
Organic Evolution**Midterm II Key**

Part I: Briefly (i.e., in a single sentence) describe or define in words all of the following (2 points each).

- 1) *Narrow Sense Heritability (in words and symbols)*— The **portion of phenotypic variation that is due to additive genetic variation**; $V_p = \frac{V_A}{V_P}$
- 2) *Metric Characters* — **Non-discretely varying characters such as weight, height, color, etc.**
- 3) *A Mixed Strategy in Game Theory* — **A behavior where the player acts one way a certain percentage of the time and an alternate way the remainder (e.g., Hawk 40% and Dove 60%)**
- 4) *Antagonistic pleiotropy* — **When two characters are controlled by the same gene or set of genes and positive changes to one character cause negative changes to the second.**
- 5) *Allometric constraints* — **Growth such that two (or more) aspects (dimensions) are correlated (e.g. high and width, length and weight, etc).**
- 6) *Mutualism* — **When the behavior of the actor benefits both the actor and the recipient**
- 7) *Inclusive Fitness* – **The fitness of an individual that includes not only the individual's fitness, but the lifetime fitness of the offspring as well.**
- 8) *Semelparity* — **A strategy where individuals reproduce only once in their life.**
- 9) *Coefficient of Relationship* — **The degree to which two individuals are related and is equal to two time the inbreeding coefficient of a hypothetical offspring that they would have if they mated**
- 10) *Reciprocal Monophyle* — **A phylogenetic relationships where a common ancestor gave rise to all the individuals of a species and only that species and a second common ancestor gave rise to all of the individuals of that species and only that species .**

Part II: Answer all of the following questions.

1) *Sexual reproduction is very, very common in animals and plants even though there are several significant disadvantages to sexual reproduction when compared to asexual reproduction.*

a) Describe the disadvantages of sexual reproduction relative to asexual reproduction. (In class I discussed two reasons why asexual reproduction might be a better strategy than sexual reproduction. Discuss and describe them here)(5 points)

Due to recombination, sexual reproduction will breakup adaptive gene complexes where asexual reproduction does not. Since sexual reproduction requires two where asexual requires only one individual for reproduction, under the same starting condition, sexual reproduction loses the game of numbers. If every reproducing individual produces 2 offspring (females in sexual individuals and all in asexual) then the sexual forms will only replace themselves every generation where the asexual ones will increase in numbers (and therefore percentage).

b) Discuss the advantages to sexual reproduction that tend to counter these disadvantages? (In class I discussed 4 reasons why sexual reproduction might be better than asexual. Discuss and describe them)(10 points)

Sexual reproduction is advantageous because new adaptive gene complexes can be formed quickly through recombination. The fixation of these complexes is also quicker because where asexual populations must wait for serial mutations sexual one can make them through recombination. This is only true for large populations where sufficient amount of mutations can occur. In small populations, sexual and asexual are similar. Even when combinations made by recombination are neutral this variation may permit a buffer against environmental change. Finally asexual individuals slowly accumulate deleterious mutations over time and cannot purge them (i.e., Muller's ratchet). Sexually reproducing individuals can purge deleterious mutations through recombination.

2) *Sexual Selection is a special type of natural selection. Cost of sexual reproduction is asymmetrical between males and females and this asymmetry usually results in male-male competition and/or female choice.*

a) *Describe in detail the specific reasons or basis for the asymmetry in cost between males and females in sexual reproduction? (6 points)*

- 1) **Females generally make larger parental investments in terms of a larger cost in producing gametes, increased energy in producing offspring, increased energy in caring for offspring, and reduced ability to produce other offspring**
- 2) **Lifetime reproductive potential is lower in females. Because of the above cost differences, females are limited in offspring production by the number of eggs (or pregnancies) she can have. The male's lifetime reproductive success is high, but limited by the number of females he can mate with.**
- 3) **Access to males is not a limited resource for females but access to females is a limited resource for males (i.e., females run the show).**

