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Problem 1:
SS: 99
Ss: 418
ss: 483
Total: 1000

SS observed frequency: 99/1000 = 0.099
Ss observed frequency: 418/1000 = 0.418
ss observed frequency: 483/1000 = 0.483

S=SS*2+Ss → S=99*2+418=616 → p= S/2N=616 /2000=0.308
s=ss*2+Ss → s=483*2+418=1384 → q=s/2N=1384/2000=0.692

SS expected frequency: $P=p^2=0.308^2=0.095$
Ss expected frequency: $H=2pq=2*0.308*0.692=0.426$
ss expected frequency: $Q=q^2=0.692^2=0.479$

$X^2 = (O-E)^2 / E$
$X^2_{SS} = (0.099-0.095)^2 / 0.095 = 0.168*10^{-3}$
$X^2_{Ss} = (0.418- 0.426)^2 / 0.426 = 0.150*10^{-3}$
$X^2_{ss} = (0.483-0.479)^2 / 0.479 = 0.033*10^{-3}$
Total = $0.168*10^{-3}+0.150*10^{-3}+0.033*10^{-3} = 0.351*10^{-3} = X^2_{total}$

df=number of genotypes-number of alleles
df=3 – 2=1

$X^2_{0.05, 1} = 3.81$
$X^2_{0.05, 1}$ vs X^2_{total}
$0.351*10^{-3} < 3.81$ → The Null Hypothesis is true, so the population follows a Hardy-Weinberg equilibrium

Problem 2:
Recessive (aa)
Affected ratio = 1/10000
a/A frequencies?
Aa frequency?

p=A
q=a
p+q=1

p^2=AA
2pq=Aa
q^2=aa

$q^2=1/10000 \rightarrow \sqrt{0.1*10^{-3}} = q= 0.01$
p+q=1 → p=1-q → p=1-0.01 → p=0.99

$p^2+2pq+q^2=1 \rightarrow 1-p^2+q^2=2pq \rightarrow 1-0.99^2+0.01^2 = 2pq = 0.0198 \rightarrow 0.0198*100 = 1.98\%$

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The frequency for the normal allele (A) is 0.99 and the frequency for diseased allele (a) is 0.01
The proportion of heterozygote individuals (Aa) is of 1.98%, almost 2 individuals out of every 100.

Problem 3:

12% men, X linked → 0.12=A
% women A? % aa if it was recessive?

For the case of the dominant trait
0.12=A=p
Male options: A=p, a=q

A in phenotype can only have probability of p → p=0.12 → p+q=1 → q=1-0.12 = 0.88= q

Female options: $AA=p^2$, $Aa=2pq$, $aa=q^2$

A in phenotype can be p^2 or 2pq, so $A_{ph}= p^2+2pq \rightarrow A_{ph}=0.12^2+(2*0.12*0.88) = 0.23$

23% of women will present this phenotype in the dominant case

In case of the recessive trait
0.12=a=q
Male options: a=q, A=p

a in phenotype can only have probability of q → q=0.12 → p+q=1 → p=1-0.12 = 0.88= p

Female options:

Recessive trait will only show if aa (q^2) → $q^2=0.12^2 = 0.0144$

1.4% of women will present this phenotype in the recessive case

Problem 4:

ss 58
Ss 42 (Stubble)
SS are dead

SS observed frequency: 0/100 = 0
Ss observed frequency: 42/100 = 0.42
ss observed frequency: 58/100 = 0.58

S=0*2+42=42 → p= S/2N=42/200=0.21
s=58*2+42=158 → q=s/2N=158/200=0.79

The frequency of allele S is 0.21 and the frequency of allele s is 0.79.

