BIOLOGY 121 Practice worksheet

TOPIC: HARDY-WEINBERG EQUILIBRIUM

1. The table below shows the genotypic frequencies of *A/A*, *A/a* and *a/a* individuals in three human populations. “*A*” and “*a*” are two alleles of a gene coding for a protein involved in brain development (specifically, the trigeminal nerve).
People who are heterozygous or homozygous *A/A* have one or more symptoms related to ACHOO syndrome, a very common condition whereby a person has the urge to sneeze upon sudden exposure to bright light (you may have ACHOO too!).

Population #	Frequency of A/A	Frequency of A/a	Frequency of a/a
1	0.33	0.34	0.33
2	1.00	0.00	0.00
3	0.04	0.32	0.64

a) For each of the populations below, calculate the frequency of allele “*A*” and allele “*a*”.
Calculation needs to be included for each population (freq A allele = (2*freq A/A individuals + freq A/a individuals)/2, and freq a allele = 1-freq A allele).
Pop 1: freq A = 0.5 and freq a = 0.5
Pop 2: freq A = 1 and freq a = 0
Pop 3: freq A = 0.2 and freq a = 0.8

b) Determine which of the populations is/are in Hardy-Weinberg equilibrium, showing all your calculations.
Steps necessary:
- use frequencies of A and a determined in part a)
- calculate expected genotype frequencies under HWE→ expected freq A/A = freq A * freq A, expected freq A/a= 2* freq A *freq a, expected freq a/a = freq a * freq a
- compare expected frequencies of each genotype to the frequencies of genotypes in the populations, reported in the table
- make a decision

Pop 2 and 3 are in HWE, pop 1 is not (too many A/A and a/a, too few A/a compared to what is expected for those allele frequencies).

c) A dictatorial government with a constantly sneezing leader takes power in the country where Population 1 lives. Under the new regime, people who do not have ACHOO syndrome (that is, the *a/a* individuals) are considered non-human and are deported to an isolated tropical island, and no *a/a* individuals are allowed into the country.

i) What will be the allele and genotypic frequencies in the remaining (non-deported) population?
Frequency of A allele = (0.33*2+0.34)/(0.33*2+0.34*2)= 0.746
Frequency of a allele = 1- frequency of A allele = 0.254

Don’t like to work with frequencies? No worries:
To calculate the new frequencies after the removal of the non-ACHOO people we proceed like in any other situation: we do “how many A alleles there are” divided by “the total number of alleles” in the population. If you find it easier to work with number, pretend that the population has 100 individuals; 33 are AA, 34 are Aa and 33 are aa and get deported.
So, after deportation we are left with only 67 people: 33 AA and 34 Aa.
Proceed to calculate allele frequencies from these numbers and you’ll get the correct results.

ii) Will this population be in Hardy-Weinberg equilibrium?

Show all your logic.
No: the expected frequencies of the A/A genotype in a population where the frequency of A is ~0.75 would be 0.75*0.75 = ~0.56, while the observed frequency of A/A individuals is 33/67=0.49. The expected frequency of a/a individuals is ~ 0.06, while we observe 0, and the expected frequency of A/a is ~0.38, while we observe 0.51 ➔ definitely not in HWE.

d) After the departure of the *a/a* individuals, the remaining members of Population 1 are very concerned about potentially having *a/a* children. If they mate randomly with respect to *A/A* vs. *A/a* genotype, what proportion of the next generation will be homozygous recessive?
Strategy #1 (based on first principles of mendelian genetics):

To have an a/a kid, both parents must be A/a AND they must both pass on the a allele.
Chance that parent #1 is A/a = 0.34/0.67=0.51
Chance that parent #2 is A/a = 0.34/0.67= 0.51
Chance that they are both A/a = 0.51*0.51=0.26

Chance they both pass on the a allele = ¼

➔ ¼ * 0.26 = ~ 0.06

Strategy #2 based on pop gen principles:
If they mate randomly, the next generation should be in equilibrium (at birth), therefore the expected frequency of a/a individuals is frequency of a * frequency of a (the "q^2" in the equation) = 0.25*0.25 = ~0.06

e) Will the strategy of the dictatorial government eventually be able to ensure the loss of the *a* allele (and fixation of the *A* allele) in Population 1?
Explain and defend your answer in light of the mechanisms of evolution.
In principle no, as there will always be heterozygotes, and the chance that two heterozygotes will mate and produce a a/a kid will never be zero. In addition, although mutations are extremely rare, their chance is not zero either, so occasionally an A allele in someone's gametes could mutate to become an a allele.
In reality, however, it is very possible that after a few rounds of deportation the a allele will become so rare that there will be so few heterozygotes that the chance of them mating will be very small, and the chance of them mating AND having an a/a kid will be even smaller. Random chance events, such as the possibility that an A/a individual will not have children, will add to the risk of losing forever the a allele from population 1.

(If you are interested in ACHOO, check http://www.omim.org/entry/100820?search=ACHOO&highlight=achoo)