1

Introduction: The Web of Life

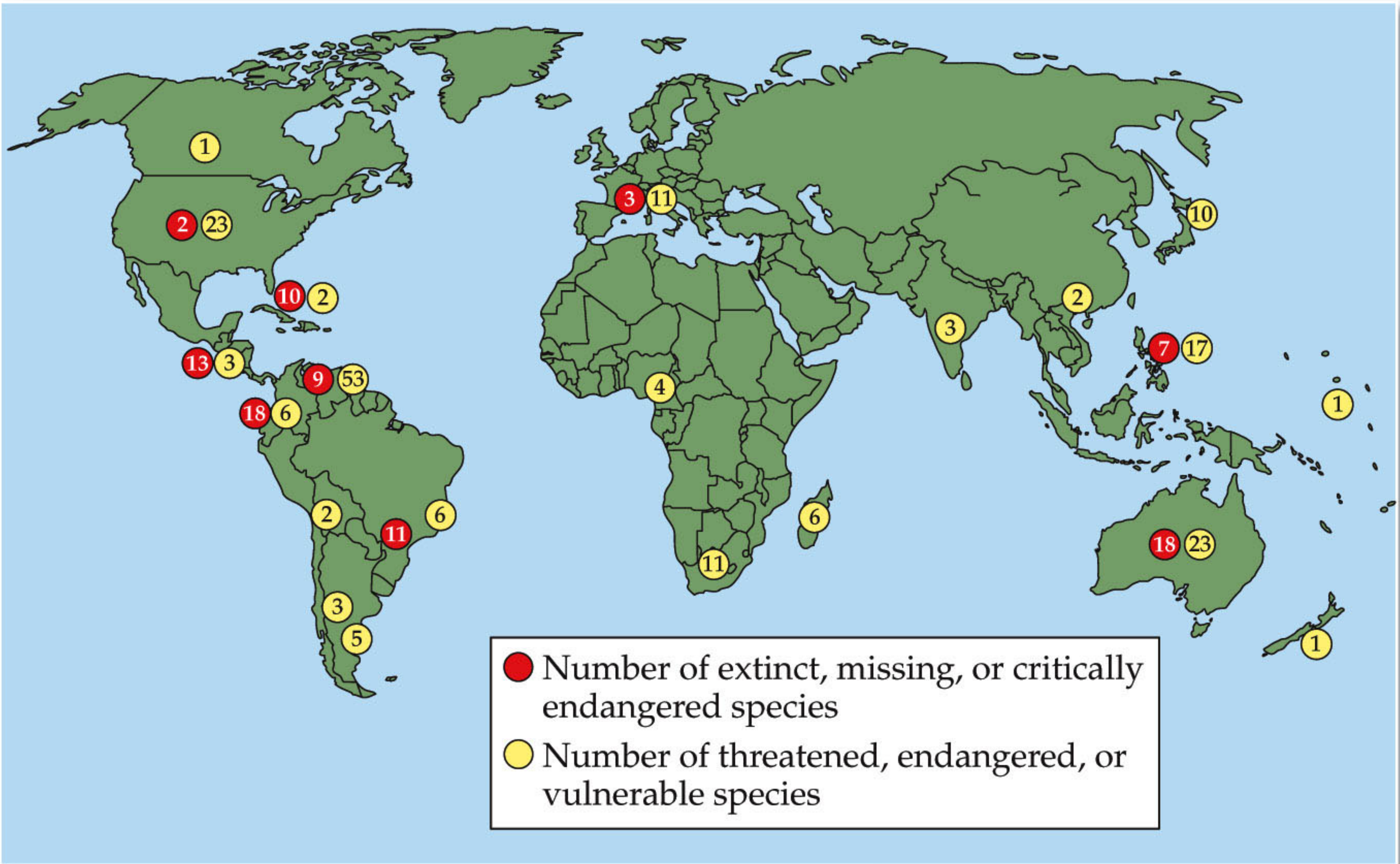
- *Case Study*: Deformity and Decline in Amphibian Populations
- Connections in Nature
- Ecology
- Answering Ecological Questions
- *Case Study Revisited*
- *Connections in Nature*: Mission Impossible?

Case Study: Deformity and Decline in Amphibian Populations

Figure 1.1 Deformed Leopard Frogs

- High incidence of deformities in amphibians
- Declining populations of amphibians worldwide

Figure 1.2 Amphibians in Decline



Case Study: Deformity and Decline in Amphibian Populations

Amphibian population declines were recent.

Many declining populations were in pristine or protected areas.

Amphibians are “biological indicators” of environmental problems.

Humans have enormous impact on the planet.

We must understand how natural systems work.

Ecology: The scientific study of how organisms affect—and are affected by—other organisms and their environment.

Concept 1.1: Events in the natural world are interconnected.

Even species that do not interact directly can be connected by shared environmental features.

Ecologists ask questions about the natural world to understand these connections.

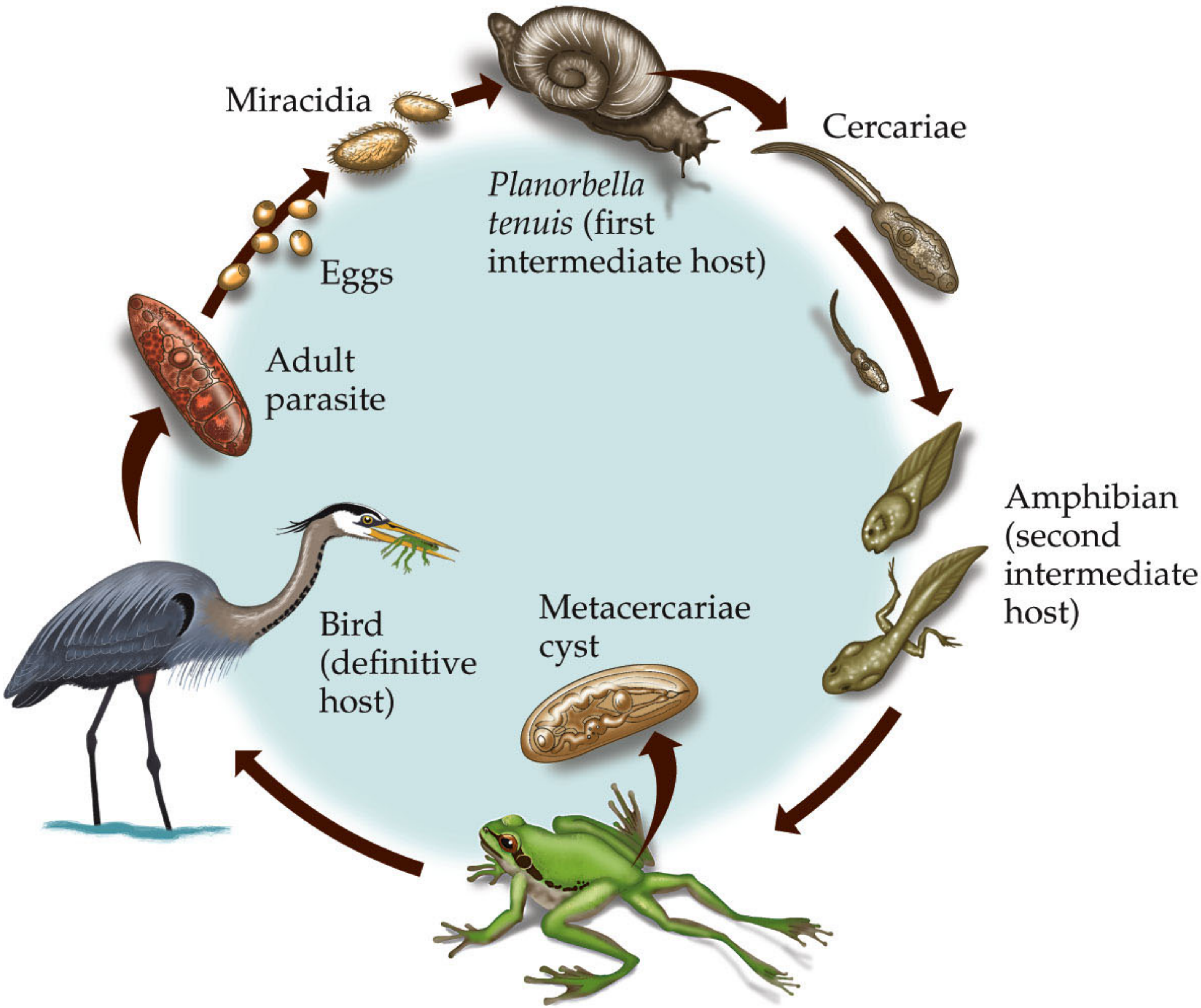
Observation of Pacific tree frogs suggested that a parasite can cause deformities.

