Group Practice Final Exam BIOL121-123 – Dr. Brett Couch

1) You are studying inheritance of a flower color and size in cultivated peas. Peas are 2N and imagine that in this species 2N=4. You begin your experiment with pure breeding parents with the following phenotypes: parent 1 had large purple flowers; parent 2 had small white flowers.

The gene for color you designate as "C" and the gene for flower size you designate "S".

The alleles of the genes are: C^P (purple); C^W (white); S^L (large); S^S (small).

The all individuals in the F_1 generation have small purple flowers. Reciprocal crosses give the same outcome (e.g. using parent 1 as the pollen parent and using parent 2 as the ovule parent then performing the reciprocal cross where parent 1 is the ovule parent and parent 2 is the pollen parent).

1a) Diagram a cell from an F1 individual at anaphase 1 of meiosis where the C and S genes are tightly linked and crossing over has not occurred. Indicate the spindle and direction of chromosome movement. Use gene and allele symbols provided. (**5 marks**)

Cell is 2n-= 4 (0.5)

Chromosomes replicated (0.5)

Chromosomes were clearly in tetrads and are now shown as separating in anaphase 1 (2 marks)

Spindle and direction of chromosome movement shown and correct (0.5)

Chromosome genotypes correct ($S^L C^P$ and $S^S C^W$) (1 mark)

Gene and allele notation correct (0.5)

1b) For the cell you diagrammed in 1a, where does segregation occur (**1 mark**)? ___Meiosis I_____

For both of the scenarios below, indicate the possible phenotypes for the F_2 offspring and their expected frequencies. (**4 marks)**

1c) The C and S genes are very tightly linked and you can ignore the effect of crossing over.

To solve this you need to draw a Punnet square where the alleles of the S and C genes are inherited as a unit.

The small allele is dominant to large and the purple allele is dominant to white.

The F1 would have the genotype $S^{L}C^{P}$ / $S^{S}C^{W}$ The $S^{L}C^{P}$ alleles are on one chromosome and the $S^{S}C^{W}$ alleles are on the other chromosome.

The punnet square would look like this

	$S^{L}C^{P}$	$S^{S}C^{W}$
$S^{L}C^{P}$	$S^{L}C^{P}$ $S^{L}C^{P}$ Large, purple	$S^{S}C^{W}$ $S^{L}C^{P}$ Small, purple
$S^{S}C^{W}$	$S^{L}C^{P}$ $S^{S}C^{W}$ Small, purple	$S^{S}C^{W}$ $S^{S}C^{W}$ Small white

The parents have the Genotypes $S^{L}S^{L}$ $C^{P}C^{P}$ and $S^{S}S^{S}C^{W}C^{W}$

1:2:1 ratio of Large purple: small, purple : small, white

1d) The C and S genes are unlinked

This is a basic dihybrid cross resulting in a 9:3:3:1 ratio since the genes are unlinked so assort independently.

9 small purple

3 small white

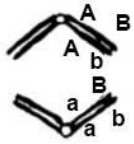
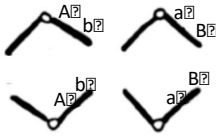
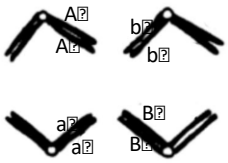
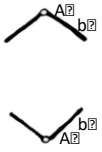
3 large purple

1 large white

1e) For the scenario in "1d", what process or processes are responsible for genetic variation among the F_2 offspring? (**1 mark**)
Segregation, independent assortment and fandom fusion of gametes

2) Consider a plant species that is diploid (2n = 4). An F_1 plant with the genotype Aa Bb was produced by a mating between two pure-breeding parents with the genotypes aaBB and AAbb. From previous experiments you have determined that alleles of the A and B genes do not assort independently. Crossing over does occur in this species.

a) Each diagram represents a single anaphase cell from the F1 (*Aa Bb*) plant. For each diagram indicate if the diagram shows chromosomes during anaphase of mitosis, meiosis I, meiosis II or if the arrangement is not possible. (**4 marks**)

	*Meiosis I – the products of this division would be haploid here there has been a single crossover between the A and B loci the recombinant types are AB and ab*		*Mitosis – the products of this division will be two diploid cells with the same genotype as the parent cell -*
	*Not possible – this is not possible because the genes are located on separate chromosomes – if the genes were located on different chromosomes this would be meiosis 1*		*Meiosis 2 – in this case we have a cell that is haploid and the replicated chromatids are being separated – the chromosome with the aB genotype is not present in this cell.*

