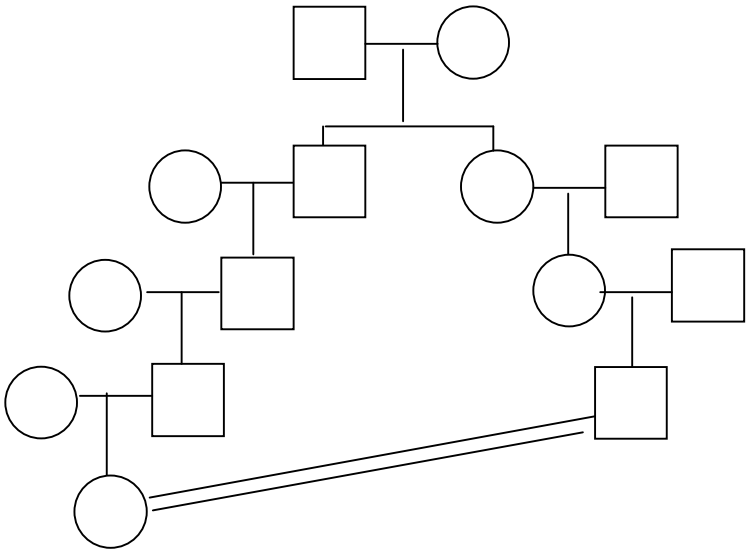
ANSWERS TO Exam Questions from Exam 3 – Eukaryotic Gene Regulation, Genome Modifications in Eukaryotes, Population Genetics

1. Consider an autosomal recessive trait that occurs at a frequency of 10^{-6} in a specific human population that is at Hardy-Weinberg equilibrium (ie. random mating is occurring).

(a)



(b) 85%

(c) decrease

(d) all three of these choices could act to keep q constant

2. You are studying regulation of the Wrm1 gene, a yeast gene that is expressed in response to heat.

(a) constitutive

(b) recessive

(c) trans

(d) dominant negative activator

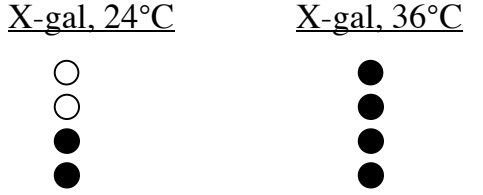
(e)

Tetrad Type A

Number of these tetrads out of a total of 90: _____86_____

Classification of these tetrads (PD, NPD, or TT): _____PD_____

Color in the spores that would be blue in color when growing on the following plates:



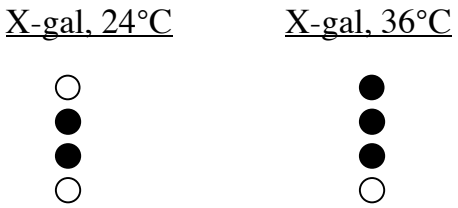
NOTE that the two plates are replicas, so the top spore on the left plate has the same genotype as the top spore on the right plate.

Tetrad Type B

Number of these tetrads out of a total of 90: _____4_____

Classification of these tetrads (PD, NPD, or TT): _____TT_____

Color in the spores that would be blue in color when growing on the following plates:



3. The scenario in this question asks a biological question that can be addressed by creating genetically engineered mice.

i) pronuclear injection

ii) the d-Nhe gene

iii) fertilized egg

iv) NheJ+/NheJ^{-}

v) randomly

vi) no

vii) you would have to cross two of the transgenic mice you made and screen for mice that are NheJ^{-} / NheJ^{-} / d-NheJ

viii) if these mice are UV sensitive, then the two genes are not interchangeable; if these mice are UV sensitive, then the two are interchangeable

4. You are studying how yeast cells grow on the sugar maltose as a carbon source.

(a)

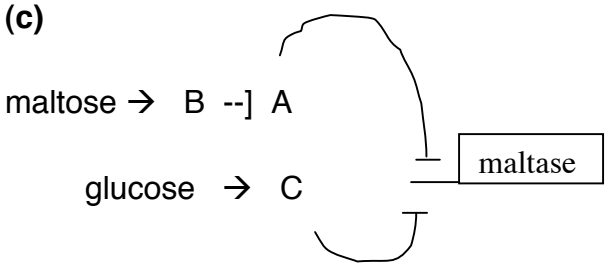
A: negative regulator, maltose

B: positive regulator, maltose

C: negative regulator, glucose

(b) constitutive

(c)



(d) Region 2

(e) Deletions 4 and 5

5. You have a mutant mouse that displays the phenotype of white fur (instead of the wild-type color for this strain, which is brown fur).