Implanted glass beads mimic the effect of the cysts of *Ribeiroia ondatrae*, a trematode flatworm.

Further studies:

Deformities of Pacific tree frogs occurred only in ponds which also had an aquatic snail, *Planorbella tenuis*, the intermediate host of the parasite.

Figure 1.3 The Life Cycle of *Ribeiroia*

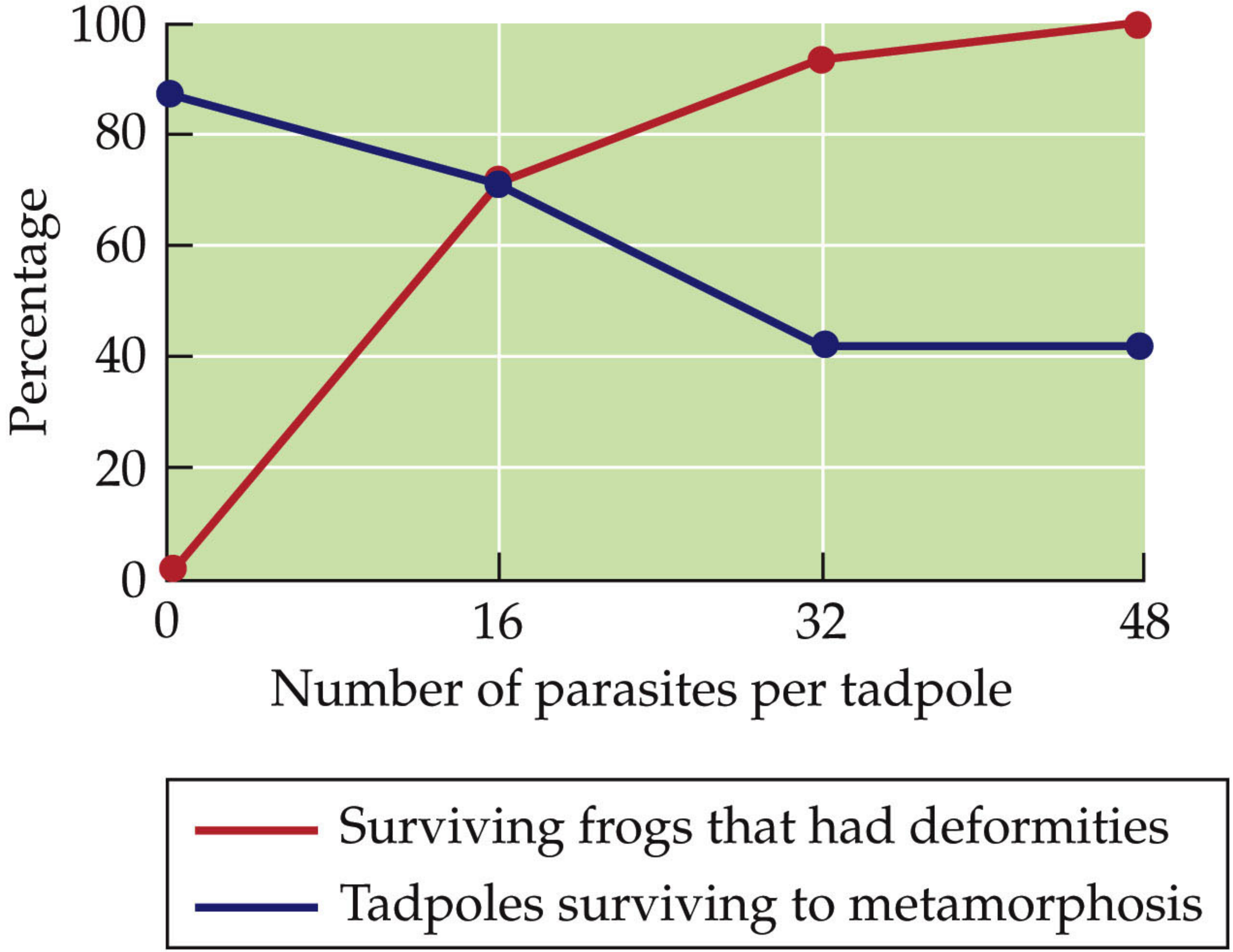


A **controlled experiment**:

Tree frog eggs were exposed to *Ribeiroia* parasites in the lab.

Four treatments: 0 (the control group), 16, 32, or 48 *Ribeiroia* parasites.

Figure 1.4 Parasites Can Cause Amphibian Deformities



ECOLOGY, Figure 1.4

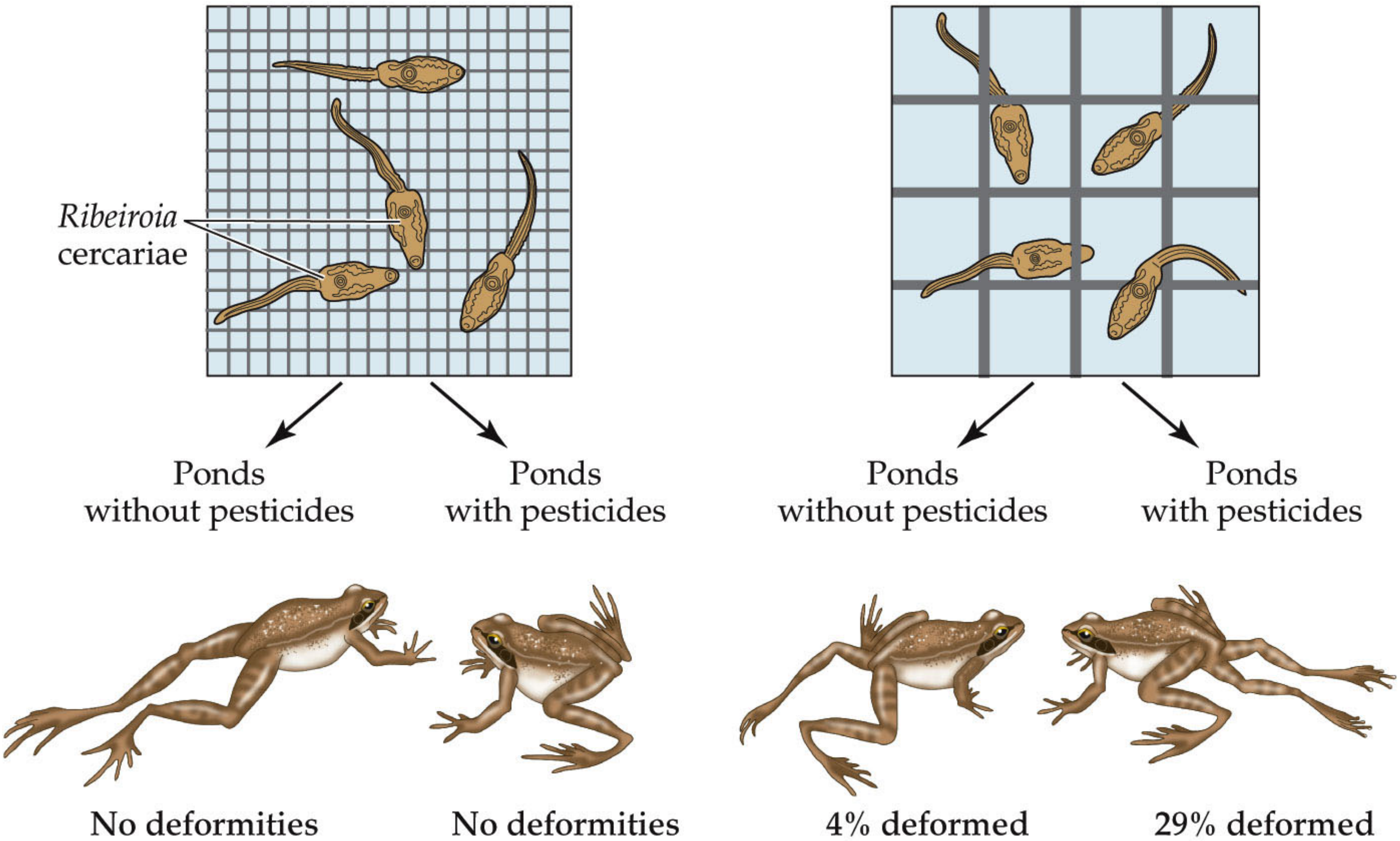
A field experiment:

Six ponds, three with pesticide contamination.

