BIO 201: Genetics and Evolution
Second Mid-Semester Examination, October 15, 2019
Total Marks: 30, Time: 1 Hour
Please write genotypes/reasoning where ever necessary

1. Define Genetic Linkage. (2 marks)

Given loci are said to be genetically linked if the loci cannot assort ~~indeper~~ independently of each other. ~~and the~~

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For example, if two loci are very close to one ~~at~~ another, it is very likely that they end up being on same chromosome and if they are very far ~~apart~~ apart, they are likely to end up on different chromosomes.

2. Consider data from a two-point mapping testcross. This kind of cross involves mating an individual heterozygous at two loci (two genes) to an individual homozygous for the recessive alleles at both. In this case, the cross can be summarized as (EeDd × eedd). Note, however, that this mating summary does not indicate the way the alleles are linked (if they are, indeed, linked) in the heterozygous parent.

E e D d 22 E e d d 116 e e D d 109 e e d d 17

(a) What frequencies of each type would you expect if the two genes assorted independently? (1 mark)

If the genes sorted independently, we would expect a 1:1:1:1 frequency of each type

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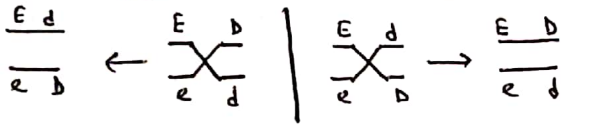
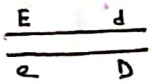
(b) Are the alleles on the parental chromosomes linked in cis or in trans? (1 mark)

1

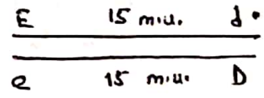


Since genes are linked, we would expect ~~crossovers occur with~~ recombination occurs with a probability less than 0.5. Since the gametes Ed and eD are produced with more frequency, we can conclude alleles on parental chromosomes are in trans.

(c) Draw the map for these two loci. (2 mark)



$P(\text{recombinant}) = \frac{39}{262} \approx \frac{3}{20} \simeq 15\%$



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∴ Distance between the ~~genes~~ loci is ≃15 m.u.

3. (i) What are Phylogenetic trees? (1 mark)

Phylogenetic trees are tree like diagrams tracing the evolutionary history of the ~~animal~~ species surviving in the present day. The root represents the common ancestor of all species and every node represents a speciation event. The leafs represent the presently surviving species.

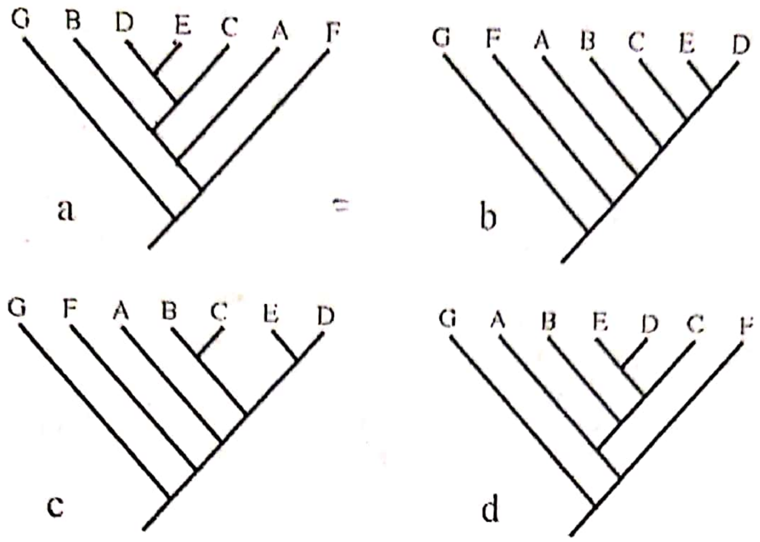
1

(ii) Consider the phylogenetic trees below. Which of the trees above shows a different relationship among the taxa than others? Explain very briefly. (2 marks)

Tree (e) shows a different relationship.

In the ~~other~~ other trees C, D, E form a clade however in (e), C lies in the out-group of the clade formed by D and E. In order to include C, B has to be included as well, which is not the case in other trees.

2



4. Consider the tree (b) in question (3.ii.) and comment on the statements below:
(i) A is equally related to F and B. (2 marks)

A is more related to B than it is to F. A & B have more common ancestors than A & F.

