SAMPLE Final Exam with Key

1. a) Briefly outline two experiments that show bees navigate by using polarized light. b) How do we know that they communicate (describe at least one experiment in your answer to b)?

Wehner and Rossel discovered the workings of the bees celestial compass by manipulating the light coming into the hive while the bee did its waggle dance (**4** pts). They showed that the sun's rays were not necessary by putting up a screen that eliminated the sun's direct rays from entering the hive, while permitting the skys polarized light to reach the hive through an opening in the top of screen. Worker bees will display the correct direction to nectar even though the sun is not visible (**4** pts). If you block out all polarized light using a plexiglass bubble, you eliminate the cue that the bees are using to tell the direction. The plexiglass absorbs polarized light in the ultraviolet wavelengths. A bee that has come back from its scouting knows the correct angle, but without the sun to guide it, the worker cannot tell which direction it should end its waggle so as to direct the workers. The data for a number of workers shows a very random pattern heading off in every direction compared to the consistent directions shown above (**4** pts).

Karl von Frisch decoded the language of bees using some clever manipulations. The tendency for bees to point in the correct direction of the nectar supply can be plotted on a circle. The height of the histogram is proportional to the number of worker bees tha tchoose that vector (i.e., typically close to the actual angle of the plant from the sun if they are correct). Few workers are far off the actual angle. In the diagram to the right, the Average Angle of the Worker Bees dance indicates that food is located approximately 100 degrees to the right of the sun. (**4** pts) A worker would fly at a bearing of 100 degrees to the sun and come upon the source of food that the scout bee had found. It appears that the worker is using the sun a reference. Key experiment to prove this -- used trained scouts and predict distance and direction of recruits, OR use robotic bee!) (**4** pts) .

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2. A junvenile bird squawks a song that it is learning in the woods but no other bird or animal is around to hear it. Is it communicating? Why or why not? (Make sure you include a definition of communication to support your answer.)

The classic defintion of communication involves an action on the part of one animal that alters the behavior of another (Wilson 1975). The essence of communication is the relationship between signaler and receiver. (**10** pts)

The key to this question is recognizing that the sender and recipient can be the same individual. The bird that sings to himself, does modify his own behavior. He changes his song in response to hearing his own voice. (**5** pts)

A junvenile bird squawks a song that it is learning in the woods is actually singing to himself to correct the song

that he sings so that it matches the song template in his head that is remembered from his youth. (**5** pts)

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3. a) Define organizational and activational effects, and explain their relationship. b) Describe how maternal behaviors in mice are activated by hormone interactions. c) What is the environmental trigger for nuturing? d) Is nurturing under genetic control?

a) The early action of hormones serves to **organize** the brain so that it has the proper neural circuitry for later acting activational events. The morphology of the body could also be organized in the same way (**4** pts). With the proper neural circuitry in place, the approapriate muscle development, the correct organ systems built (e.g., sexual organs), the body is ready for the **activational events** that typically begin with the first breeding attempt. It is at this time that the latent sexual tendencies are awakened in the juvenile. The triggers for maturation can be genetic, or environmental. Whatever the cause or trigger, sexual maturation, requires hormones to activate physiological and neurophysiological systems (**4** pts).

b) The hormones involved in the development of maternal behaviors in mammals are linked to the hormone changes in both progesterone and estrogen. Progesterone levels are typically quite high during pregnancy, but as the date of birth approaches Progesterone levels begin to fall and Estrogen levels begin to rise. It is the synergistic action of both Progesterone and Estrogen at birth that seems to trigger maternal behaviors in female mice (**4** pts).

c) However, it is the actual presence of pups per se, that triggers the following maternal

behaviors:

1.retrieval response of pups when the pups are not in the nest,

2.the nursing crouch of the female. (**4** pts)

d) Brown and her colleagues have succeeded in creating a mutation in a single gene, fosB, that appears to extinguish nurturing behaviors in female mice. The hypothalmus in female mice has been shown to be critical for nurturing behavior in lesion experiments. It appears that the gene products of fosB are expressed in the preoptic area, which is located in the hypothalmus. (**4** pts)