Commented [MOU1]: The extra discussion is to help students understand the answer but is not required for marks in this case

3) Male seahorses in the genus *Hippocampus* are responsible for parental care of offspring. Males have a structure called a brood pouch. Mating involves females transferring eggs to the brood pouch of the male; the male's sperm is also transferred to the brood pouch. Males do not mate with multiple females. The embryos within the eggs develop within the brood pouch. Most of the nutrients for development of the embryo come from resources in the egg. The brood pouch provides protection and some nutrients for the developing offspring. Females do not contribute to care of offspring following fertilization. In females, larger individuals produce more eggs, larger eggs and larger offspring. Females vary in size within populations.

3a) In some situations, males preferentially select larger females to mate with. Based on the information above, briefly explain the reasoning underlying the hypothesis that male seahorses may prefer to mate with larger females. Your answer should be logical and make specific reference to the fitness effect of male choice on male fitness. (**5 marks**)

- Male fitness in this case is not determined by the number of females a male can mate with. Since males only mate with one female then need to invest in care of offspring, male fitness is determined by egg quality and number. Male fitness limited by the number of offspring from a mating that survive and reproduce – there would be for males choosing females that will increase the number of offspring produced by a male and the probability that these offspring will survive and reproduce – which would result in increase in male fitness (the number of offspring fathered by the male that survive and reproduce)
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3b) Imagine that subsequent studies have shown that in a common environment in the lab, large females consistently have larger offspring regardless of the size of the male parent and the survival rate for large offspring is higher than for smaller offspring. Your friend suggests that female size may be a trait that could experiences sexual selection. Do you agree with his claim? (**1 mark**)

Yes / No (circle one)

Commented [MOU2]: Remove answer from student version.

3c) Explain why or why not with specific reference to each of the three main criteria required for selection.
(3 marks)

Criteria for Selection	Explanation
Variation in population	Yes, females vary in size.
Variation is heritable	Yes, there appears to be a genetic component as large females have larger offspring in a common environment – i.e. offspring look like parents and this does not seem to be influenced by environment.

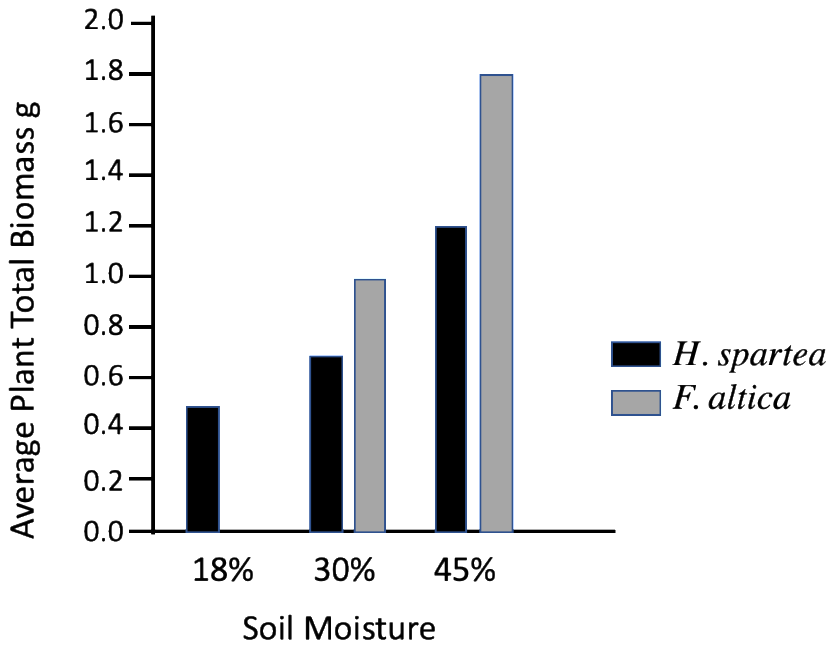
Differences in fitness	There seems to be a difference in fitness as larger individuals have increased survival

4) *Hesperostipa spartea* (*H. spartea*) or porcupine grass, grows in grasslands of south-eastern British Columbia. Another common grass species, *Festuca altaica* (*F. altica*), also grows in this habitat. Small hills are present in this habitat, with soil moisture and nitrogen varying consistently from the top of the hill to the bottom (Table 1A).