Six cages in each pond, three with mesh size that allowed parasite to enter.

Figure 1.5 Do *Ribeiroia* and Pesticides Interact in Nature? (Part 1)

Figure 1.5 Do *Ribeiroia* and Pesticides Interact in Nature? (Part 2)



ECOLOGY, Figure 1.5 (Part 2)

Hypothesis: Pesticides decrease the ability of frogs to resist infection by parasites.

Another lab experiment: Tadpoles reared in presence of pesticides had fewer white blood cells (indicating a suppressed immune system) and a higher rate of *Ribeiroia* cyst formation.

(A) Eosinophils

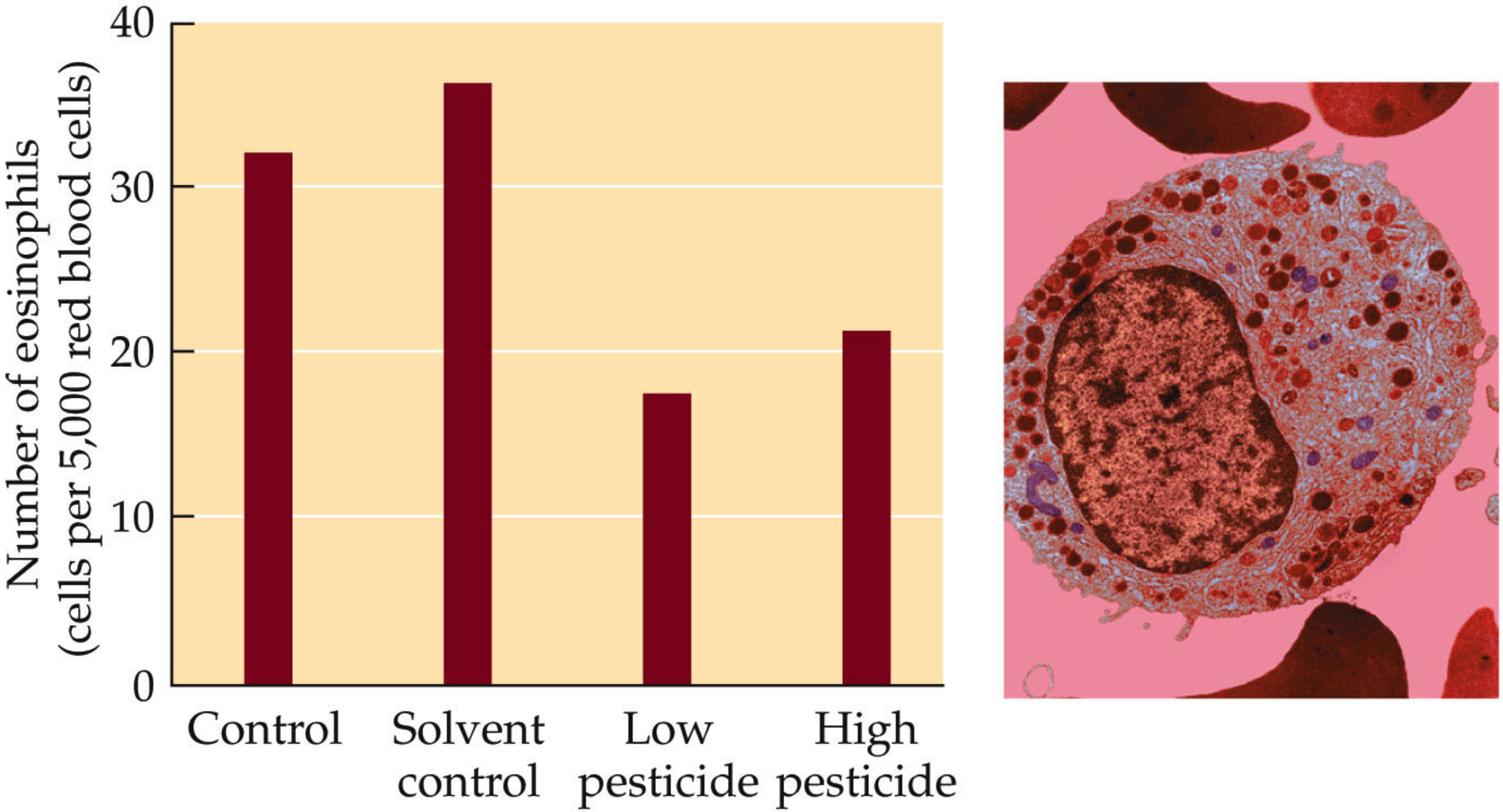
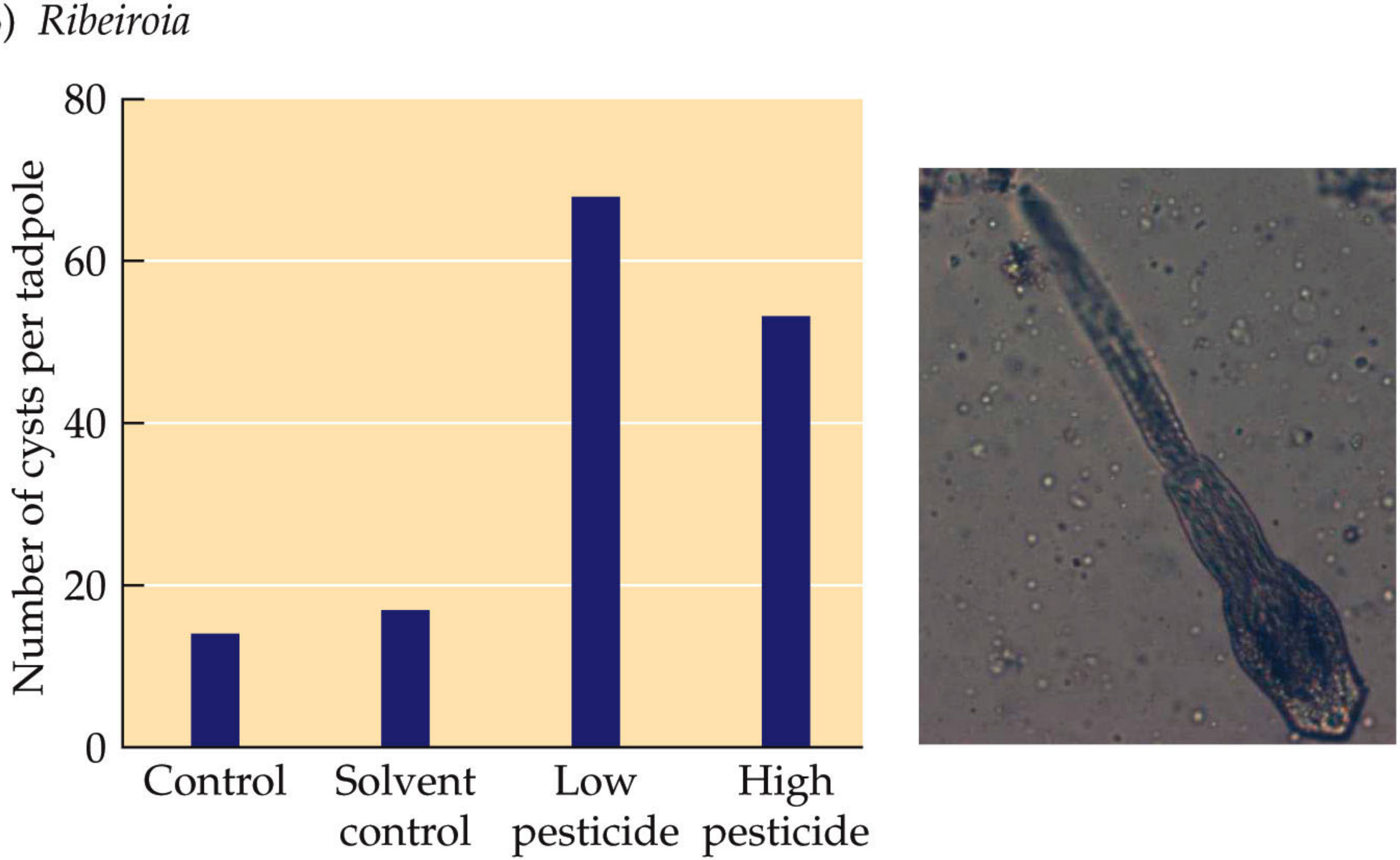


Figure 1.6 Pesticides May Weaken Tadpole Immune Systems (Part 2)



Connections in Nature

Synthetic pesticide use began in 1930s; use has increased dramatically.

Amphibian exposure to pesticides has also increased.