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4. a) In bee colonies all workers have the same morphology yet workers are clearly specialized in various roles. Describe two different roles or tasks that workers perform, and discuss one theory that explains how these tasks are allocated. b) In contrast to bees, ants produce several different kinds of workers. Describe two different roles that worker ants have, and discuss how (mechanisms) and why (adaptive explanation) two environmental factors influence caste determination in ants.

a) For early studies of marked bees, it was clear that an individual worker performed a single task over the course of several days, seemingly specialized in one of the following roles: (**4** pts 2 of 4 listed below are required):

1. nursery -- bees that tend to the needs of developing larva
2. honey comb and food larger -- responsible for comb maintenance, and caching of honey
3. forager -- individuals that go foraging to know food sources
4. scout -- individuals that seek out known food sources.

(**8** pts Only 1 of 3 answers listed below is required)

Mechanisms

Environmental determination of tasks: "foraging for work". One theory holds that these defined developmental roles are largely due to a random process, that is spatial correlated with the center of the hive. Because all bees are born in the nursery, this is the first environment that they encounter. If there is a simple rule, that workers look around their local environment, and begin working on tasks that need to be done then young newly born workers will immediately take up tasks in the nursery. As a worker toils away at their task, by chance, all tasks may be filled in the nursery, and the worker moves outside of the nursery arena to "forage for more work". The next place she would encounter is the outer hive, where maintenance tasks might be open for her working instincts. Eventually, these individuals begin wandering and interact with the workers in the larder to get food for the growing embryos. She would continue with this task until displaced yet again to foraging for new tasks. After performing tasks in the larder, the worker begins interacting with foragers and assumes such tasks, especially if she is displaced by younger workers that have now moved into the larder. Finally, the foragers interact with the scouts and assume such tasks. The exposure to new environments and opportunities for work leads to the development of specialization with age. The task allocation is simple, forage for work. If no work is in the immediate vicinity, them move a little farther from the center of the hive and look for undone tasks.

Genetic determination of tasks. There are indeed other theories to account for the correlation between the age of a bee and the various tasks that occur further and further from the hive. Even though workers are very similar to one another and their relatedness is very high (r=0.75 vs the usual 0.50 for sexual offspring), they do receive different material from their female parent, the queen. These subtle genetic differences might pre-dispose them to different tasks in the hive (e.g., nursery vs scout or morge vs guard).

Age dependent determination of tasks. Yet another theory contends that worker development is programmed by changes that are dependent on age and physiology. For example, a young worker might have a different hormonal composition than older workers. Differences in the internal state of the workers then leads to differences in behavior. A key hormone might be involved in the progressive change in tasks with age. For example, injecting a "young" nurse worker with Juvenile Hormone will cause her to precociously shift her tasks and become a forager. Changes in levels of juvenile hormone with age may control task allocation.

b) In the case of may species of social ants, the workers are further divided into specialized tasks such as small general purpose worker, large worker for hauling large objects, special warrior castes of various types, including some species in which individuals have a turret on their head and inject noxious chemical warfare toxins and repellents. The underlying selective reasons for such shifts in the number of workers with warrior castes, has to do with colony economics.

Adaptive Explanation (8 pts)

The most efficient colony is likely to leave more descendant colonies.

A colony has an upper limit to overall size that is governed by:

1. the travel costs of individuals to food,
2. the return travel costs (which can be substantial in that an ant can haul 10 X its body weight in food),

3. and the amount of energy required by the colony.

Thus, an old colony should be less concerned with expanding its territory, and the number of workers begins to decline with colony age. Defense of the colony from raids from adjacent colonies becomes a more important issue. Hence a shift in focus from workers to soldiers in young versus old colonies. (**4** pts)

1 of 2 ways (**4** pts)

Environmental temperature. Variation in the temperature of development has a dramatic effect on the relative number of workers compared to other specialized tasks. For example, early in the spring, it is necessary to produce more workers because attrition during the course of the winter has reduced the number of workers. By biasing the production of larger numbers of workers at the lower temperatures, the colony will get a more rapid growth spurt. As the temperature heats up during mid summer, and the colony is at close to its maximum carrying capacity, the number of eggs developing into workers begins to taper off.

