either parent is defined as black, the entire population will eventually be black if there is any interracial mating. In the United States, this would occur in 500 years with random mating, or 2500 years with the present assortative mating practices. The model of four loci controlling pigmentation provides that at that time the number of pigment genes in an individual will obey the binomial distributuion with p=.125 and n=8, so that approximately .34 of the population will have no pigment genes, approximately .39 will have one pigment gene (octoroons), approximately .20 will have two pigment genes (quadroons), .06 will have three pigment genes, about .01 will have four pigment genes (mulattos), and about .001 will be darker. But populations have transitioned from pigmented to unpigmented and vice-versa in 2,500 years, so mutation, migration, and selection may impact what we look like when we are all black.

Keywords: human pigmentation, pigment selection, race

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1. Introduction

The diversity of human pigmentation from around the globe is one manifestation of the diversity of human genetics which has been poured into the American melting pot. Pigmentation has arisen and been lost many times around the globe, with different etiologies associated with different occurences [Jablonski and Chaplin 2017; Sturm 2008; Parra 2007]. There are selection arguments for the variation, but they do not provide a full explanation [Jablonski and Chaplin 2017]. Although pigment genes are generally semi-dominant, culturally pigmentation is treated as dominant, with the child of a black individual being classified as black without consideration of the amount of pigment that is manifested. This provides an interesting variation on the interaction of biological and cultural evolution.

The present work models what would happen to pigmentation in the United States based on the present racial composition of the Unites States. It first answers the question of when we will all be culturally (pedigree) black, and then discusses the pigmentation distribution at that point in time. The possible impact of mutation, migration, and selection on the result in then discussed.

2. When will we all be black?

The model entails a population of fixed size N, with n blacks in the population (n will change with time). Under random mating, the increment in the number of blacks each generation is given by

$$\Delta n = N((n/N)^2 + 2(n/N)(1 - n/N)) - n = n(1 - (n/N))$$

which reflects that progeny of two blacks (relative frequency $(n/N)^2$) or a black and a non-black (relative frequency $2(n/N)(1 - n/N)$) will be black. This is the standard logistic equation where the malthusian parameter $r = 1$ and the carrying capacity $K = N$. It is also equivalent to equation (5) in Chang (1999), since this is an example of pedigree inheritence. The solution to the continuous approximation differential equation $dn/dt = n(1 - n/N)$ is $n(t) = N/(1 + (N/n_0)e^{-t})$.

If mating is not random, we can model that s among the blacks and non-blacks mate with their own type and $(1 - s)$ mate at random. This will change the difference equation to

$$\Delta n = N(s(n/N)+(1-s)((n/N)^2+2(n/N)(1-n/N)))-n = (1-s)n(1-(n/N))$$

. This will change the differential equation to $dn/dt = (1-s)n(1-n/N)$, which has the solution $n(t) = N/(1+(N/n_0)e^-(1-s)t)$. Time is just rescaled by a factor of $(1-s)$.

The estimated 2016 population based on the 2010 census is 323,127,513, so 320,000,000 is a reasonable value to use for N. Thirteen percent of that population were African American, so 40,000,000 is a reasonable value to use for n. The logistic equation only asymptotically approaches 320,000,000, but in 22 generations n will be within 1 individual of 320,000,000. With a generation time of about 23 years, this will occur in half a millennium (500 years). In 2015, about 13% of the population was African American, and about 18% of their marriages were interracial. This provides a value of s of about .8 so that $(1-s)$ is about .2, which will increase the time until we are all black about five-fold (to 2500 years). Of course, if all African Americans married outside their race, their number would double every generation and in three generations they would increase from one-eighth of the population to the entire population and we would all be black. And if $s = 1$, the number of blacks would not increase.