Any action (increased pesticide use by people) can have unanticipated side effects (more frequent deformities in amphibians).

Fertilizer use may also be a factor:

Fertilizer in runoff to ponds increases algal growth.

Snails that harbor *Ribeiroia* parasites eat algae.

Greater numbers of snails result in greater numbers of *Ribeiroia* parasites.

Many human actions have also increased human health risks.

Damming rivers in Africa increases habitat for snails that carry schistosomiasis.

New diseases, such as AIDS, Lyme disease, Hantavirus, Ebola, and West Nile fever may be related to human actions.

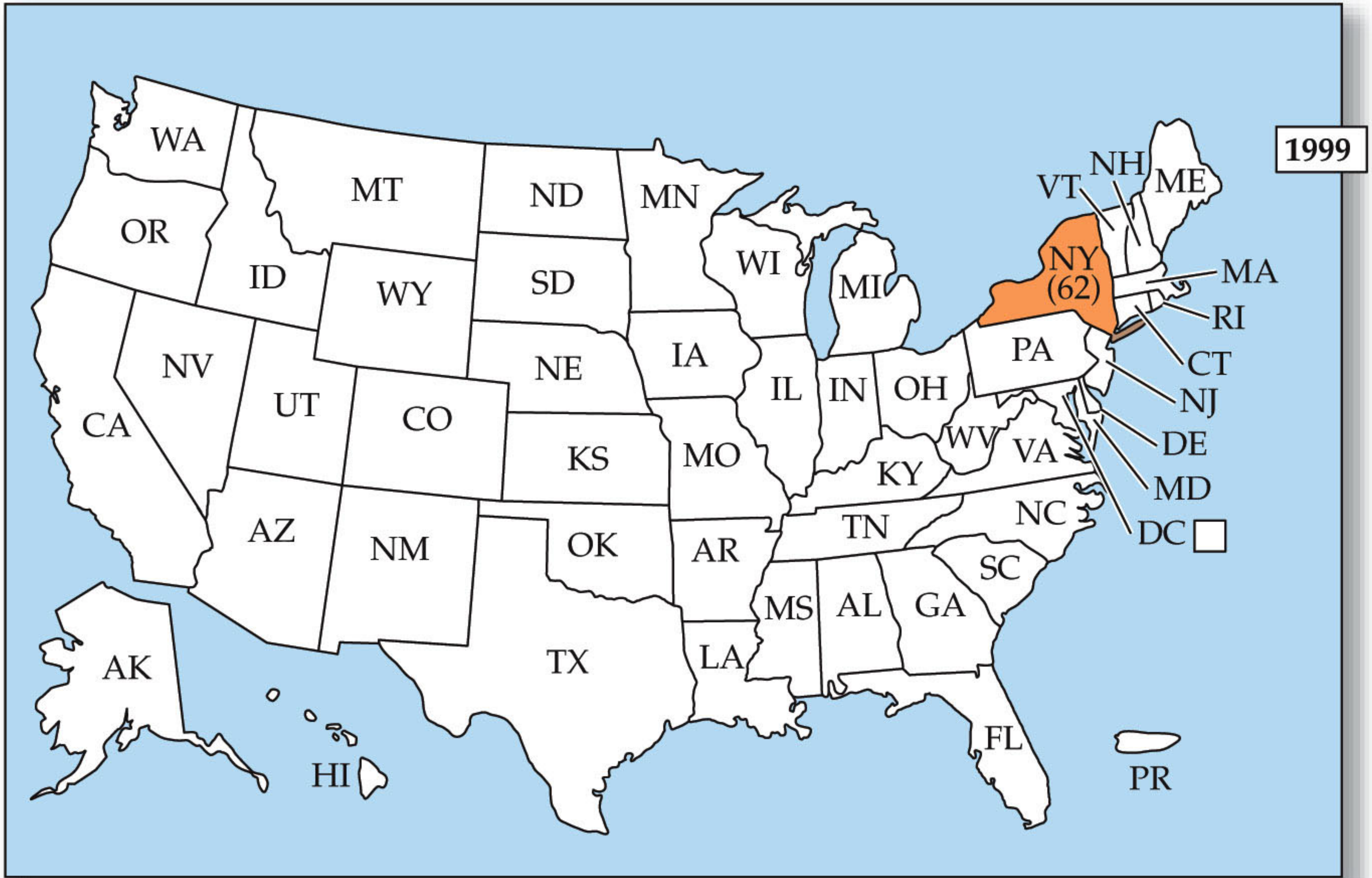
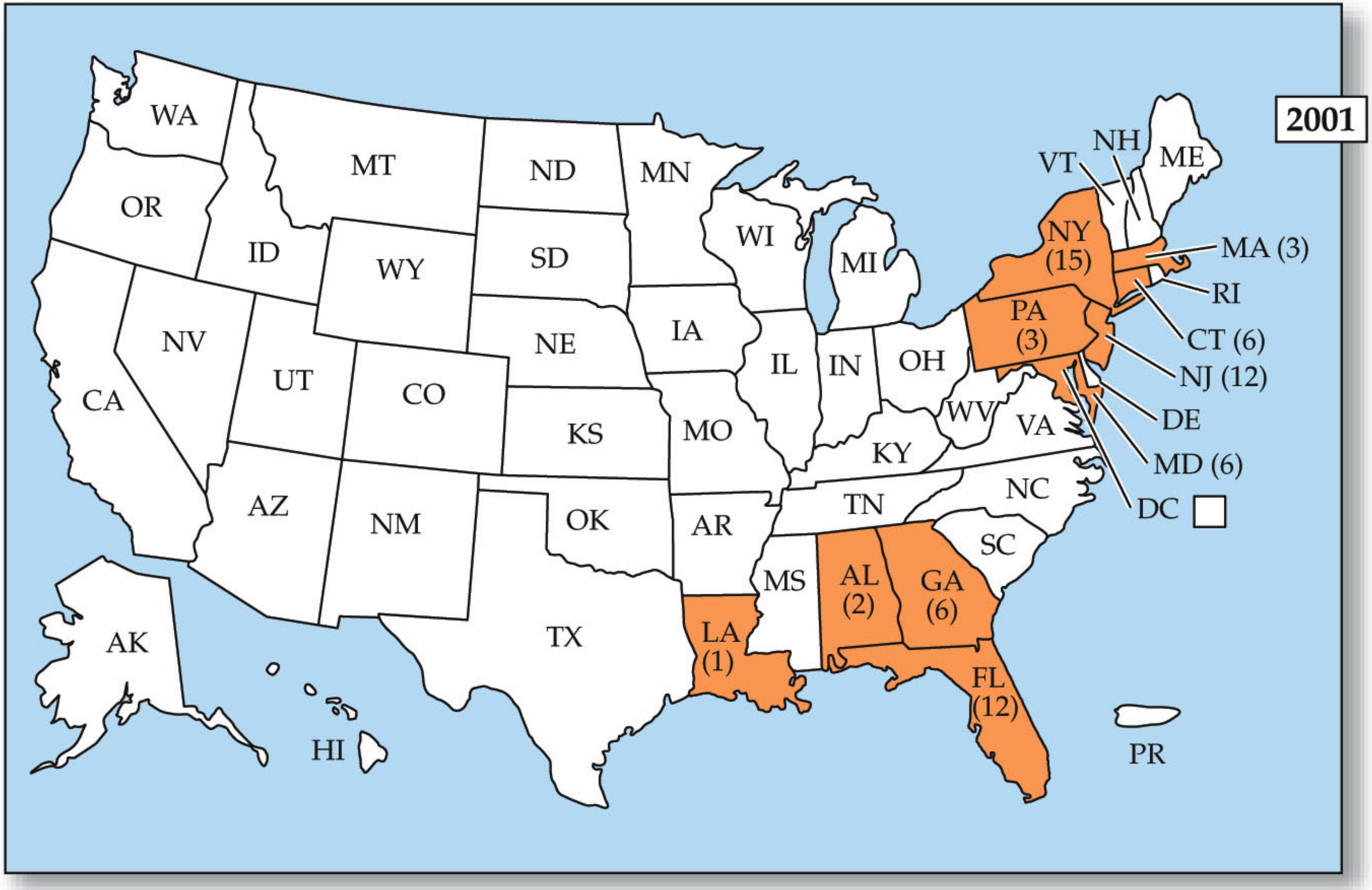

1999
WA
OR
CA
NV
ID
MT
WY
UT
CO
AZ
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
WV
VA
PA
NY
(62)
VT
NH
ME
MA
RI
CT
NJ
DE
MD
DC
AK
HI
PR

Figure 1.7 Rapid Spread of a Deadly Disease (Part 2)



Concept 1.2: Ecology is the scientific study of interactions between organisms and their environment.