This results in males competing for females and females being choosy.

b) *Name and describe at least three of the forms that male-male competition can take (I gave you 4 in class). (6 points)*

- 1) **male-male combat – males can physically interact with each other. This can be for physical access to mates or to hold limited resources necessary for females. This generally results in male characteristics that promote winning a combat (e.g., size, aggressiveness, armor, weaponry, etc.)**
- 2) **Sperm competition – competition can be not physically between the males, but after copulation. There can be a competition in the amount, quality, and timing of sperm transfer, female guarding, and/or length of copulation etc.**
- 3) **Infanticide – when social structure is affected by male competition winner males may kill young that he did not father. This clearly leads to a male – female fitness conflict.**
- 4) **development of sneaker strategy in males to avoid male – male conflict and potential harm resulting from losing.**

c) *Name and describe at least three of the ways that female choice might happen (I gave you 4 in class). (6 points)*

- 1) **Good Genes hypothesis – females may chose males that have the best, most fit genes so that the offspring will have good genes. this can be through direct display (vigorous, good looking males are genetically superior) or handicap (any male that can maintain an energetically expensive or risky character is more fit).**
- 2) **Good Father hypothesis – females chose males that can best provide for their offspring (i.e., provide large territories with lots of food, best nest, most devoted, etc.)**
- 3) **Preexisting Sensory bias – females preference for a particular characteristic evolved first for different reasons then male mating display followed (frog calls and species identity).**
- 4) **Sexy Son hypothesis – female choice can be arbitrary relative to current reproductive success (i.e., fitness) but due to a particular female preference, females will produce sons that are more attractive to females. This can lead to Runaway Sexual Selection where the population is actually at lower mean population fitness due simply to open-ended female preference.**

3) *It is very difficult to explain how altruism could evolve. Nonetheless, altruistic-like behaviors appear to be quite common in natural populations.*

a) *Define altruism? (4 points)*

Altruism is when the actions of an actor benefit the recipient at a fitness cost to the actor.

I indicated that each of the following might actually explain the observation of apparent altruism. Describe in detail each of the following. Be sure to include why it is not actually altruism (use examples if necessary but not exclusively). (3 points each)

b) **Manipulation** – An individual may be doing an action that results in a fitness loss to itself because they are being deceived and believe that there is actually a fitness gain to them. Although the actor would be reducing their fitness to the benefit of the recipient, the intent of the actor was not altruistic

c) **Tit-for-tat** – An actor may perform an action that reduces their own and increases the recipient's fitness in the current interaction because they are reasonably assured that in future interactions this will be reciprocated. For Tit-for-tat to work, individuals must interact repeatedly with opportunities for altruism on each participation part, have good memories, the cost cannot be larger than the benefit, and the actor cannot predict future behavior accurately.

d) **Kin Selection** – An actor may perform an action that reduces his or her own fitness and increases the recipient's fitness if the recipient is genetically related to the actor. In general, the benefit modified by the degree of relatedness must be equal to or larger than the cost (i.e., $B \times r \geq C$)

5) Each of the questions below refers to Game theory. a) What is an evolutionary stable strategy? (2 points)

An evolutionary stable strategy is a strategy that once all individuals in the population adopt this strategy it cannot be replaced by any other strategy.

b) Describe the Hawks and Doves game assuming that both Hawk and Dove are pure strategies (2 points)

In the Hawks and dove game, the participants interact for a benefit. When Hawks interact with other hawks they will fight until one individual wins, but there is a cost incurred for fighting. When Hawks interact with doves they gain the full benefit without incurring a cost because doves do not fight. When a dove interacts with another dove one wins and the other walks away with no cost incurred.

c) Fill in the payoff matrix below assuming Hawk and Dove are pure strategies (use “C” for the cost and “B” for the benefit) (2 points)

When opponent is:

		Dove	Hawk
Pay off to:	Dove	$\frac{1}{2}B$	0
	Hawk	B	$\frac{1}{2}(B - C)$

d) If the benefit is greater than the cost (i.e., $B > C$), is there an evolutionary stable strategy if Hawk and Dove are pure strategies? If so, what is it and why? If not, why not? Be sure to describe all conditions that are ESS if more than one exists (2 points)

When $B > C$ Hawk is an ESS. The payoff to being a dove is never greater than being a Hawk (i.e. $\frac{1}{2}B + 0$ is always less than $B + \frac{1}{2}(B - C)$ as long as $B - C$ is positive). A population of only Doves would be replaced by a Hawk mutation.

e) Fill in the payoff matrix below assuming a mixed strategy of Hawk and Dove where the probability of an individual acting like a Hawk is p and acting like a Dove = $1 - p$ (use “C” for the cost and “B” for the benefit). (2 points)

When opponent is:

		Dove	Hawk
Pay off to:	Dove	$(1-p)\frac{1}{2}B$	$p(0)$
	Hawk	$(1-p)B$	$p\frac{1}{2}(B - C)$

f) If the benefit is less than the cost (i.e., $B < C$), is there an evolutionary stable strategy with a mixed strategy? If so, what is it? (2 points)

When $B < C$ there is an ESS when the frequency of being a hawk is equal to the benefit divided by the cost (i.e., $p = \frac{B}{C}$).

6) Species are identified and categorized in several ways and there are several different “species concepts” that evolutionary biologists recognize.

a) Describe or define the Biological Species Concept including strengths and weaknesses (3 points).

Biological Species groups of interbreeding natural populations that are reproductively isolated from other such groups. This is a more mechanistically based but it can't deal with clonal or asexual organisms, is hard to test in every situation, and cannot be used with fossil

b) Name and describe the 4 premating (prezygotic) and 4 postmating (postzygotic) reproductive isolating mechanisms and give an example (8 points).

PREMATING:

- i) potential mates do not meet either spatially or temporally
- ii) mates meet but do not recognize each other as potential mates
- iii) copulation occurs but there is no transfer of gametes for mechanical reasons
- iv) gamete transfer occurs but egg is not fertilized. Usually sperm - egg recognition problem

POSTMATING:

- i) zygote dies - likely chromosomal incompatibility
- ii) zygote does not die but hybrid individual is inviable
- iii) hybrid is viable but sterile
- iv) hybrid is viable and fertile but reduced viability or fertility is uncovered in later generation hybrids.

c) Name 3 other species concepts (3 points).

- i) Evolutionary
- ii) Phylogenetic
- iii) Recognition
- iv) Ecological

6) How species arise or are formed is a central question in evolutionary biology. Describe in detail each of the models for species formation below.

a) **Allopatric Speciation** (both vicariant and founder types) (3 points) —

In vicariant allopatric speciation, an extrinsic barrier to population mixing separates population geographically. Over time, either through drift or differential selection, the populations diverge and become different species. If enough time has elapsed and reproductive isolating barriers have formed, then the species will continue to exist even if the extrinsic barrier is removed. If reproductively isolating mechanisms have not arisen then the species will form a secondary hybrid zone.

In founder allopatric speciation, a new area that is isolated from the old is colonized by a chance event. Once in the new area, the founding population can diverge either by drift or differential selection. This can be either by adaptive divergence (i.e., different fitness landscape in the two environments) or by peak shift (i.e., same fitness landscape, but accelerate drift in the small founder population facilitates peak shifting).

b) **Parapatric Speciation** (2 points) —

In parapatric speciation, an environmental gradient or clinal variation in selection pressure cause a continuously distributed species to diverge. If the fitness of the hybrid is lower than the parental specie in all areas then the two extents of the range of the species will become two different species.

c) **Sympatric Speciation** (2 points) —

In sympatric speciation, a new species arise in the same area as the parental species. There is no apparent geographic separation. This may happen if chromosomal incompatibility arises often by hybridization