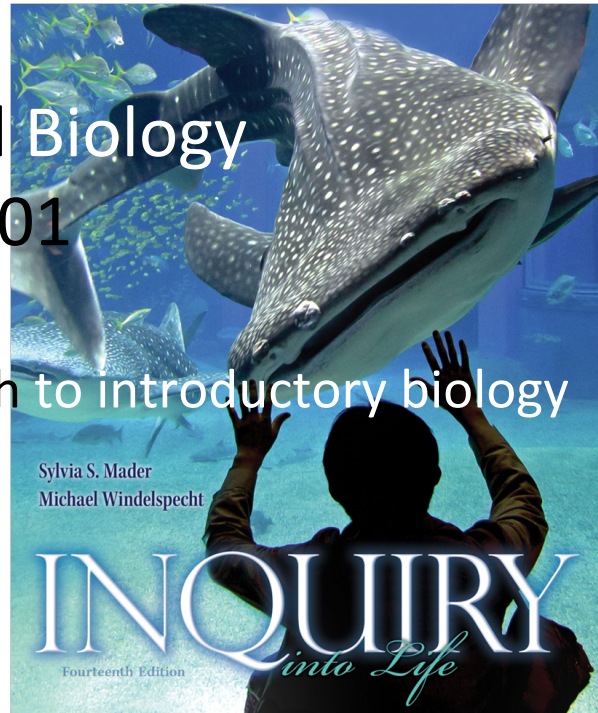


# Fundamental Biology

BI 1101

an interdisciplinary approach to introductory biology

Anggraini Barlian,  
Iriawati  
Tjandra Anggraeni  
SITH-ITB



## Five Levels of Organization

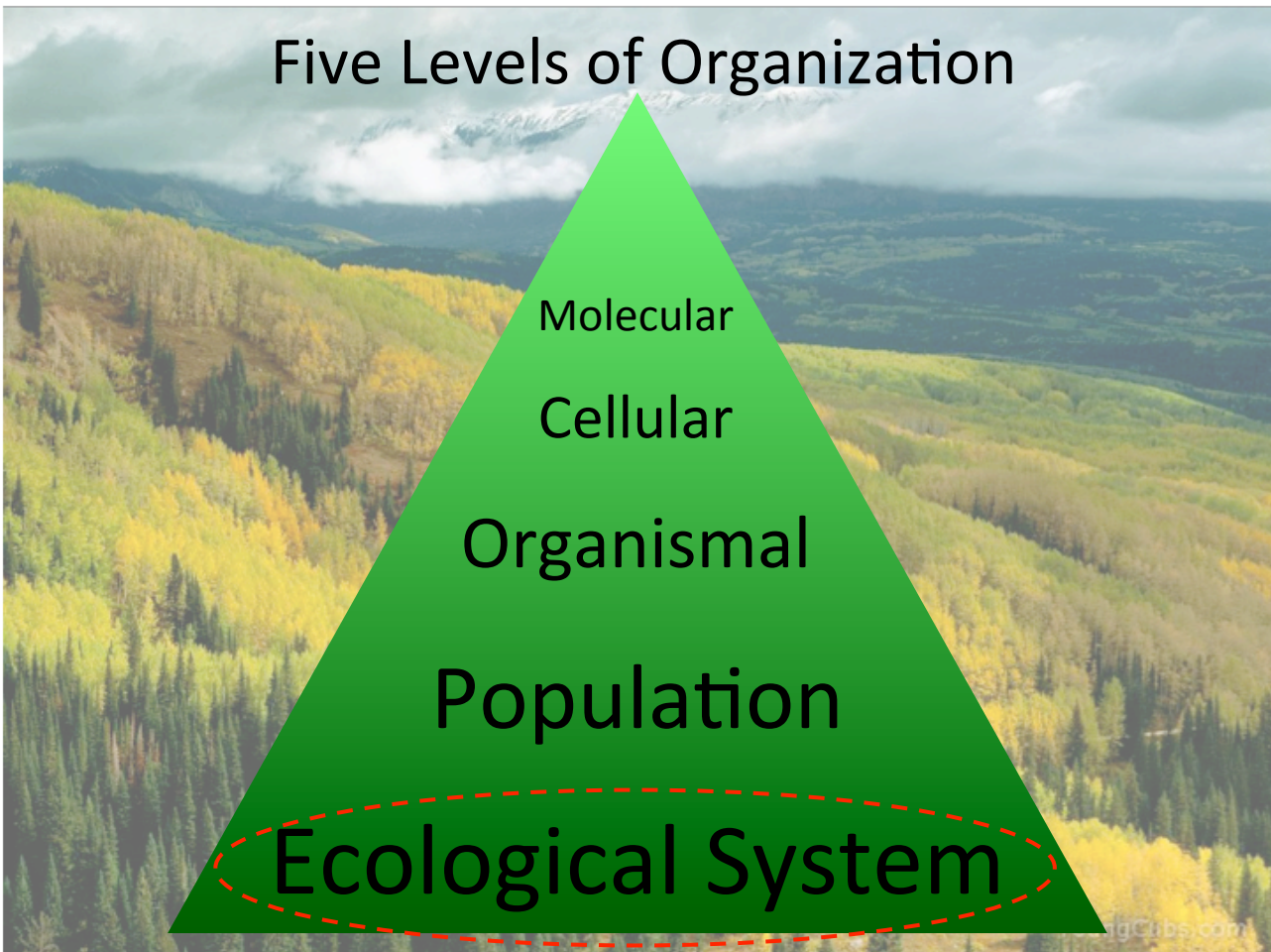
Molecular

Cellular

Organismal

Population

Ecological System



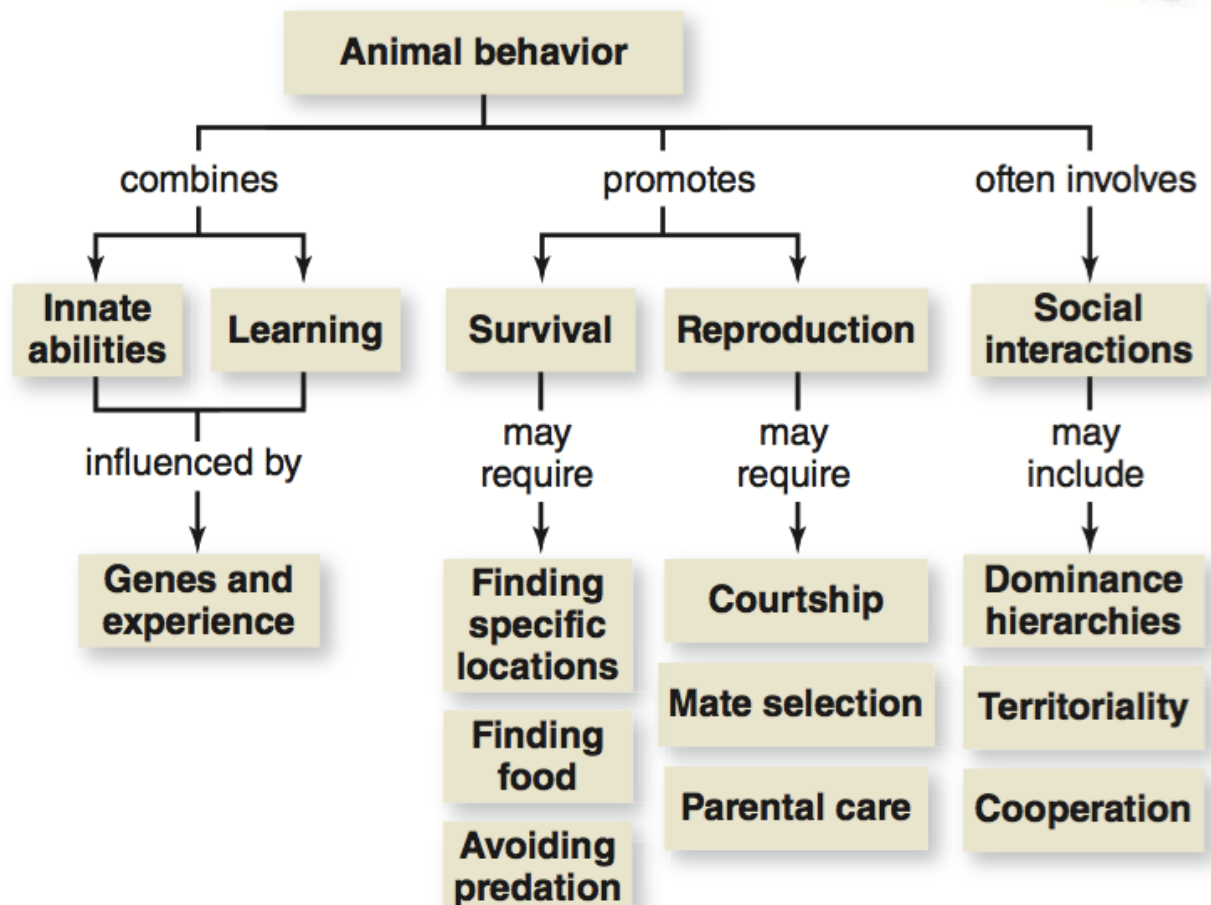
## **BEHAVIORAL BIOLOGY**

### **Learning outcome**

After this chapter, students are able to:

1. Define and distinguish between the proximate and ultimate causes of behavior.
2. Describe the adaptive advantage of innate behaviors.
3. Describe the respective roles of genetics and the environment in shaping behavior.
4. Define the seven types of learning and note the adaptive advantages and examples of each.
5. Compare the types of signals used by nocturnal and diurnal animals.

6. Explain how endocrine disruptors may be introduced into the environment and describe the consequences of this pollution.
7. Define social behavior and sociobiology, providing examples of each.
8. Define a territory and describe the ways in which territories are used, identified, and defended.
9. Explain how dominance hierarchies are maintained and identify their adaptive value.
10. Define altruism and kin selection and describe examples of each.
11. Explain how genes and environmental factors contribute to human social behavior.



# Introduction

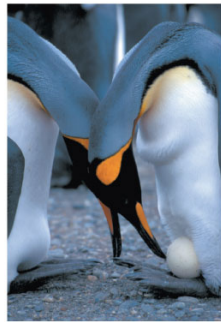
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- Mating is one of the most fundamental activities in the animal world.
- Male peacocks expend considerable time and energy trying to attract a mate.
- Prairie voles
  - share a nest,
  - share in the care of their young, and
  - mate for life.

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## Big Ideas



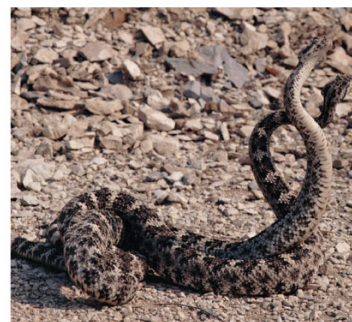
**The Scientific Study of Behavior**



**Learning**



**Survival and Reproductive Success**



**Social Behavior and Sociobiology**

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# THE SCIENTIFIC STUDY OF BEHAVIOR

## Behavioral ecologists ask both proximate and ultimate questions

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- **Behavior** encompasses a wide range of activities.