Ecology is a branch of biology.

Environmental science incorporates concepts from the natural sciences (including ecology) and the social sciences, and focuses on solutions to environmental problems.

Early ecological views:

1. There is a “balance of nature,” in which natural systems are stable and tend to return to an original state after disturbance.

2. Each species has a distinct role to play in maintaining that balance.

Scientists now recognize that ecological interactions are more complex.

One view that stood the test of time: Events in nature are interconnected.

“You can never do just one thing.”

TABLE 1.1

Some Ecological Maxims

1. You can never do just one thing.
   Organisms interact with each other and with their physical environment. As a result, events in nature are connected and what affects one organism or place can affect others as well.

2 Everything goes somewhere.
   There is no "away" into which waste materials disappear.

3. No population can increase in size forever.
   There are limits to the growth and resource use of every population, including our own.

4. There is no free lunch.
   An organism's energy and resources are finite, and increasing inputs into one function (such as reproduction) results in a tradeoff in which there is a loss for other functions (such as growth).

5. Evolution matters.
   Organisms evolve or change over time—it is a mistake to view them as static. Evolution is an ongoing process because organisms continually face new challenges from changes in both the living and nonliving components of their environment.

6. Time matters.
   Ecosystems change over time. When we look at the world as we know it, it is easy to forget how past events may have affected our present, and how our present actions may affect the future.

7. Life would be impossible without species interactions.
   Species depend on one another for energy, nutrients, and habitat.

Ecology

Ecologists study interactions in nature across many levels of organization.

Ecological studies usually emphasize individuals, populations, communities, or ecosystems.

Figure 1.8 Levels of Biological Organization (Part 1)

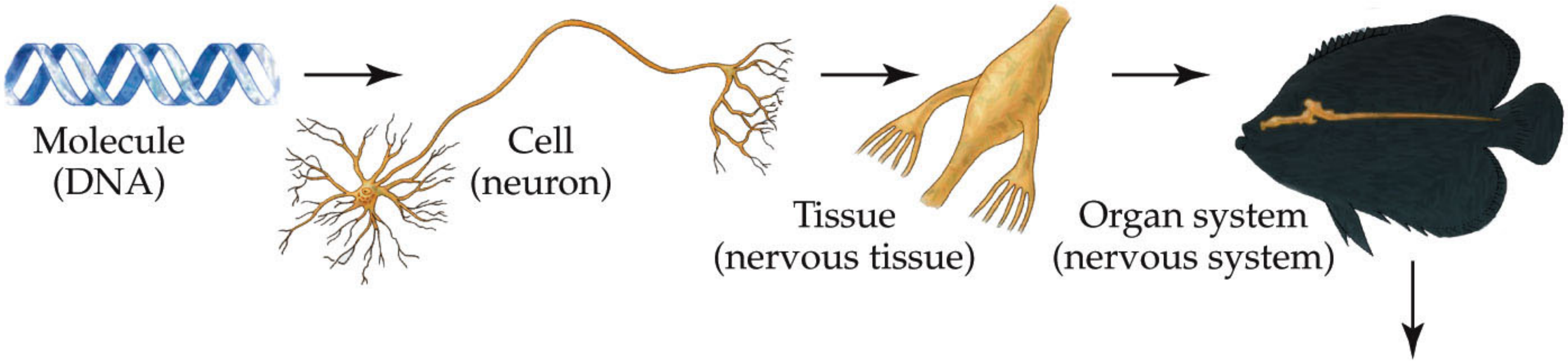
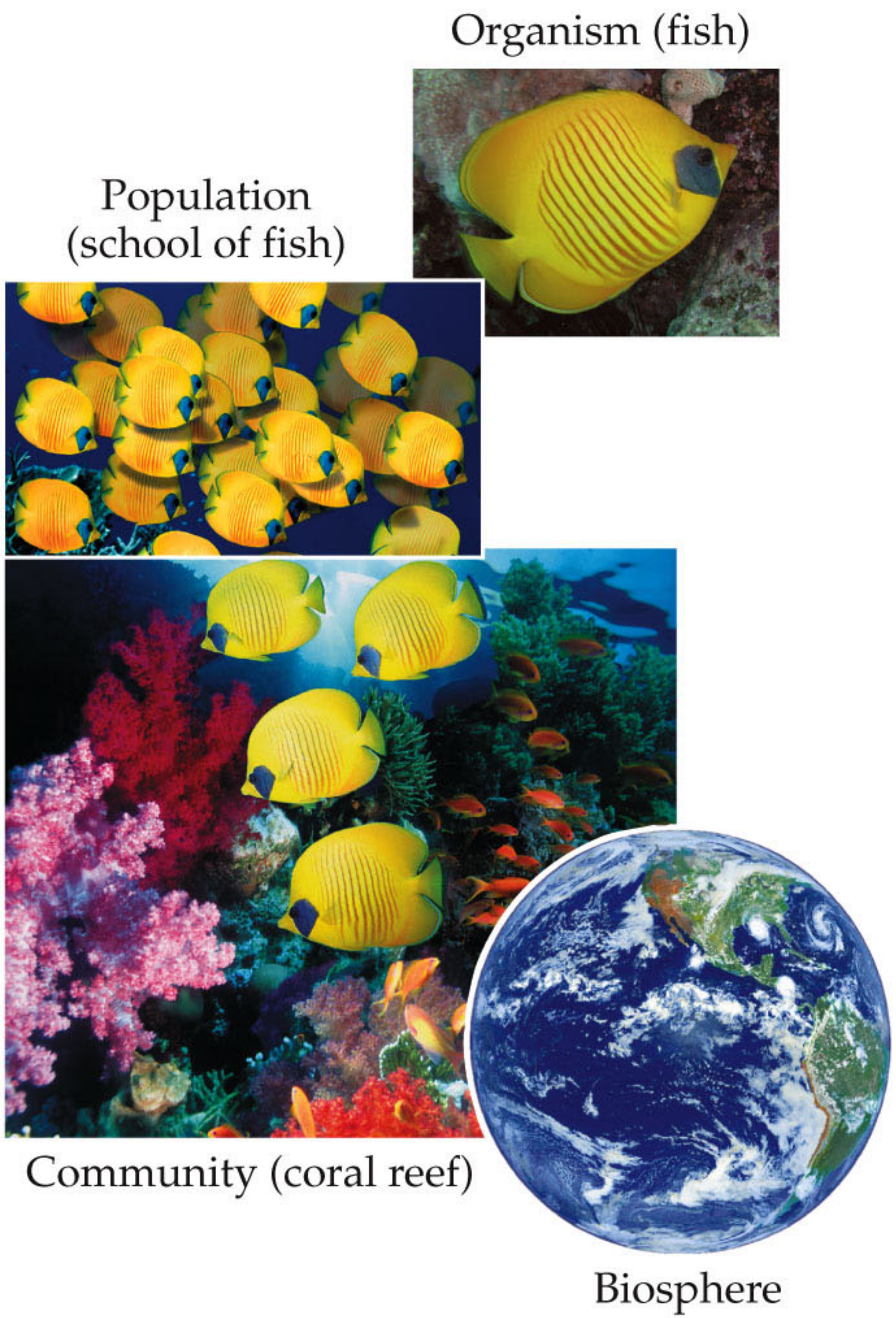


Figure 1.8 Levels of Biological Organization (Part 2)