1. gene targeting
2. the allele of whfr that is found in the mutant mouse
3. ES cells
4. wild-type
5. The whfr locus
6. Mate the chimeric heterozygote that results to wild-type to get a non-chimeric heterozygote. Then mate two non-chimeric heterozygotes together, and 1/4 of their progeny will be the mouse you want.
7. if the mouse has white fur, then the whfr mutation itself is sufficient to cause the white fur phenotype. If the mouse is brown, then a combination of mutations must have caused the white mutant mouse to be white.

6. An allele that causes the recessive phenotype of microcephaly has a frequency **q** = 0.0001 in a randomly-mating population in Hardy-Weinberg equilibrium.

(a) frequency = 10^{-8}

(b) h = 0.00009

(c) q = 0.0000447

7. You are studying a yeast strain that will grow using the sugar raffinose as a carbon source.
(a) the mutations both give recessive phenotypes and are in different genes
(b) uninducible
(c) raffinose --] 2 --] 3 → Raf1
(d) you would get all PDs, which would each have two uninducible spores and two constitutive spores

8. Suppose that, in an isolated population, there exists a very rare inherited anemia which is autosomal recessive.
(a) q^2
(b) 2pq, which approximately equals 2q
(c) (1/16)
(d) 0.008Fq = 0.001q
(e) 0.008 Fq = q^2
so q = 0.001

9. You are studying the sihZ gene in mice, and you isolate a mutation called "regX" that disrupts proper transcriptional regulation of the sihZ gene.
(a) pronuclear injection
(b) insert the regX mutant allele distal from the sihZ gene
(c) use the regX allele from the regX mutant animal. Do not put the sihZ open reading frame on this fragment. This fragment will integrate randomly.
(d) fertilized egg, wild-type animal
(e) no additional breeding
(f) If the sihZ gene is properly regulated in the transgenic animal, then the element works in cis and is a regulatory DNA region upstream of the sihZ gene. If the sihZ gene is improperly regulated in the transgenic animal, then the element works in trans and encodes a regulatory protein.

10. A early nonsense mutation in the yeast **URA9** gene gives an intermediate level of growth without the nucleotide uracil being provided in the growth medium (Ura+/$^{-}$).
(a) You have isolated a suppressor mutation that is unlinked to the original mutation. This suppressor mutation alone gives a Ura+ phenotype. The suppressor may be in a tRNA gene, causing a nonsense-suppressing allele of this tRNA gene.
(b) You have isolated a synthetic mutation that is unlinked to the original mutation. This synthetic mutation alone gives a Ura+/- phenotype. The synthetic mutation may be in another gene that is partially necessary for synthesis of the nucleotide uracil, such that, without the function of this gene, the cell is Ura+/-, but without the function of this gene and without the function of Ura9, the cell is fully Ura-.
(c) The suppressor mutation and the synthetic mutation are tightly linked.
(d) The tRNA suppressor mutation must also suppress the mutation will isolated in part **(b).** Thus the synthetic mutation (which on it's own gives a Ura+/- phenotype) also must be a nonsense mutation of the same category (opal, ochre, amber) as your original mutation. This allows a triple mutant strain (with the original mutation, the synthetic mutation, and the suppressor mutation) to have a Ura+ phenotype.

11. Trekking in the Himalayas, you discover a "founder generation" of 1000 goats barricaded on all sides by high peaks and massive glaciers.
(a) f(A) = 0.3 and f(a) = 0.7
(b) no
(c) f(A) = 0.3
(d) f(AA) = 0.09 and f(Aa) = 0.42 and f(aa) = 0.49

12. The scenario in this question asks a biological question that can be addressed by creating genetically engineered mice.

i) pronuclear injection
ii) the PrfM gene from the mouse that can smell perfume
iii) fertilized egg
iv) a homozygous knockout of PrfM
v) randomly
vi) no
vii) none
viii) If you ever generate a mouse that can smell, then the mutation was intragenic. If you never get a mouse that can smell, then the mutation was extragenic.