  - A behavior is an action carried out by muscles or glands under the control of the nervous system in response to an environmental cue.
  - Collectively, behavior is the sum of an animal's responses to internal and external environmental cues.
- **Behavioral ecology** is the study of behavior in an evolutionary context.

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## Behavioral ecologists ask both proximate and ultimate questions

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- The questions investigated by behavioral ecologists fall into two broad categories.
  1. **Proximate questions** concern the immediate reason for the behavior.
    - How is it triggered by **stimuli** (environmental cues that cause a response)?
    - What physiological or anatomical mechanisms play a role?
    - What underlying genetic factors are at work?
    - **Proximate causes** are the answers to such questions about the immediate mechanism for behavior.
  2. **Ultimate questions** address why a particular behavior occurs. **Ultimate causes** are the evolutionary explanations for behavior.

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# Fixed action patterns are innate behaviors

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- Lorenz and Tinbergen were among the first to demonstrate the importance of **innate behavior**, behaviors that are
  - under strong genetic control and
  - are performed in virtually the same way by all individuals of a species.

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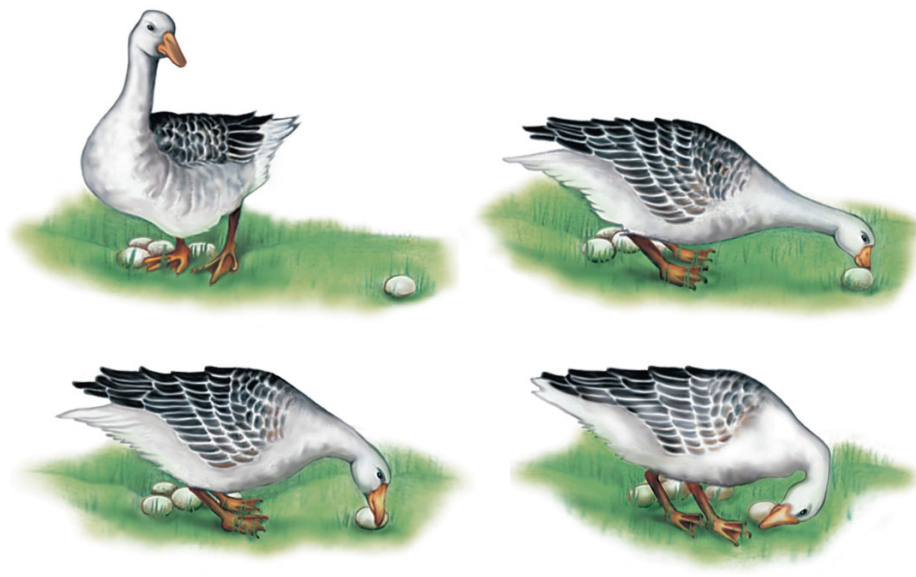
# Fixed action patterns are innate behaviors

---

- Many of Lorenz's and Tinbergen's studies were concerned with behavioral sequences called **fixed action patterns (FAPs)**,
  - an unchangeable series of actions
  - triggered by a specific stimulus.
  - Once initiated, the sequence is performed in its entirety, regardless of any changes in circumstances.
  - Examples include
    - reproductive behaviors and
    - behaviors that must be done correctly the first time to survive, such as a young chick hatched out on a cliff ledge, starting to fly.