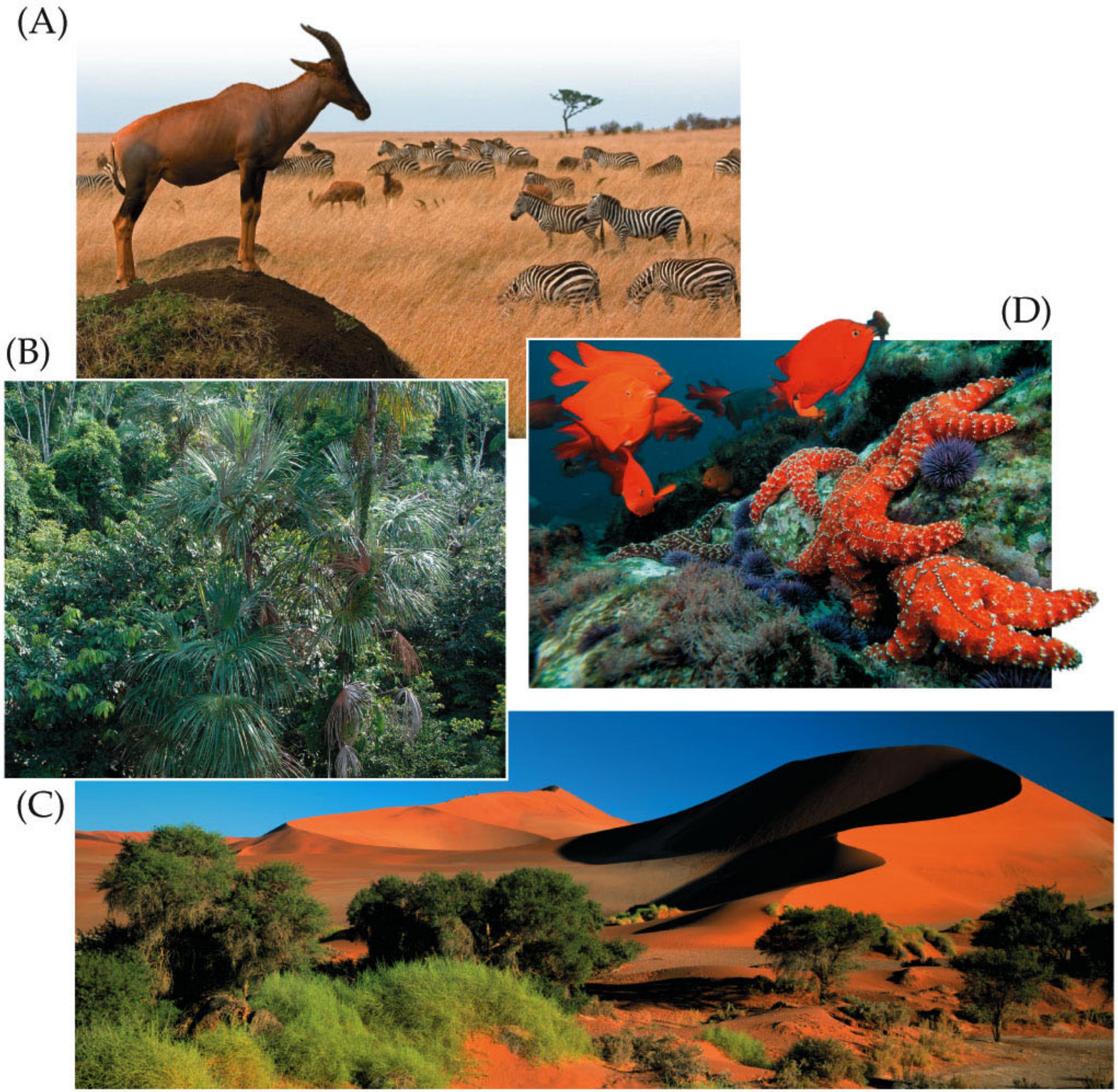


ECOLOGY, Figure 1.8 (Part 2)

A **population**: A group of individuals of a single species that live in a particular area and interact with one another.

A **community**: An association of populations of different species living in the same area.

Figure 1.9 A Few of Earth's Many Communities



ECOLOGY, Figure 1.9

An **ecosystem:** A community of organisms plus the physical environment in which they live.

All the world’s ecosystems comprise the **biosphere**—all living organisms on Earth plus the environments in which they live.

Ecology

Every ecological study must be done at an appropriate scale, both spatially and temporally.

Small spatial scale: Soil microorganisms.

Large spatial scale: Atmospheric pollutants.

Short temporal scale: Leaf response to sunlight.

Long temporal scale: How species change over geologic time.

All living systems change over time.

Evolution:

(1) A change in the genetic characteristics of a population over time.

(2) Descent with modification—organisms gradually accumulate differences from their ancestors.

TABLE 1.2

Key Terms for Studying Connections in Nature

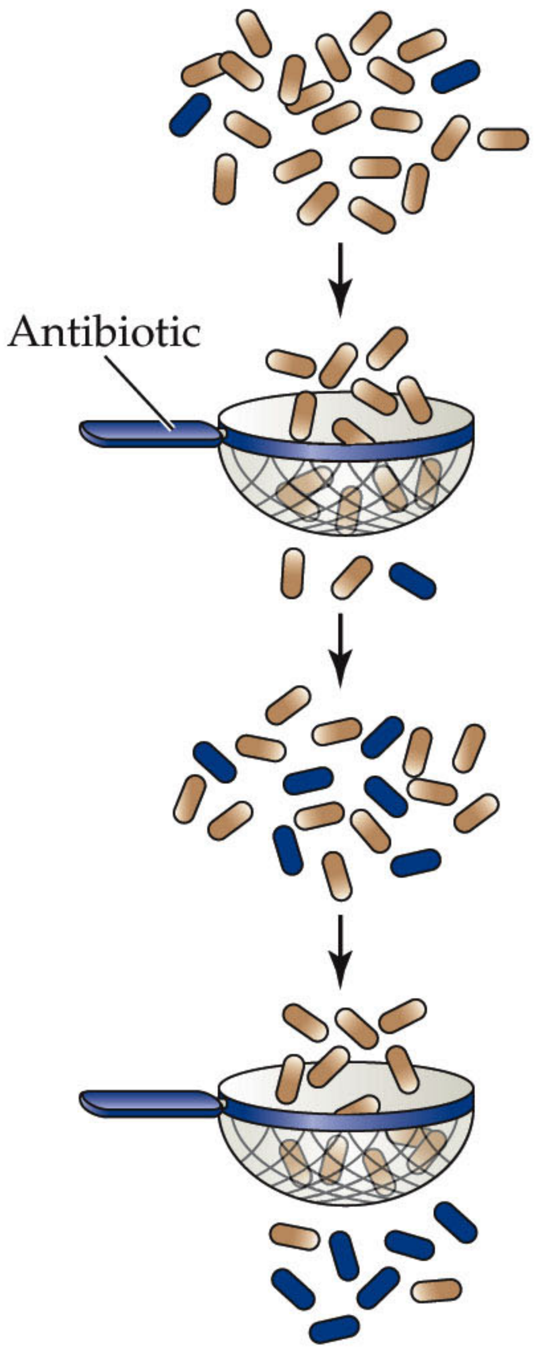
Term	Definition
Adaptation	A feature of an organism that improves its ability to survive and reproduce in its environment
Natural selection	An evolutionary process in which individuals that possess particular characteristics survive or reproduce at a higher rate than other individuals because of those characteristics
Consumer	An organism that obtains its energy by eating other organisms or their remains
Producer	An organism that uses energy from an external source, such as the sun, to produce its own food without having to eat other organisms or their remains
Net primary productivity (NPP)	The amount of energy (per unit of time) that producers fix by photosynthesis or other means, minus the amount used in cellular respiration
Nutrient cycle	The cyclic movement of a nutrient between organisms and the physical environment

Natural selection: Individuals with particular **adaptations** tend to survive and reproduce at a higher rate than other individuals.

If the adaptation is heritable, the offspring will tend to have the same characteristics that gave their parents an advantage.

As a result, the frequency of those characteristics may increase in a population over time.