Queen age. This shift can also be achieved by some mechanism of worker versus soldier allocation that is tied to the age of the female. As a queen grows old, and as her colony ages, she begins to lay fewer of the worker caste. A young queen should produce many more workers than an old queen. A young queen and hence a young colony must grow rapidly and thus relatively more workers are beneficial. However as a colony grows older and has expanded to its maximum size in both numbers and the "territory" from which it harvests food, the colony must also consider shifting more members to roles involving colony defense. Hence fewer workers and more soldiers are produced by an old versus a young queen.

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5. a) Can an animal that is learning be foraging optimally? Why or why not? b) In a general sense, what are the environmental conditions that favor a learning-based foraging strategy? Relate this idea to the foraging environment, and memory limitation observed in bumble bees.

a) Optimal foraging models were erected using the assumption that the forager has omniscient knowledge of the environment, and thus nothing to learn. The main premise of foraging under incomplete information is that acquisition of information for making optimal choices is costly, and must be traded off against current utility. (**4** pts)

b) The simple answer is that learning cannot be adaptive when there is nothing to learn. For instance, in an environment that is completely invariable over time and space a learning strategy is at a disadvantage. Because of the uniform nature of the environment, there are no choice spots to learn about and an animal can just forage without concern for the "grass being greener on the other side of the fence. In this case, an inflexible strategy that forages at the maximal rate throughout is likely to prevail under natural selection. This suggests that one environment that will support learning strategies is one that is variable among foraging bouts but predictable within foraging bouts. Thinking in terms of our patch use models of the marginal value theorem, the biggest concern for a forager is to find the right patch among many patches that vary in quality. (**8** pts)

b) Risk aversion in bumble bees: Risky colored flowers had a single high yielding flower for every two zero yield flowers. Non-varying flowers provide 2 microliters in every flower. Foraging bumblebees appear to use a short memory window for making floral choices, and the spatial pattern of nectar distribution may often be highly spatially autocorrelated. High spatial autocorrelation would imply that a single flower on the same plant is likely to be representative of all flowers on that plant. If the bumble bee samples the flower and detects low nectar then it

might associate the color of that flower with low reward, and avoid such flowers in the future. It will then focus its energy on the other kind of flower which is more stable in reward. (**8** pts)

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6. There are two lines of evidence supporting the idea of parental care in Maiasaurus. a) Describe the comparative argument based on extant bird embryology and development. b) Describe the phylogenetic argument regarding parent care (be sure to reference your answer to at least two modern groups, and define which is the outgroup in your argument).

Examination of fossil eggs and embryos using CAT scans and they have a number of fossil dino "nestlings" for lack of a better word. From the bone structure of these nestlings, a functional morphology can argue that the nestlings were incapable of roaming the landscape. They have an altricial pattern of bone development. Altricial birds, like most songbirds participate in a phase of extended parental care. In altricial birds, the chicks are born relatively helpless, and the parents feed the young over an extended period. This life history pattern is contrasted with the development of most ducks in which the chicks hatch in a precocial developmental state, and they immediately leave the nest and forage on their own. The mother bird stays with chicks and guards her little flock of young, but the birds take care of their own feeding and are very capable of locomotion. The bone development of altricial and precocial birds is quite different. So from an argument based on functionals morphology of fossil embryo and chick development, Maiasaurus nestlings were altricial and remained in the nest for a long period of time. (**10** pts)