---

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# Behavior is the result of both genetic and environmental factors

- Animal behavior often involves a combination of genetic programming and environmental factors.
  - Genetic engineering in fruit flies has been used to investigate genes that influence behavior. Genes have been identified that govern
    - learning and memory,
    - internal clocks,
    - courtship, and
    - mating behaviors.

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TABLE 35.3

COURTSHIP BEHAVIOR OF FRUIT FLIES WITH NORMAL OR MUTATED FRUITLESS (FRU) GENE

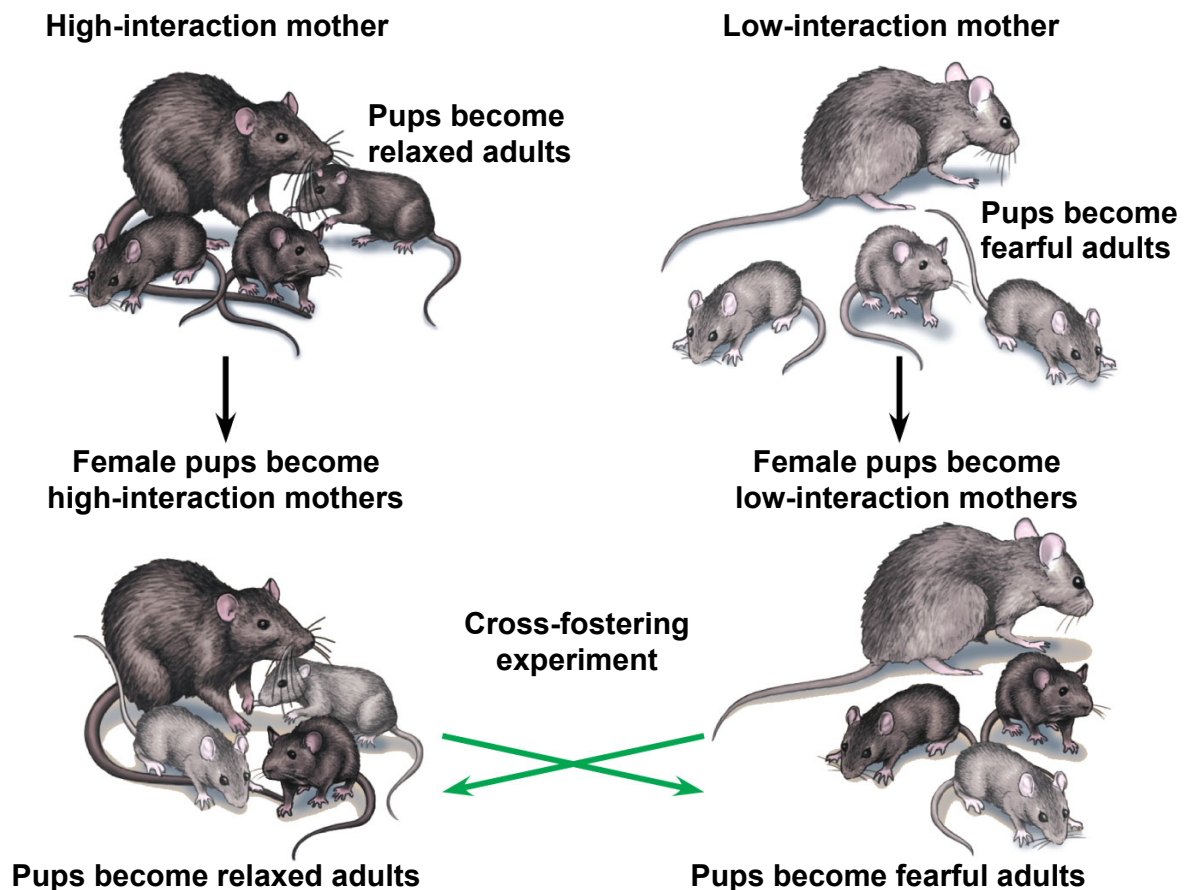
	Male	Genetically Altered Female
Normal male fru	Courts females	Courts females
Mutated male fru	Courts males	—

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# Behavior is the result of both genetic and environmental factors

- Cross-fostering experiments are useful for studying environmental factors that affect behavior. Studies of rats reveal that behavioral changes can be passed to future generations,
  - not through genes, but
  - through the social environment.
  - Interactions with the mother change the pattern of gene expression in the pups, thus affecting the development of parts of the neuroendocrine system that regulate the fight or flight response.

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# LEARNING

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## Habituation is a simple type of learning

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- **Learning** is modification of behavior as a result of specific experiences.
- Learning enables animals to change their behaviors in response to changing environmental conditions.
- There are various forms of learning, ranging from
  - a simple behavioral change in response to a single stimulus to
  - complex problem solving using entirely new behaviors.

---

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TABLE 35.4

TYPES OF LEARNING

Learning Type	Defining Characteristic
Habituation	Loss of response to a stimulus after repeated exposure
Imprinting	Learning that is irreversible and limited to a sensitive time period in an animal's life
Spatial learning	Use of landmarks to learn the spatial structure of the environment
Cognitive mapping	An internal representation of the spatial relationships among objects in the environment
Associative learning	Behavioral change based on linking a stimulus or behavior with a reward or punishment; includes trial-and-error learning
Social learning	Learning by observing and mimicking others
Problem solving	Inventive behavior that arises in response to a new situation

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## Habituation is a simple type of learning

- **Habituation** is one of the simplest forms of learning.
  - An animal learns not to respond to a repeated stimulus that conveys little or no information.
  - In terms of ultimate causation, habituation may increase fitness by allowing an animal's nervous system to focus on stimuli that signal
    - food,
    - mates, or
    - real danger.



# Imprinting requires both innate behavior and experience

---

## ■ Imprinting is

- generally irreversible learning and
- limited to a specific phase in an animal's life called a **sensitive period**.
- Examples include
  - a young bird learning to identify its parents and
  - song development in birds.