13. You are studying the regulation of Gln1, a yeast gene involved in glutamine synthesis.
(a) constitutive
(b) yes, at 37cM
(c) ten of those 17 spores
(d) glutamine –] 8 --] 7 --] 1

14. Albinism is a rare condition that is inherited as an autosomal recessive phenotype in many animals, including humans.
(a) q = 0.0135
(b) Uncle-niece: (1/8)
Grandparent-grandchild: (1/4)
(c) Fq = (1/16) (0.0135)
(d) 0.0058

15. The genetics of the eye disease known as retinitis pigmentosa (RP) are complex in humans, with many dozens of genes implicated.
(a) 1. transgene
2. mutant RP5
3. fertilized egg
4. wild-type
5. random
6. none

(b) 1. gene targeting
2. the RP11 gene disrupted by a gene encoding antibiotic resistance
3. ES cells
4. wild-type
5. The RP11 locus
6. Mate the chimeric heterozygote that results to wild-type to get a non-chimeric heterozygote. Then mate two non-chimeric heterozygotes together, and 1/4 of their progeny will be the mouse you want.

(c) Mate the mouse from part **(b)** to the Rpx strain. If Rpx is mutant in Rp11, then you will get all mice with retinitis pigmentosa. If Rpx is not mutant in Rp11, then you will get all unaffected mice from this cross.

16. To study the regulation of yeast genes that are necessary for the utilization of the sugar sucrose, you construct a fusion of **Suc1** (a gene encoding a sucrose-hydrolyzing enzyme) to the *E. coli* gene for ß-galactosidase.
(a) the two mutations both give recessive phenotypes and are in different genes
(b) no
(c) uninducible
(d) sucrose --] 3 --] 2 → Suc1

17. Diagrammed below is a consanguineous mating of an uncle and niece.
(a) F = (1/8)
(b) (1/8) * 30,000 = 3750 genes
(c) if autosomal dominant, incidence = (4/1,000,000)
(d) if autosomal recessive, incidence = 6.46×10^{-6}
(e) if autosomal dominant, mu = (4/1,000,000)
(f) if autosomal recessive, mu = (4/1,000,000)
(g) if autosomal dominant, incidence = (1/50,000)
(h) if autosomal recessive, incidence = (1/50,000)

18. You generate genetically engineered mice that are homozygous for a $P_{amylase}$-LacZ transgene insertion.
Propose a breeding experiment to test the hypothesis that the sh mutation is in the same gene as the transgenic insertion mutation.

ANSWER: Breed sh mutant mice to the transgenic mice. If the offspring have big hearts, then the two mutations were in different genes. If the offspring have small hearts, then the two mutations were in the same gene.

19. Yeast cells have a set of enzymes that can synthesize the amino acid histidine.
(a) it gives a recessive phenotype and is in a different gene than the His4 mutation
(b) yes, at 40 cM
(c) histidine → 10 --] 11 → 4
histidine --] 11 --] 10 --] 4
(d) uninducible
(e) histidine → 10 --] 11 → 4

20. Consider an autosomal recessive disease in humans that is caused by possessing a specific loss-of-function allele at a single gene locus.

(a) q = 0.0002

(b) $2pq * 2pq = 1.6 * 10^{-7}$

(c) $7.8 * 10^{-8}$

(d) $1.36 * 10^{-7}$

(e) $Fq = (1/16)\ (0.00028) = 1.75 * 10^{-5}$

(f) no to **(c)** and no to **(d)**

(g) yes to **(c)** and no to **(d)**

21. You are studying a recessive eye-color mutant phenotype (called *pinkeye*) in the mouse.

(a) Propose an experiment

i) gene targeting

ii) the A gene disrupted by a gene encoding antibiotic resistance

iii) ES cells

iv) wild-type

v) the A locus

vi) yes it would

vii) Mate the chimeric heterozygote that results to wild-type to get a non-chimeric heterozygote. Then mate two non-chimeric heterozygotes together, and 1/4 of their progeny will be the mouse you want.

viii) The mouse you create has pink eyes, then you should cross this mouse to a pinkeye mouse that you already have. If all offspring have pink eyes, then the pinkeye mouse strain is mutated in gene A. If all offspring have normal eyes, then the pinkeye mouse strain is mutated in gene B.

(b) Propose an experiment

i) pronuclear injection

ii) the wild-type A gene

iii) fertilized egg

iv) an egg resulting from the mating of two pinkeye mice mating

v) randomly

vi) no

vii) none

viii) If the mice have normal eyes, then the pinkeye mouse strain was mutant in gene A. If the mice have pink eyes, then the pinkeye mouse strain was mutant in gene B.

22. An autosomal recessive inherited disease with a selective disadvantage of 0.1 occurs at a frequency of 10^{-4} in a randomly mating population.

(a) (1/1000) alleles

(b) Mating between two unrelated individuals: $q^2 = 0.01$

Brother-sister mating: $Fq = 0.025$

(c) (1/2)[p(boy)] + (1/2)[p(girl)] = 0.005