2

(ii) G is more similar to the common ancestor of all the organisms depicted in the phylogeny than E. (2 marks)

1

This is a wrong statement. Less speciation does not imply more similarity with the common ~~ancest~~ ancestor.

5. Differentiate between Selection, Evolution and Adaptation. (3 marks)

2.5

Selection → the process of favouring the fitness of ~~ce~~ members of a population bearing a certain phenotype.

Evolution → a population is said to undergo evolution when the population acquires a certain ~~characte~~ character which is heritable and the ~~....~~ further generations express a greater frequency of the character.

Adaptation → it refers to the ability of an individual to adjust in a different environmental ~~co~~ condition and is not necessarily heritable.

6. (i) What is broadsense heritability? (1 mark)

Broadsense heritability depend on genetic and environmental variance i.e $V_H = V_G + V_E$

$$\boxed{H^2 = \frac{V_G}{V_G + V_E}}$$

1

(ii) Certain scientists assayed heritability of some traits in a *Drosophila melanogaster* population that had adapted to the lab environment for a long time. They created several families by pairing males and females. From each of these pairs, they collected eggs. Half the eggs laid by a female were grown under environmental stress and the other half were grown under stress-free condition. The traits were measured on both parents and offspring. Assume that they then did a parent-offspring regression to calcualte heritabilities under stressed and stress-free conditions. Assume that their results are summarised below. Based on these data, answer the following questions:

Trait	Heritability in stress-free condition	Heritability in stressed condition
Lifespan	0.02	0.0047
Wing length	0.58	0.134
Bristle number	0.69	0.519

(a) How can heritabilities be different for the same trait? (1 mark)

Heritability depends inversely on variance due to environment, in stressed conditions it causes a lesser heritability of the trait as it starts to depend on environment.

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(b) What is the most probable reason for heritabilities being lower under stress condition than under stress free condition? (1 mark)

Probably because under environment stress factors needs to change so traits are less heritable than they are in a stress free condition where fitness is not as significant a driving force

1

(c) Why is heritability lowest for Lifespan? (2 marks)

Lifespan greatly depends on fitness which changes for every environment thus it is the least heritable trait unless conditions are stress free.

2

(d) Heritability for Bristle number shows very little change between stress-free and stressed conditions. What does this tell us about the trait? (2 marks)

It says it does not contribute much towards the fitness of the organism. The more the trait is contributing towards fitness, the lesser is the heritability

2

SINGH.S

7. Three spined sticklebacks are a type of fresh water fishes. Assume that they live for about 3 years. They have armour plates on their body surface which are expected to give protection from predators. Kitano et al (2008, Current Biology 18 (10): 769-774) studied the number of armour plates in a population of sticklebacks in Lake Washington in USA. Their results are given below.

(a) Clearly summarise the results that are in favour of the conclusion that the number of armour plates has evolved in this population between the years 1957-2005. (2 marks)

(1) The mode as well as the mean has shifted towards the phenotype with a greater count of armour plates — as given in the histograms.

(2) The percentage of the population having armour plates has increased over the years.

2

(b) What additional data would be required to conclusively show that this character has evolved? (2 Marks)

In order to conclude that the population has evolved, we would require to collect data of the offsprings of the fishes in 2005 and check if the offsprings ~~are~~ exhibit a similar distribution of armour plate count — ~~which~~ if this is the case, it can be concluded that the population has evolved from having low count of armour plates to having a high count of armour plates, and the trait is heritable — not just ~~adapti~~ adaptation to a different environment.

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(c) In 1957, the lake was extremely polluted and the visibility within water was very low. In early 1960s a clean up of the lake was done and the water clarity improved over the next few years, there by increasing visibility. The lake has a predator of sticklebacks – a fish called trout. The authors hypothesise that as visibility in the water increased, the predators could easily locate and attack the sticklebacks. Increased plate number helped the stickelbacks survive the attacks. Thus armour plate number increased. How would you test this hypothesis? (2 marks)

The hypothesis assumes the presence of predators cause selection and there by evolution. To test this hypothesis, if we can remove the predators and isolate them from the population somehow and observe the ~~follo~~ following generations.

If the progeny tends to revert to having low count of armour plates, we can conclude that the predators are the cause of evolution, justifying the hypothesis.