**PLAY**

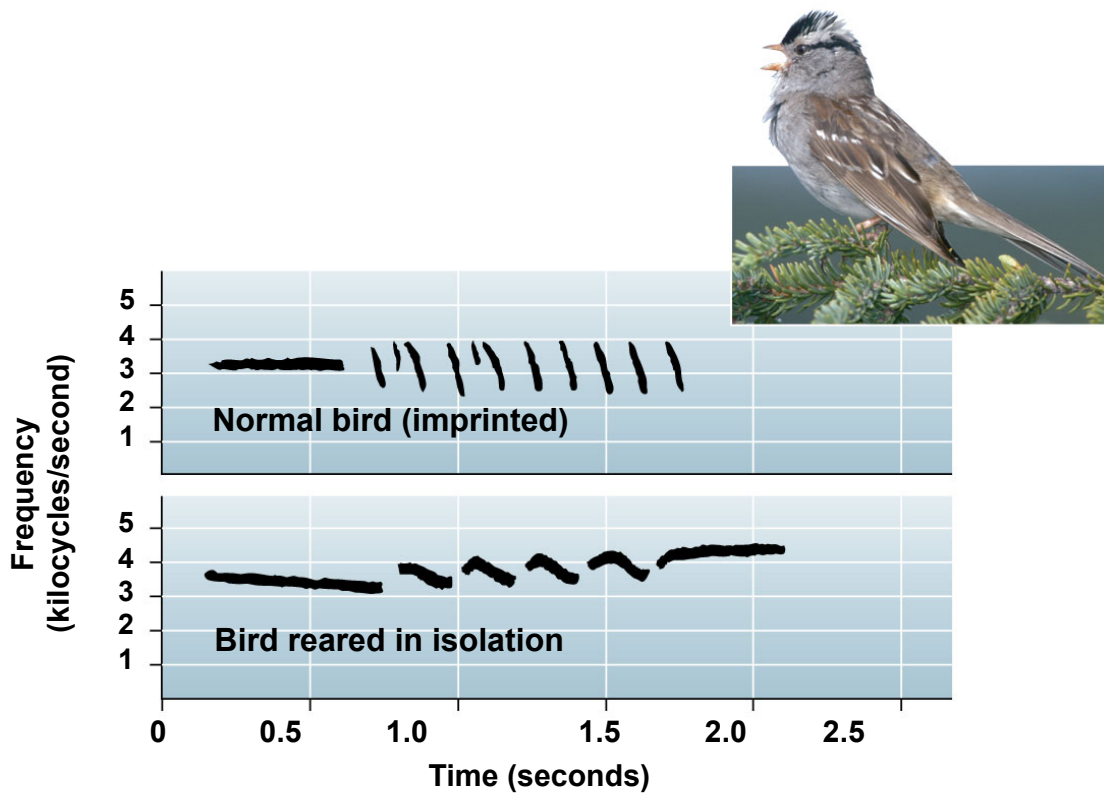
Video: Ducklings

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Figure 35.5A



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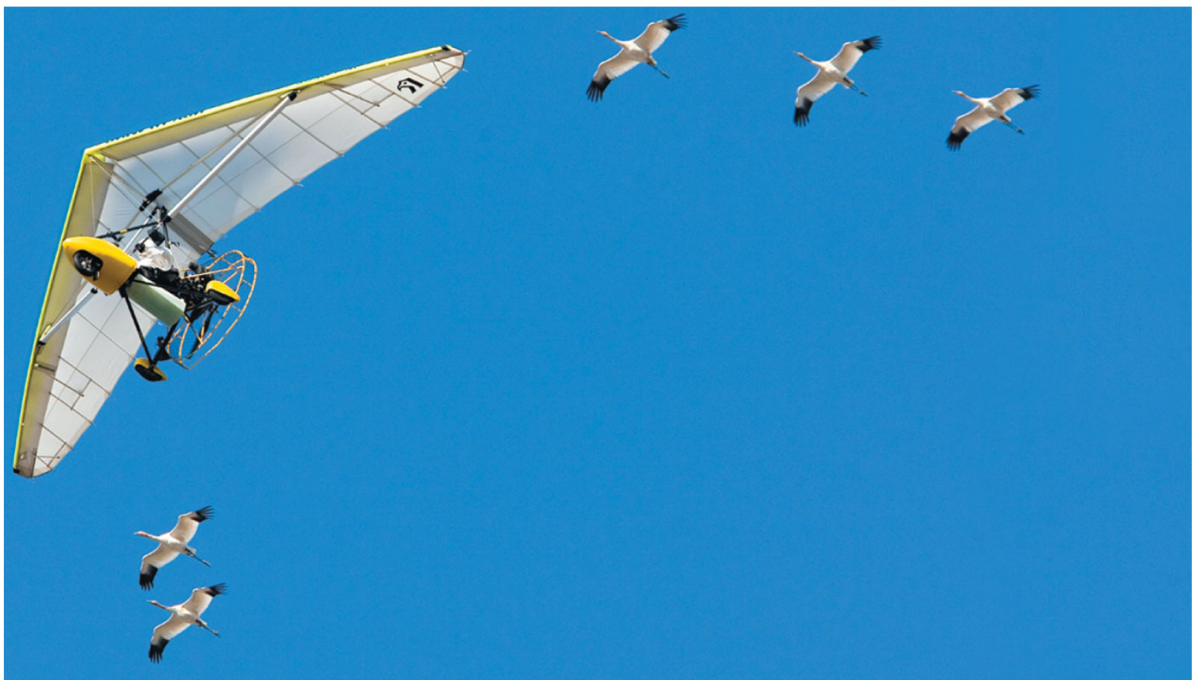
## CONNECTION: Imprinting poses problems and opportunities for conservation programs

- In attempting to save species that are at the edge of extinction, biologists sometimes try to increase their numbers in captivity.
  - Artificial incubation in captivity is often successful.
  - But without parents available as models for imprinting, the offspring may not learn appropriate behaviors.
  - Biologists have invented new ways to save species that recognize the importance of parenting behavior.



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Figure 35.6B



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## Animal movement may be a simple response to stimuli or require spatial learning

---

- **Kinesis** is a random movement in response to a stimulus. A kinesis may be
  - merely starting or stopping,
  - changing speed, or
  - turning more or less frequently.

---

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## Animal movement may be a simple response to stimuli or require spatial learning

---

- **Taxis** is a response directed
  - toward (positive taxis) or
  - away from (negative taxis) a stimulus.
  - Many stream fish, such as trout, exhibit positive taxis in the current, automatically swimming or orienting in an upstream direction.

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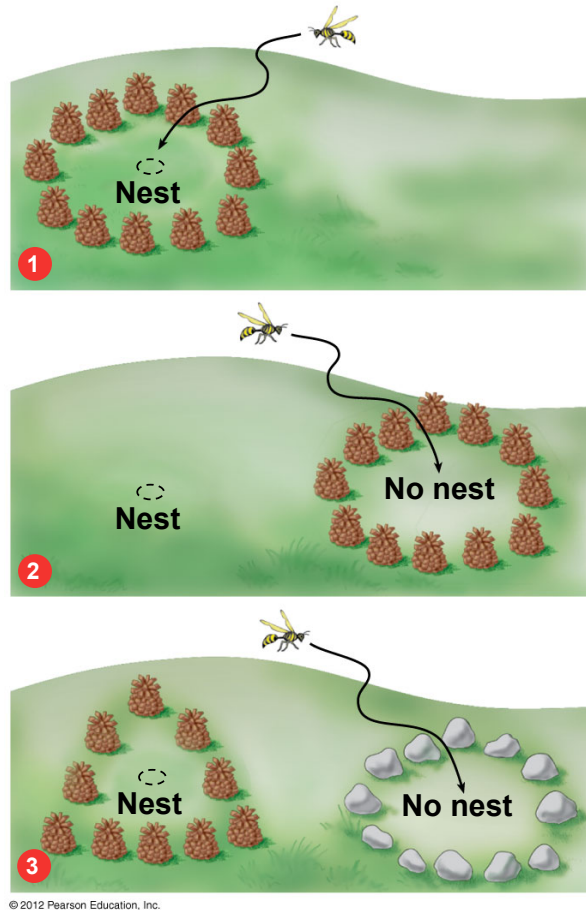


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## Animal movement may be a simple response to stimuli or require spatial learning

---

- In **spatial learning**, animals establish memories of landmarks in their environment that indicate the locations of
  - food,
  - nest sites,
  - prospective mates, and/or
  - potential hazards.
  - The digger wasp uses landmarks to keep track of her nests.