Figure 1.10 Natural Selection in Action



ECOLOGY, Figure 1.10

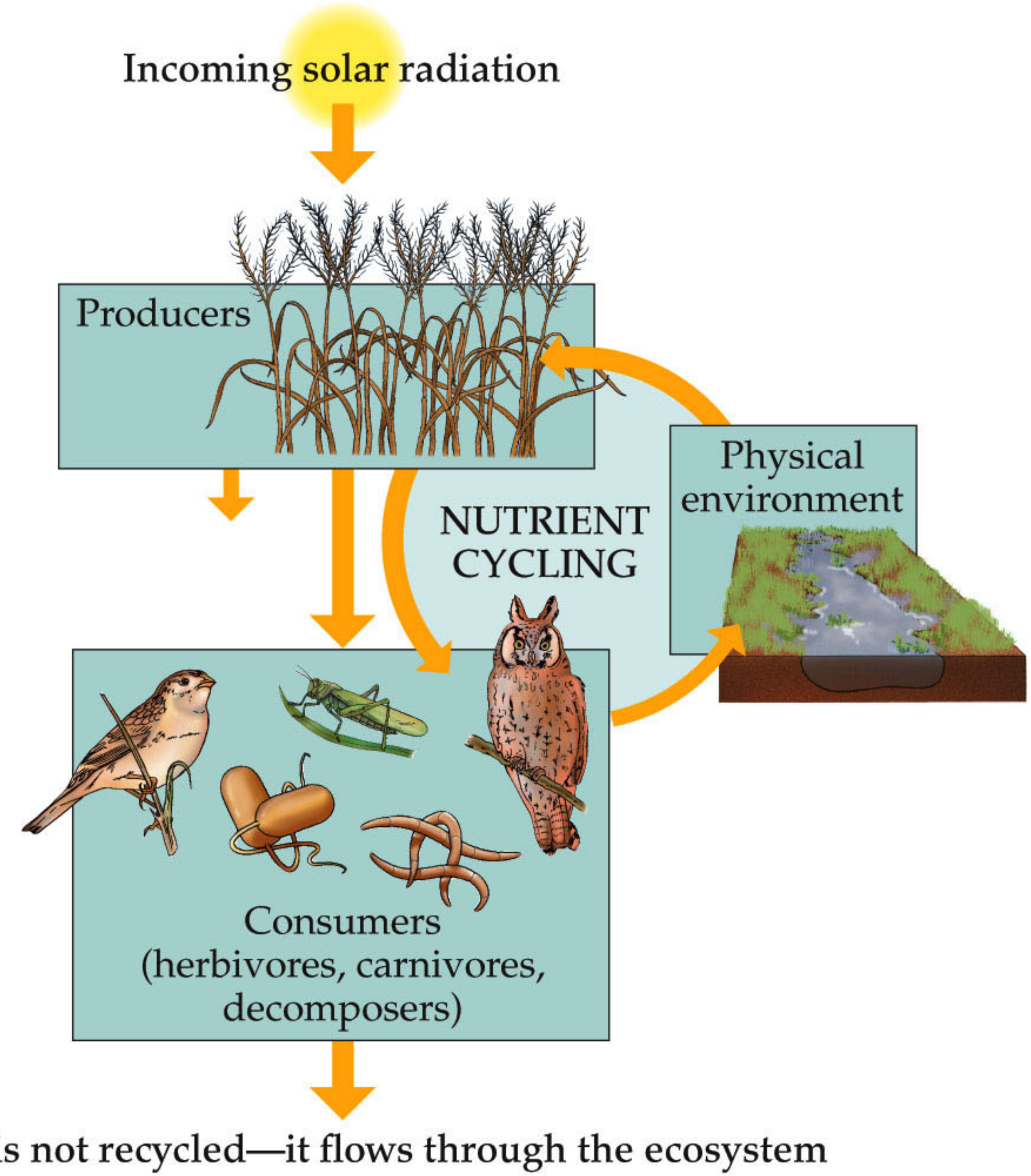
Ecosystem processes: Movement of energy and materials.

Energy enters the community when **producers** capture energy from an external source, such as the sun, and uses that energy to produce food.

Net primary productivity (**NPP**): Energy that producers capture by photosynthesis or other means, minus the amount they lose as heat in cellular respiration.

Energy moves through ecosystems in a single direction only—it cannot be recycled.

Nutrients are continuously recycled from the physical environment to organisms and back again.



ECOLOGY, Figure 1.11

Nutrient cycle: Cyclic movement of nutrients such as nitrogen or phosphorus between organisms and the physical environment.

Life would cease if nutrients were not recycled.

Concept 1.3: Ecologists evaluate competing hypotheses about natural systems with experiments, observations, and models.

Answering Ecological Questions

Ecologists use several methods to answer questions about the natural world:

- Observational studies in the field.
- Controlled experiments in the laboratory.
- Experiments in the field.
- Quantitative models.

An observational field study:

Johnson et al. (1999) surveyed ponds to determine that frogs with deformities were only present if the parasite's intermediate host snail was also present.

A controlled experiment:

Johnson et al. (1999) also tested their observations by exposing tadpoles to different levels of the parasite *Ribeiroia* in the laboratory.

A field experiment:

Kiesecker (2002) compared frogs from three ponds containing pesticides with frogs from three ponds that had no pesticides.

Ecological experiments can be done at different scales:

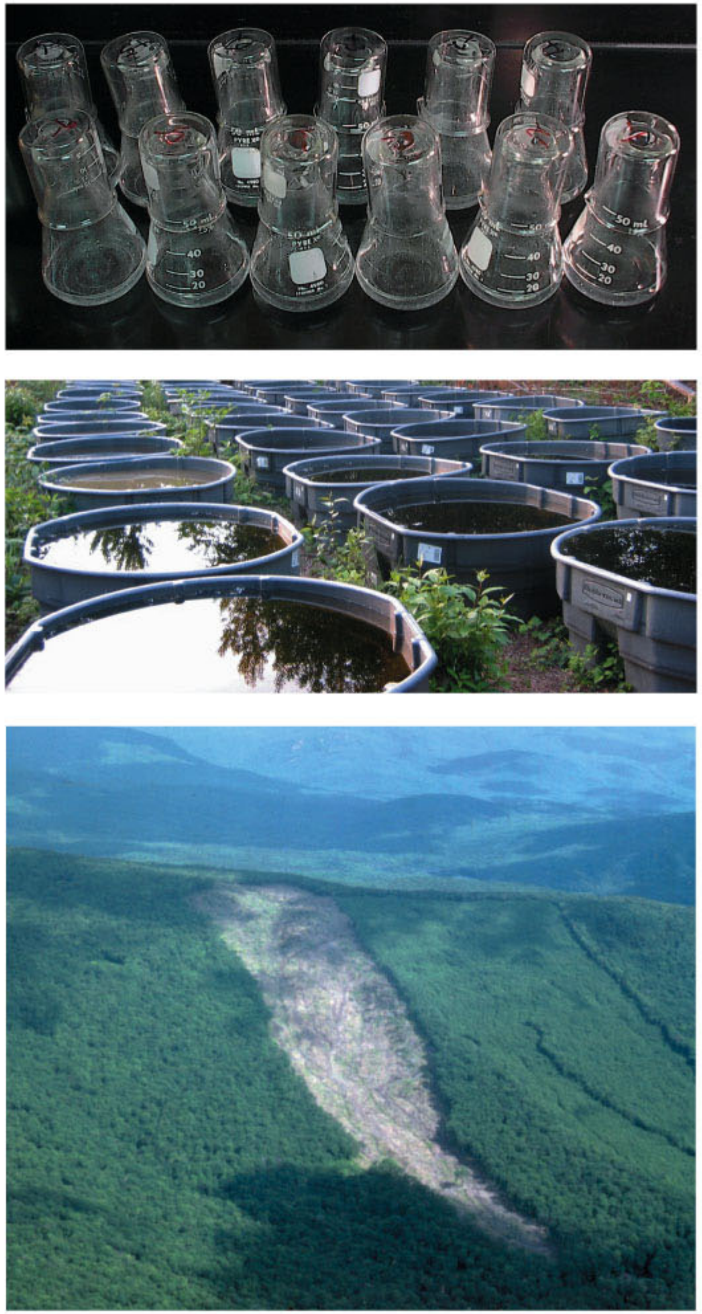
Small-scale laboratory experiments in test tubes or flasks, to whole-lake experiments.

Figure 1.12 Ecological Experiments

(A)

(B)

(C)



ECOLOGY, Figure 1.12

Answering Ecological Questions

Sometimes experiments are difficult or impossible to perform.

Example: When questions concern events occurring over large geographic scales, such as global warming.

Observational studies can be conducted over large regions or long time periods.

Answering Ecological Questions

The study of global warming involves using a mixture of observational studies, small-scale experiments, and quantitative (mathematical or computer) models.

Experimental design:

(1) **Replicate**—perform each treatment more than once.

(2) Assign treatments at random.

(3) Statistical analysis is used to determine significant effects.

Figure 1.13 Experimental Design and Analysis

Replication: As the number of replicates increases, it becomes less likely that the results were actually due to a variable that was not measured or controlled.

Assigning treatments at random helps to limit the effects of unmeasured variables.

Answering Ecological Questions

Scientists learn about the natural world by a series of steps called the **scientific method**:

1. Make observations and ask questions.
2. Use previous knowledge or intuition to develop possible answers (hypotheses).
3. Evaluate hypotheses by performing experiments, doing observational studies, or using quantitative models.

Answering Ecological Questions

4. Use the results to modify the hypotheses, to pose new questions, or to draw conclusions about the natural world.

The process is iterative and self-correcting.

Case Study Revisited: Deformity and Decline in Amphibian Populations

Studies have suggested that no single factor can explain decline of amphibian populations.

The declines seem to be caused by complex factors that often act together and may vary from place to place.