Table 1A. Average soil moisture and nitrogen levels in grassland habitats in south-eastern British Columbia

Location on hillside	Soil Moisture Level (%)	Soil Nitrogen mg/kg
Top of hill	< 20	660 mg/kg
Side of the hill	20 – 40	740 mg/kg
Hollows between hills	> 40	880 mg/kg

In the grassland you are studying, *H. spartea* occurs almost exclusively on the tops of hills while *F. altica* is found exclusively on the sides of the hills and in the hollows between the hills. Greenhouse experiments, where plants were grown in individual pots, were performed to assess the influence of water on productivity. In this experiment nitrogen was provided in excess so was not limiting. All differences in growth were statistically significant at (P=0.05).



4a) Why do you think *H. spartea* occur almost exclusively on the tops of hills? Briefly explain your reasoning. (**2 marks**)

H. spartea is likely competitively excluded from the sides of hills by F. altica and only occurs in places where F, altica does not occur (tops of hills) - in the lab experiment *F. altica had much greater growth than H. spartea in soil moisture conditions of 30% and 45%*

4b) Why do you think *F. altica* only occurs on the sides of hills and in the hollows between hills? Briefly explain your reasoning? (**2 marks**)

F. altica can't grow in the moisture conditions at the top of the hill >20% - in the greenhouse study F. altica did not grow at 18% soil moisture but H. spartea was able to grow. .

4c) You set up an experiment to determine the factor(s) that influence the distribution of *H. spartea* and *F. altica*. You create plots at the top and bottom of the hills. For both the top and bottom of the hill, you

have three treatments: *H. spartea* alone, *F. altica* alone and plots with a mixture of *H. spartea* and *F. altica*. You plant the same number of individuals in each plot and measure the biomass at the end of the experiment.

Given your explanations for the distribution of each species in 4a and 4b, generate a figure showing the expectations of the average plant total biomass for this experiment. (**5 marks**)

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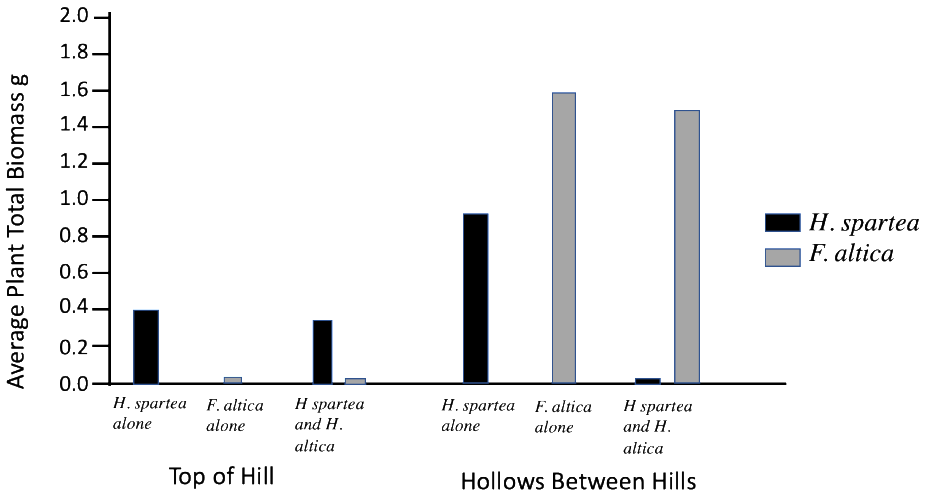

4d) Thinking back to the experiment we discussed in class on the effect of changes in rainfall frequency on grasslands, how do you think changes in rainfall frequency could affect the distribution of *H. spartea* and *F. altica*. (**2 marks**)

Commented [MOU3]: Other sections may want to remove if you did not discuss the manipulated watering-grassland experiment.

-Increased variability in rainfall will likely result in periods of increased drought – drier conditions on the tops, sides and bottom of the hills. F. altica appears to be sensitive to low moisture – might expect the

sides of the hill to become drier and F. altica may only occur in the hollows between the hills. H. spartea may change its distribution to the side of the hill. Depending on the tolerance of H. spartea for drought conditions it may no longer be able to grow on the tops of the hills.