## Movements of animals may depend on cognitive maps

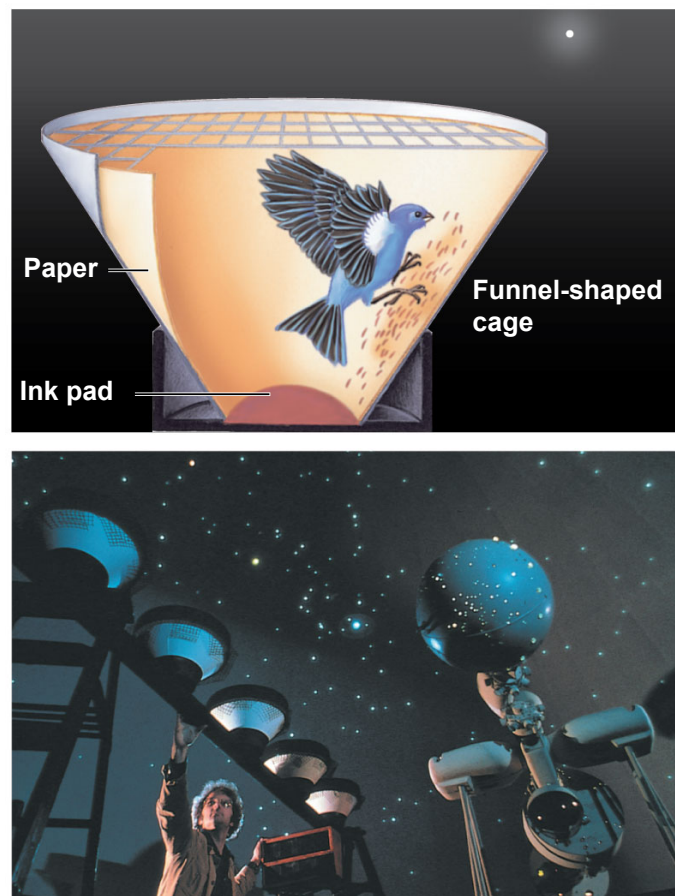
- An animal can move around its environment using landmarks alone.
- A **cognitive map**
  - is a more powerful mechanism and
  - uses an internal representation, or code, of the spatial relationships among objects in an animal's surroundings.
  - The most extensive studies of cognitive maps have involved animals that exhibit **migration**.

# Movements of animals may depend on cognitive maps

- Migrating animals stay on course using a variety of cues.
  - Gray whales seem to use the coastline to pilot their way north and south.
  - Birds migrating at night navigate by the stars.
  - Monarch butterflies appear to migrate using only innate responses to environmental cues.
  - Some songbirds show the interaction of genes and experience in migration.

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Figure 35.8



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## Animals may learn to associate a stimulus or behavior with a response

---

- **Associative learning** is the ability to associate one environmental feature with another.
  - In one type of learning, an animal learns to link a particular stimulus to a particular outcome. For example, a dog may expect to go for a walk if the owner picks up the leash.
  - **Trial-and-error learning** is an animal's ability to learn to associate one of its own behaviors with a positive or negative effect.
  - Memory is the key to all associative learning.

---

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# Social learning employs observation and imitation of others

---

- **Social learning** is learning by observing the behavior of others.
  - Many predators learn some of their basic hunting tactics by observing and imitating their mothers.
  - Alarm calls of vervet monkeys in Kenya provide an interesting example of how performance of a behavior can improve through social learning.

---

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Figure 35.10



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# Problem-solving behavior relies on cognition

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- **Cognition** is the ability of an animal's nervous system to perceive, store, integrate, and use information gathered by the senses.
  - Some animals have complex cognitive abilities that include **problem solving**, the ability to apply past experience to novel situations.
  - Problem-solving behavior
    - is highly developed in some mammals, especially dolphins and primates, and
    - has been observed in some bird species.

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Figure 35.11A



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Figure 35.11B



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# SURVIVAL AND REPRODUCTIVE SUCCESS

## Behavioral ecologists use cost-benefit analysis to study foraging

---

- Animals forage in a great many ways.
  - Some animals, such as crows, are feeding “generalists.”
  - Other animals, such as koalas, are feeding “specialists.”
- The mechanism that enables an animal to find particular foods efficiently is called a **search image**.

---

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## Behavioral ecologists use cost-benefit analysis to study foraging

---

- Animals with food choices face trade-offs involved in selection. The amount of energy may vary considerably in
  - locating,
  - capturing, and
  - preparing prey for consumption.

---

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## Behavioral ecologists use cost-benefit analysis to study foraging

---

- **Optimal foraging theory** predicts that an animal's feeding behavior should provide
  - maximal energy gain with minimal energy expense and
  - minimal risk of being eaten while foraging.
  - In England, a researcher tested part of this theory by studying insectivorous birds called wagtails, which often eat dung flies.

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Figure 35.12A



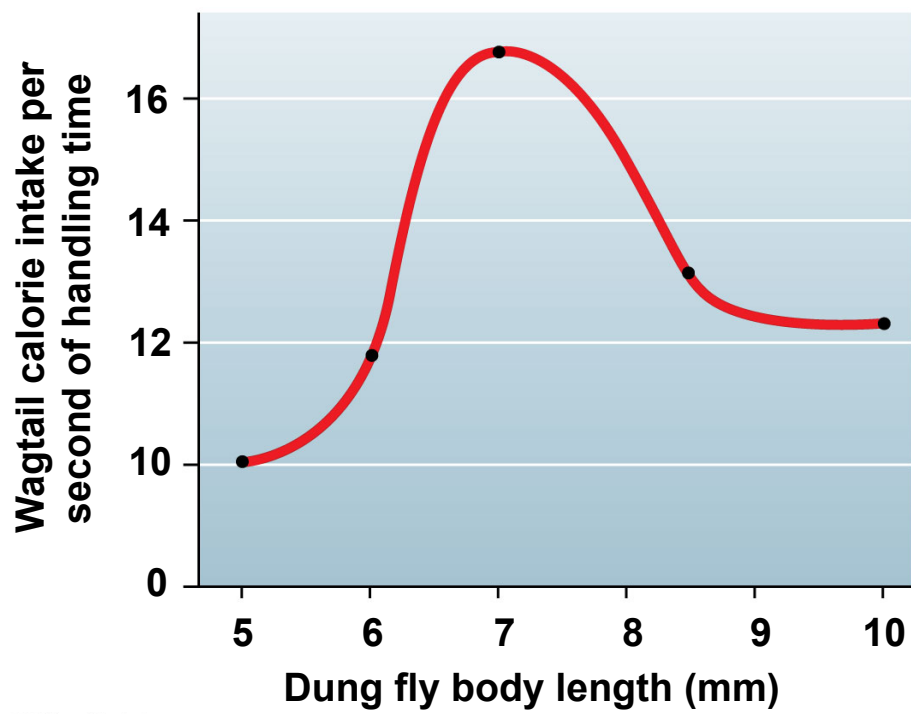
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Figure 35.12B