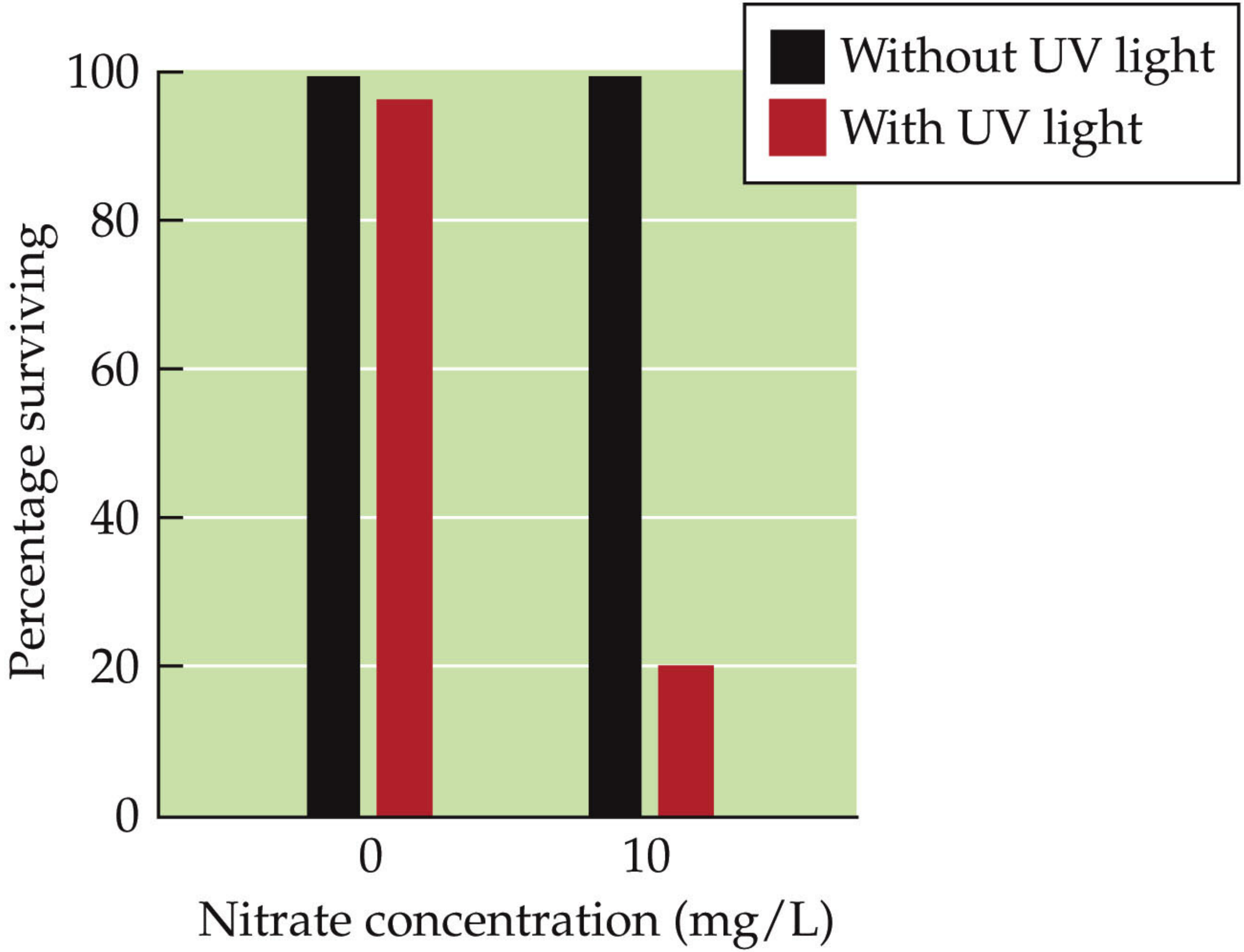
Case Study Revisited: Deformity and Decline in Amphibian Populations

Hatch and Blaustein (2003) studied the effects of UV light and nitrate on Pacific tree frog tadpoles.

At high elevation sites, neither factor alone had any affect. But together, the two factors reduced tadpole survival.

At low elevation sites, this effect was not seen.

Figure 1.14 Joint Effects of Nitrate and UV Light on Tadpole Survival



ECOLOGY, Figure 1.14

Case Study Revisited: Deformity and Decline in Amphibian Populations

The effects of pesticides are also complex.

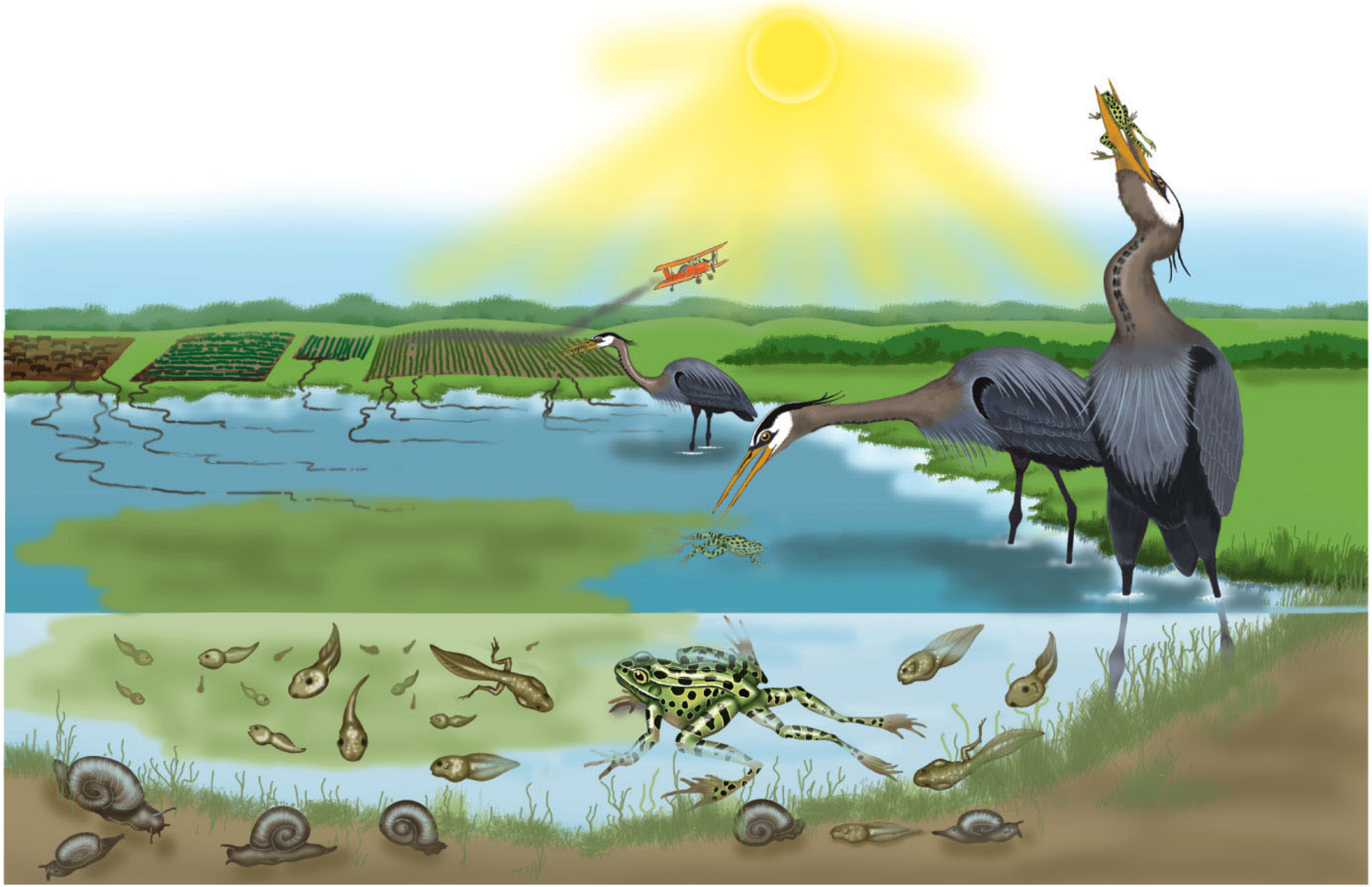
Some studies show that tadpoles are more susceptible when under stress, such as presence of predators.

Case Study Revisited: Deformity and Decline in Amphibian Populations

A broad set of factors can cause frog deformities, but little is known about how these factors interact.

There remains much to be discovered in the field of ecology.

Figure 1.15 Complex Causation of Amphibian Deformities



Connections in Nature: Mission Impossible?

The natural world is vast, complex, and interconnected.

But ecologists think that it is not impossible to understand it.

Ongoing efforts are sure to be challenging, exciting, and important to the well-being of human societies.