If we consider birds to be extant dinosaurs or at the very least the nearest living relatives of dinosaurs, then this suggests the possibility that some dinosaurs could have had female/male-based parental care and in particular, female/male-based is more likely in altricial birds. Next is there evidence for parental care in crocs. Yes females guard the nest, and when the little crocs hatch they begin vocalizing. The female uncovers the hatchlings and transports the young to the water. In some crocs even the males participate in this behavior and it appears that male and female crocs can protect their young some time after they hatch. Because crocs are an outgroup in nearly every dino/bird phylogeny, this suggests that dinos had the capacity for male parental care. (**10** pts)

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7. a) What is reciprocal altruism? b) What conditions favor the evolution of reciprocal altruism based on a consideration of iterated tit-for-tat and the prisoners's dilemma? c) Describe a biological example (discussed in class) that satisfies the conditions described in b).

a) Bob Trivers (1971) considered the case of true altruism and the conditions for the spread of altruistic genes. If an altruist distributed their acts randomly in the population, the altruist gene would ultimately disappear as cheaters could easily take advantage of the altruist, but not give back in return. The altruist must recieve some benefit from its actions and cheaters would give nothing in return, which is the essence of reciprocal altruism. Trivers also realized that altruists might spread if altruist did not distribute their good deeds randomly, but distributed them to other individuals that showed evidence of reciprocity. Under such conditions, a reciprocal altruism might evolve. Individual recognition of individuals and other reciprocal altruists is key! (**4** pts)

A short-term high gain strategy is to defect. However, cooperation is the key in the long run. Why? One of the solutions that did very well in the Iterated Prisoner's dilemma was the Tit-for-Tat strategy. Consider our students, they might get caught and loose grades, but they still pass the course. So if their partner cooperates, they should

too. They keep up this strategy throughout school. If their partner defects then they defect, and end the association. There are in fact three play movements underlie the Tit-for-Tat strategy: Nice in which both players cooperate on the first move of the game, Retaliatory in which a player defects if an individual defected on the prior move, and Forgiving in which a player cooperates with a past defector that now has chosen to cooperate. In the long run, the nice tit for tat will be the best strategy, thus it pays to cooperate, providing the individual recognition and descrimination exists to exclude the cheaters. (**8** pts)

There are 3 options: neighbor-neighbor dear enemy, predator inspection, hermaphroditic fish

to get **8** pts you must explain one interms of the iterated prisoner's dilemma and mention

how the game is iterated, the individual recognition that is involved, and the penalty in the long run from defection that thwarts the advanteges of short-term gain.

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8. a) Describe the phylogeny for homonids in terms of the origins of bipedalism and brain size. Which came first: bipedalism or brain size increase? b) Discuss the allometric arguments for the diversification of brain size in lineages of apes, australopithecus, and homo (a graph with correctly labeled axes is useful). Which lineage has relatively larger brains and why?

a) First, functional anatomy of the nearly complete skeleton of Lucy indicates a pelvic architecture that is clearly on the way to bipedalism if not largely bipedal. Second, the most fascinating fossil find concerns the discovery of 3+ million footprints that below to an australopithecine. It shows a bipedal set of footprints with a prominent heal mark, large big toe that is in-line with the long axis of the foot (in contrast with ape footprints). Must list one piece of evidence (**4** pts). While brain size of Australopithecines was ~30% larger than the great apes, the real increase in size occured in H habilis and after (e.g., Homo) (**4** pts).

b) The proper way to make such comparisons of brain volume relative to body size is to use allometric plots (log-transformed) of brain size relative to body size. If brain volume scales isometrically with body mass, we would expect that these two traits would be proportional to one another. The lineages of great apes fall on a line with a slope of 0.34 which suggests that brain size scales with the 1/3 power of body mass. The lineages of australopithecines fall on a line with a slope of 0.33 which suggests that brain size also scales with the 1/3 power of body mass. Note that the line for australopithecines is higher than great apes and australopithecines did indeed have larger brains relative to body size compared to the great apes, even thought the increase was only 1.3 times larger. In contrast the lineages of homo fall on a line with a slope of 1.73. Brain size was evolving rapidly from Homo habilis, the handy man (2.1 million years ago), to H. erectus (~200 years ago), to H. sapiens in the present. (**12** pts).