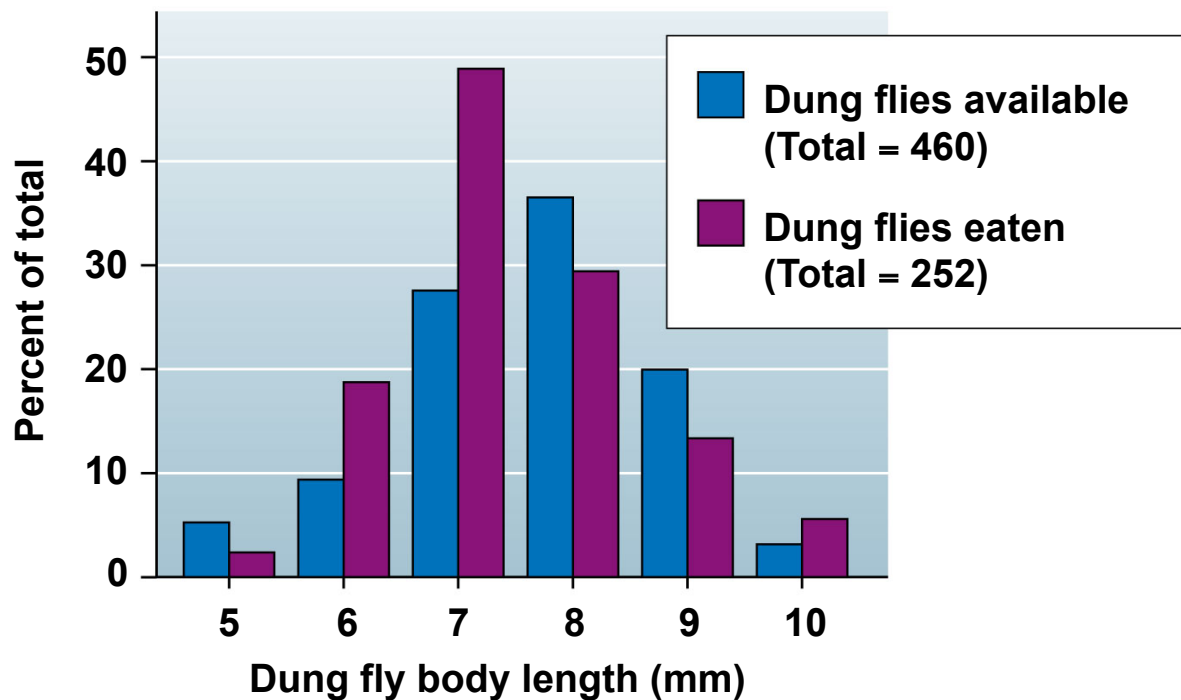


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Figure 35.12D



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## Communication is an essential element of interactions between animals

- Interactions between animals depend on some form of signaling between the participating individuals.
- Animal communication includes
  - sending,
  - receiving, and
  - responding to signals.

## Communication is an essential element of interactions between animals

---

- Forms of communication vary considerably and many animals use more than one type of signal simultaneously.
  - Nocturnal mammals use odor and sound.
  - Diurnal birds use visual and auditory signals.
  - Fish may use visual, electrical, and/or auditory signals.
  - Honeybees “dance” to signal to other bees the location of a food source.

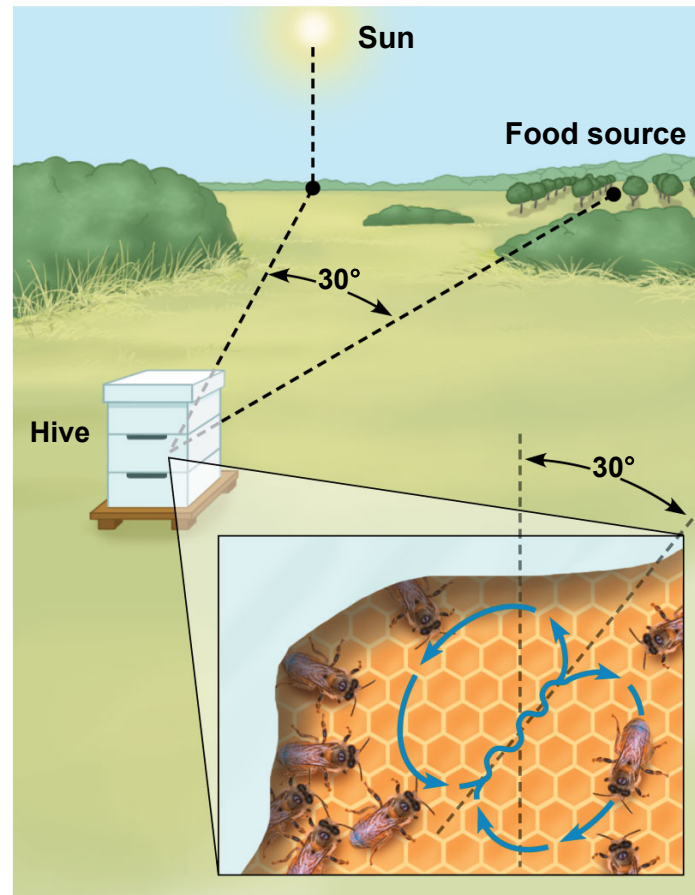
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Figure 35.13B