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Otherwise, it might be so that armour plates ~~some~~ serve some other purpose besides providing protection and the other purpose is the agent of selection and cause of evolution.

(d) Name the selective agent in this hypothesis mentioned in part (c). (1 mark)

A directional selection is indicated in the hypothesis — which is determined by the ability of sticklebacks to survive their natural predators — the trouts.

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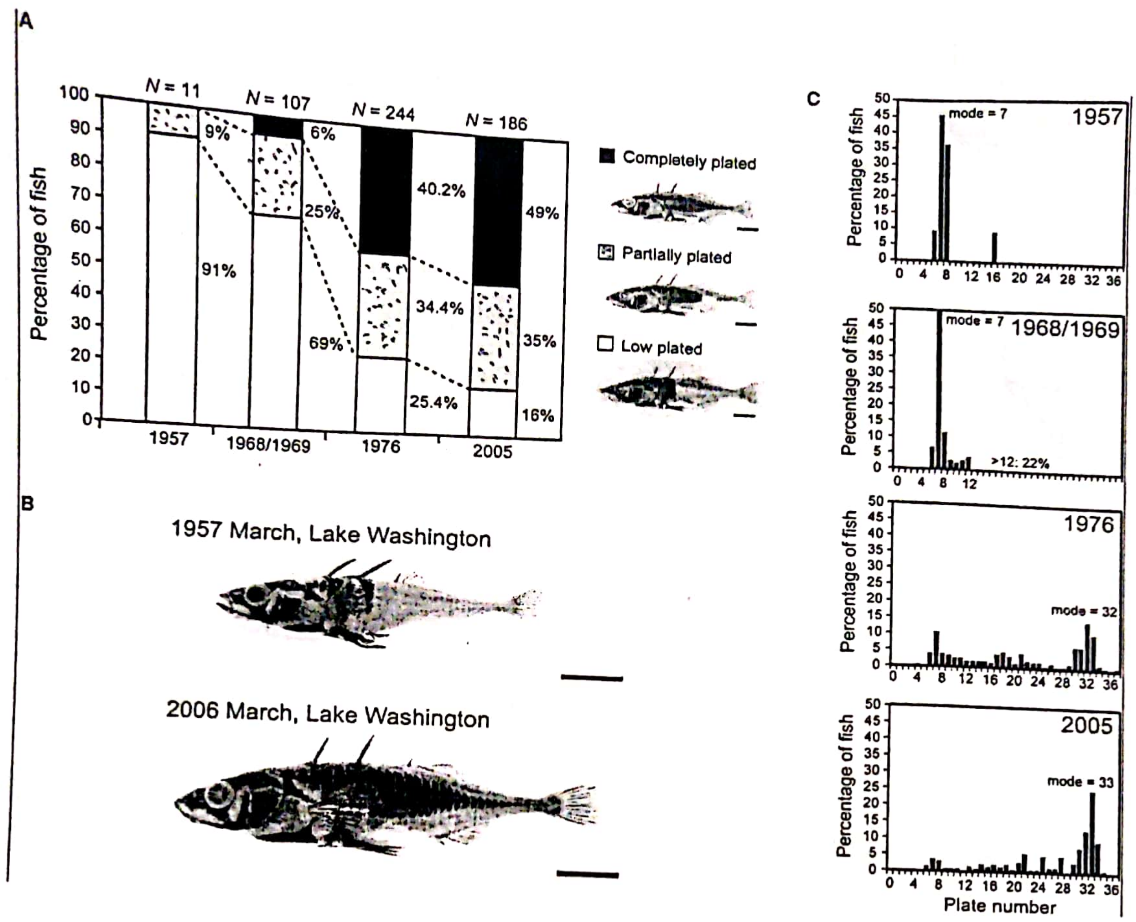

Figure 1:
(A) Temporal change in the frequency of the completely plated (black bar), partially plated (gray bar), and low-plated (white bar) morphs in Lake Washington sticklebacks. Sample sizes are shown above the graph. Right panels show representative images of the three stickleback morphs.
(B) Representative images of sticklebacks collected via midwater trawling during March 1957 and March 2006 in the northern pelagic zone of Lake Washington.

(C) Histograms of lateral-plate number for sticklebacks collected in 1957, 1968–1969, 1976, and 2005. Sample sizes are the same as those in Figure 1A. The most-common plate number is also shown in each panel as a mode.