SS expected frequency: $P=p^2=0.21^2=0.044$
Ss expected frequency: H=2pq=2*0.21*0.79=0.332
ss expected frequency: $Q=q^2=0.79^2=0.624$

$X^2 = (O-E)^2 / E$
$X^2_{SS} = (0-0.044)^2 / 0.044 = 0.044$
$X^2_{Ss} = (0.42- 0.332)^2 / 0.332 = 0.023$
$X^2_{ss} = (0.58-0.624)^2 / 0.624 = 0.003$
Total = $0.003+0.023+0.044= 0.07 = X^2_{total}$

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df=number of genotypes-number of alleles
df=3 – 2=1
$X^2_{0.05, 1} = 3.81$
$X^2_{0.05, 1}$ vs X^2_{total}
0.07 < 3.81 → The Null Hypothesis is true, so the population follows a Hardy-Weinberg equilibrium

Problem 5:
4 alleles
6-9 TTA each
p=0.43
q=0.37
r=0.18
s=0.02

Genotype number = (alleles*(alleles+1))/2 → 4*(4+1)/2 = 20/2 = 10
10 genotypes are possible

The frequency of heterozygotes can be calculated with

total = $p^2+2pq+2pr+2ps+q^2+2qr+2qs+r^2+2rs+s^2 = 1$
htz = $2pq+2pr+2ps+2qr+2qs+2rs$

f= htz/total → f= 0.65/1=0.65
The expected frequency for an heterozygote is of 0.65

Problem 6:
0.04 recessive (aa) → q^2=0.04
(alle
$q^2=0.04 \rightarrow \sqrt{0.04}=0.2$
p=1-q → p= 1-0.2 = p=0.8

The frequency for the recessive allele is of 0.2, the frequency of the dominant allele is of 0.8.

	A	a
A	AA	Aa
a	Aa	aa

The probability of a descendant of 2 carriers presenting the recessive trait is of 0.25, if the progenitors were not carriers(and dominant) it would be of 0%.

Problem 7:
93 mice
alleles A1 and A2
Observed:
A1A1=0.226
A1A2=0.4
A2A2=0.374

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$p = A1A1 + (A1A2) / 2 = 0.226 + 0.4 / 2 = 0.426$
$q = 1 - p = 1 - 0.426 = 0.574$

Expected:
$P = p^2 \rightarrow P = 0.18$
$2pq = 0.49$
$q^2 = 0.33$

$X^2 = (O-E)^2 / E$
$X^2_{A1A1} = (0.226-0.18)^2 / 0.18 = 0.012$
$X^2_{A1A2} = (0.4-0.49)^2 / 0.49 = 0.016$
$X^2_{A2A2} = (0.374-0.33)^2 / 0.33 = 0.006$
Total = $0.012+0.016+0.006 = 0.034 = X^2_{total}$

df=number of genotypes-number of alleles
df=3 – 2=1
$X^2_{0.05,\,1} = 3.81$
$X^2_{0.05,\,1}$ vs X^2_{total}
$0.034 < 3.81 \rightarrow$ The Null Hypothesis is true, so the population follows a Hardy-Weinberg equilibrium

Problem 8:
35% white mice → aa

$q^2 = 0.35 \rightarrow \sqrt{0.35} = q = 0.59$
$p = 1-q \rightarrow p = 1-0.59 = 0.41$

The frequency for the recessive allele is of 0.59, the frequency of the dominant allele is of 0.41.

$p^2 = 0.41^2 = 0.168$
$q^2 = 0.35$
$2pq = 2*0.59*0.41 = 0.484$

The frequency for the recessive homozygote is of 0.35, the frequency of the dominant homozygote is of 0.168 and the frequency for the heterozygote is of 0.484.

Problem 9:
Cows
BB=0.81
Bb=0.18
bb=0.01

Bulls
BB=0.33
Bb=0.66

??

Problem 10:
20 individuals → 40 alleles
2 Cc → 2 c alleles
18 CC

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$2/40 = 0.05 = q$
$p = 1\text{-}q \rightarrow p = 1\text{-}0.05 = p = 0.95$
$q^2=0.05^2=0.0025$ → proportion of cc individuals

The incidence of cystic fibrosis in the island will be of 0.25% (1 out of 400 individuals will be cc)