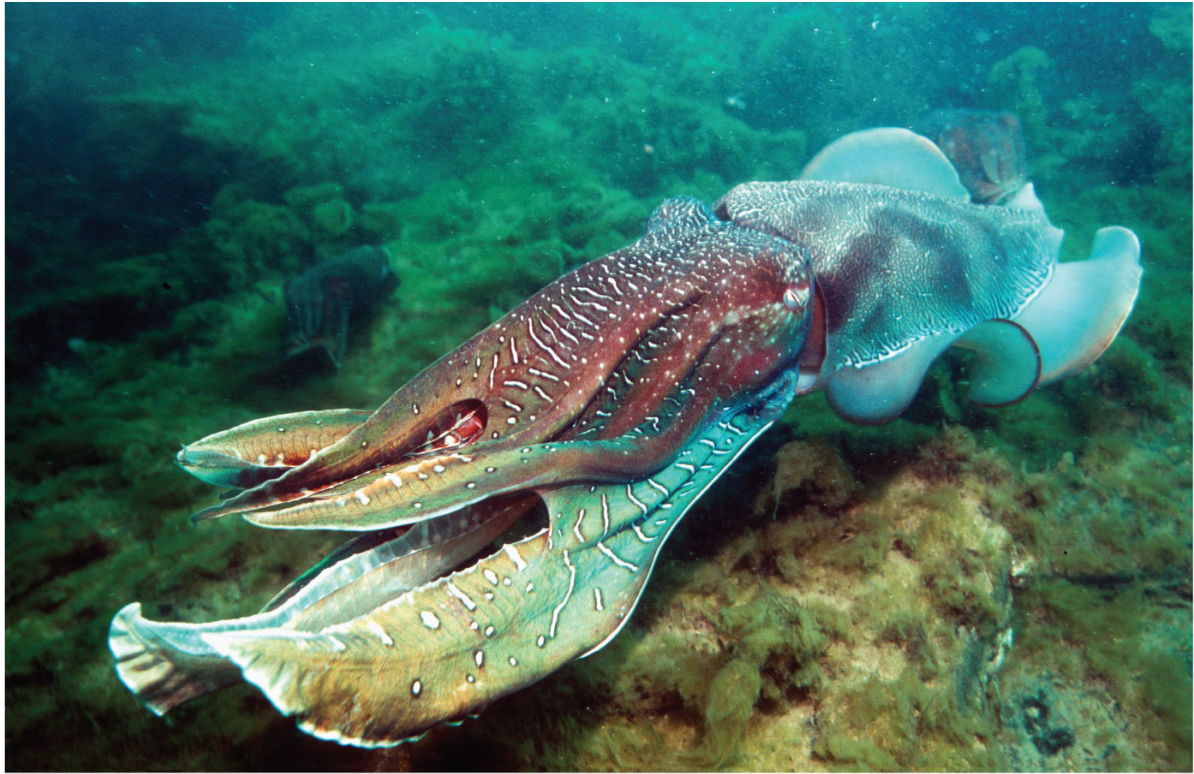
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## Mating behavior often involves elaborate courtship rituals

- Careful communication is an essential prerequisite for mating.
  - In many species, prospective mates must perform an elaborate courtship ritual.
  - The ritual confirms that individuals are of the same species, of the opposite sex, physically primed for mating, and not threats to each other.

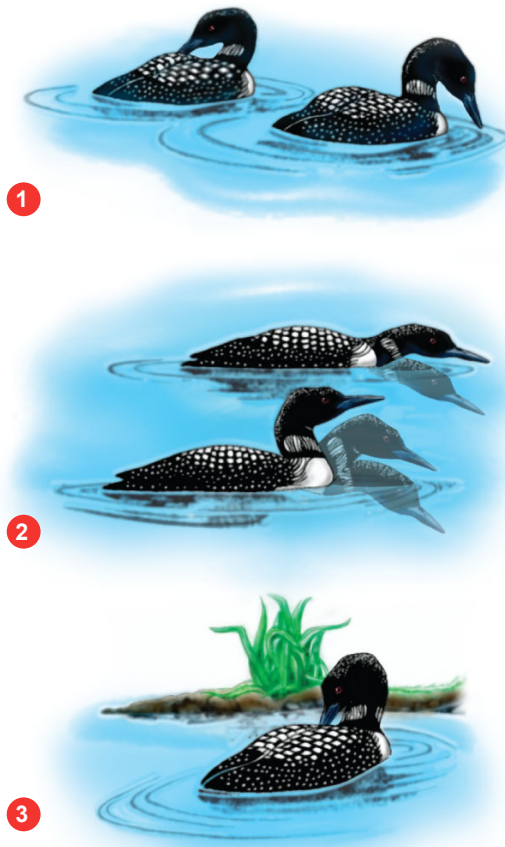


Figure 35.14A



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Figure 35.14B



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## Mating systems and parental care enhance reproductive success

---

- Animal mating systems fall into three categories.
  1. **Promiscuous** systems have no
    - strong pair-bonds or
    - lasting relationships between males and females.
  2. **Monogamous** systems have
    - one male and one female and
    - both parents participating in parental care.
  3. **Polygamous** systems
    - have one individual of one sex mating with several of the other and
    - usually consist of one male and many females.

## Mating systems and parental care enhance reproductive success

---

- The needs of offspring and certainty of paternity help explain differences in
  - mating systems and
  - parental care by males.

---

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Figure 35.15



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## CONNECTION: Chemical pollutants can cause abnormal behavior

- Endocrine-disrupting chemicals in natural environments may cause
  - abnormal behavior and
  - reproductive abnormalities.
- Examples of the effects of endocrine-disrupting chemicals in natural environments include
  - a drop in the intensity of nest-guarding behavior in certain male fish exposed to pollutants that mimic the female hormone estrogen and
  - masculinization of female mosquitofish anatomy.

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Figure 35.16A

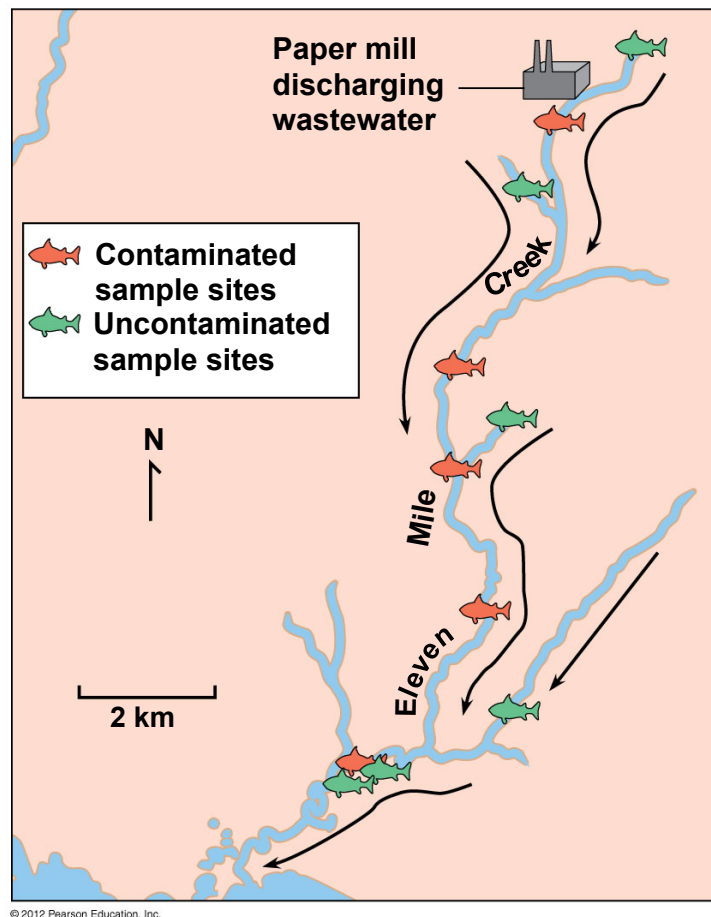
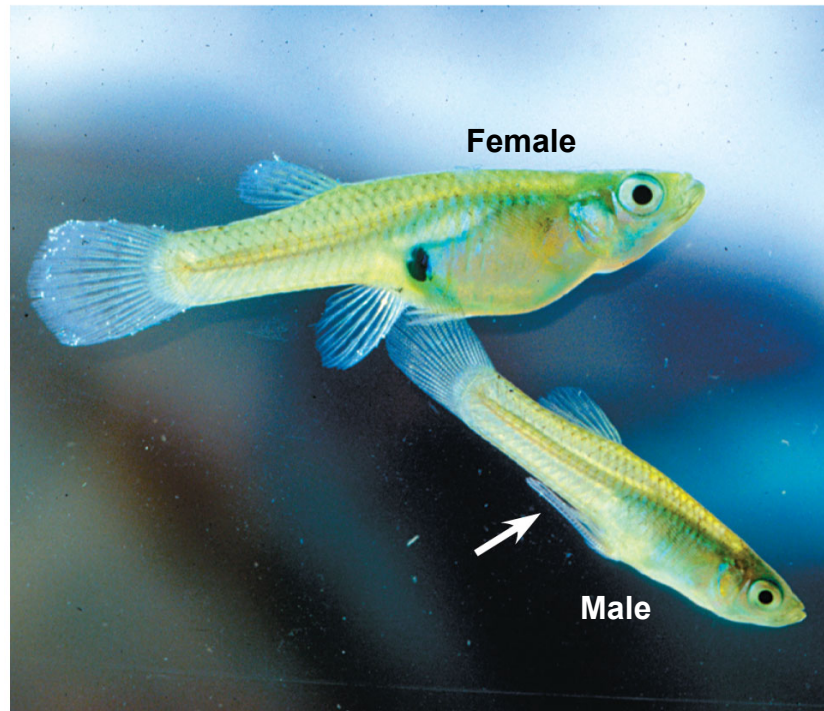