3. Remark on common ancestors

Chang noted that the rate of increase will have little variation (be essantially deterministic) once the descendant class is large (blacks in this context). Hence the estimates of 500 and 2500 above should be fairly precise, if the assumptions of the model are true. For $s = 0$, the time until the population has a common ancestor (which could be black or non-black) is 653 years, and the time until every ancestor is a common ancestor is 1155 years. If s is indeed selfing, The expected growth of ancestral classes will will be multiplied by $1-s$, and the variation will also be multiplied by $1-s$ so the growth (increase?) of descendant classes will still be essentially deterministic and the expected time until a common ancestor for $s = .8$ will be 3265, and the expected time until every ancestor is a common ancestor will be 5779. If s=1, this analysis gives an infinite expected time, because the black pedigree cannot penetrate the white pedigree. Rather, the fluctuation of the two subpopulation sizes in accordance with the Poisson progeny distribution [Crow and Kimura 1970, p.431] will determine when one subpopulation will become fixed (which subpopulation will already have a common ancestor). The expected time until the black subpopulation becomes fixed, hence until the there is a black common ancestor (conditioned on the black subpopulation becoming fixed) is 1.38×10^{10} years, and the time until the white population becomes fixed, hence until there is a white common ancestor (conditioned on the white subpopulation becoming fixed) is 4.37×10^{9} years. Weighting these by the probabilities of fixation yields 5.55×10^{9} years.

will still be

4. What will we look like then?

There is some evidence that there are four major loci controlling pigmentation in the African population [G. S. Barsh 2003]. This is consistent with the classical terminology of mulatto, quadroon, and octoroon. Indeed this is an oversimplification, but it will give some indication of what may occur. Many African Americans have less than the full pigmentation of their ancestors due to outbreeding, but there are also many individuals with lighter pigmentation of Asian, Amerindian, or other origin which will contribute to the pigmentation of the population.

The model we employ is that pigmentation is determined by four additive loci of equal weight. The initial condition is that one-eighth of the population carries 8 pigment genes, while seven eighths of the population carries no pigment genes. After thorough admixture, everyone will have on average one pigment gene, with the actual number of pigment genes governed by the binomial distribution ($B(8, .125)$) This would provide that 34% of the population would have no pigment alleles, 39% would carry one pigment allele (octoroons), 20% would carry two pigment alleles (quadroons), 6% would carry three pigment alleles, 1% would carry four pigment genes (mulattos), and only .001 would be darker. Skin color is independent of other racial characteristics, so one could still see the facial shape of African Americans in many members of the population including light skinned individuals. If there were more loci, there would be less variation from the octoroon shade.

5. Effect of mutation, selection, and migration

The time frame for everyone having African ancestry under current assortative mating (2500 years) is also the time frame in which pigmentation has been acquired or lost in poulations in the past [Wikipedia: Human Skin Color]. For Example, England was populated by dark skinned individuals 10,000 years ago [New Scientist Daily News 2018]. The lighter skin tone may have been introduced when the beaker people replaced 90% of the genetic material in England 4500 years ago [M. Kennedy 2018], hence it may be inappropriate to model the genetic composition of this population based solely on mutation and selection. Because pigmentation has been acquired or lost independently in different populations, we can assume adequate mutation occurs for genetic change. But because pigmentation is different shades in Africa, Asia, and the Americas, we can assume that what mutations occur restricts the possibilities for evolution.

Selection favors an appropriate skin tone for the solar exposure. Near the equator, dark skin is favored to prevent danger from radiation, but near the poles light skin is necesssary to allow vitamin D synthesis [Parra 2007]. How important skin color has been, and why it is important can be debated [P.M. Elias, G. Menon, B.Wetzel, and J. Williams 2010], but modern practices of clothing/indoor living and vitamin supplements may make selection less important than it was in prehistory.

Without selection, lack of migration would allow establishment of populations with different skin pigmentation by drift, and indeed this has facilitated the establishment of populations in the past. But greater migration today allows an essentially panmictic population. Assortative mating due to choice rather than geography will be necessary to maintain or establish races. Heterozygosity for a random mating population is reduced to approximately $(1-s)$ (actually $\frac{1-s}{1+.5s}$) of the panmictic level where s of each genotype mate only with their genotype and $(1-s)$ mate randomly. Hence a high degree of assortative mating is necessary to make heterozygous genotypes rare (most individuals homozygous).