Figure 35.16B



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## SOCIAL BEHAVIOR AND SOCIOBIOLOGY

## Sociobiology places social behavior in an evolutionary context

---

- Biologists define **social behavior** as any kind of interaction between two or more animals, usually of the same species.
- **Sociobiology** applies evolutionary theory to the study and interpretation of social behavior to explain how social behaviors
  - are adaptive and
  - could have evolved by natural selection.

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## Territorial behavior parcels out space and resources

---

- Many animals exhibit territorial behavior.
  - A **territory** is an area, usually fixed in location,
    - which individuals defend and
    - from which other members of the same species are usually excluded.
  - Territories are usually used for
    - feeding,
    - mating,
    - rearing young, or
    - a combination of these activities.

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Figure 35.18A



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Figure 35.18B



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## Agonistic behavior often resolves confrontations between competitors

---

- In many species, conflicts that arise over limited resources, such as food, mates, or territories, are settled by **agonistic behavior**, which
  - is social behavior that consists of threats, rituals, and sometimes combat that determines which competitor gains access to a resource and
  - can directly affect an individual's evolutionary fitness.

**PLAY**

Video: Chimp Agonistic Behavior

**PLAY**

Video: Snake Ritual Wrestling

**PLAY**

Video: Wolves Agonistic Behavior

---

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Figure 35.19



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## Dominance hierarchies are maintained by agonistic behavior

---

- Many animals live in social groups maintained by agonistic behaviors.
- **Dominance hierarchy** is the ranking of individuals based on social interactions. Examples include
  - pecking order in chickens and
  - hierarchies among the females within a wolf pack.

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Figure 35.20



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## EVOLUTION CONNECTION: Altruistic acts can often be explained by the concept of inclusive fitness

---

- Many social behaviors are selfish because natural selection favors behaviors that maximize an individual's
  - survival and
  - reproductive success.
- **Altruism** is defined as behavior that reduces an individual's fitness while increasing the fitness of others in the population.

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## EVOLUTION CONNECTION: Altruistic acts can often be explained by the concept of inclusive fitness

---

- The concept of **inclusive fitness** describes an individual's success at perpetuating its genes by
  - producing its own offspring and
  - helping close relatives, who likely share many of those genes, to produce offspring.
- Natural selection favoring altruistic behavior that benefits relatives is called **kin selection**. Thus, genes for altruism may be propagated if individuals that benefit from altruistic acts are themselves carrying those genes.

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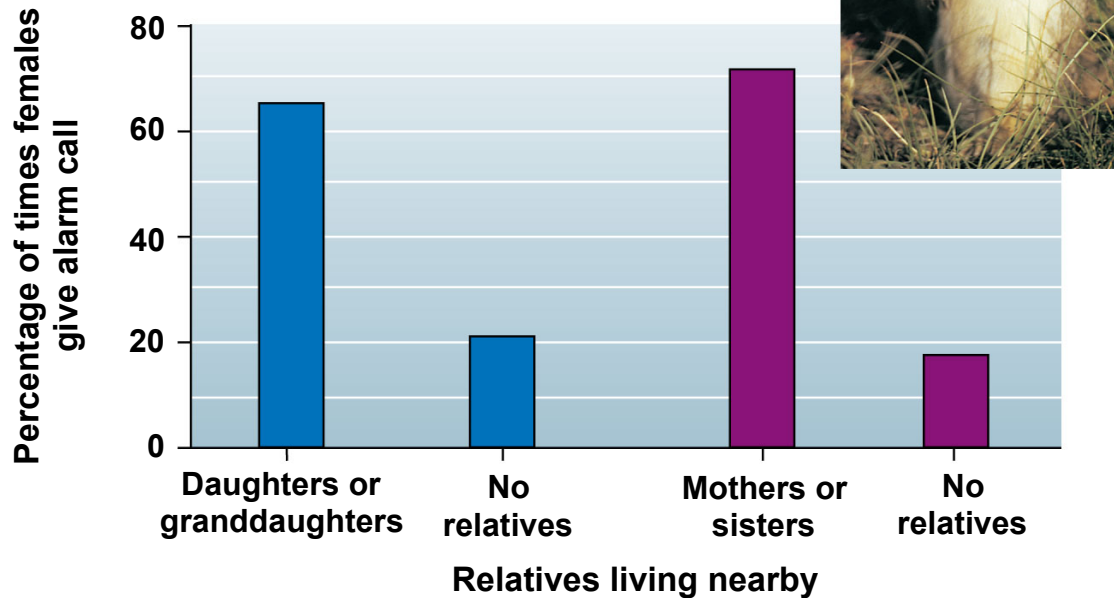
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## **EVOLUTION CONNECTION: Altruistic acts can often be explained by the concept of inclusive fitness**

---

- A classic study of Belding's ground squirrels, which live in regions of the western United States, provided empirical support for kin selection.





## SCIENTIFIC DISCOVERY: Jane Goodall revolutionized our understanding of chimpanzee behavior

- Dr. Jane Goodall has studied the behavior of chimpanzees in their natural habitat, in East Africa, since the early 1960s.
- Her research indicates that
  - chimps make and use tools and
  - male dominance hierarchies and reconciliation behaviors are integral parts of the lives of many primates.



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Figure 35.22B



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## **Human behavior is the result of both genetic and environmental factors**

---

- Twins provide a natural laboratory for investigating the origins of complex behavioral traits.
- Results from twin studies consistently show that for complex behavioral traits such as general intelligence and personality characteristics, genetic differences account for roughly half the variation among individuals.
- Genes do not dictate behavior but, instead, cause tendencies to react to the environment in a certain way.

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## **Human behavior is the result of both genetic and environmental factors**

---

- The mechanisms and underlying genetics of behavior are proximate causes.
- Sociobiologists explore the ultimate causes of human behavior.



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