Biological Bafflers, Discrepant Data, Fascinating Facts & Quizzical Quandaries

Thomas O'Brien

NATURE is inherently fascinating and fun to observe and interact with: Witness childrens' playful, curious explorations. Beyond these simple, direct sensory encounters, modern science reveals a world far stranger and full of wonder than even a child's active imagination can create. This world is full of "discrepant data, fascinating facts and quizzical quandaries" that delight and challenge the hands, heads and hearts of children of all ages. Biology education should be built on an awareness and appreciation of:

1. The pervasiveness, diversity and interdependence of living organisms and their varied answers to basic survival questions.
2. The ability of the individual learner to actively construct meaning from interactions with this world.

Unfortunately, the FUNdaMENTAL aspects of the science of LIFE are all too often inadequately developed and biology, the last science course taken by the most students, becomes deadly. National Research Council publications argue that: "We are failing to relate the science of life to the experience of living . . . The task of learning becomes a treadmill, a daily but endless routine with no useful goals and little sense of accomplishment" (Goldsmith 1990). Biology textbooks are characterized as "a forced march through the phyla, rather than a problem-oriented look at diversity, evolutionary and ecological relationships . . ." (Rosen 1989). Conventional "two-by-four" biology teaching limits students' experiences to answers found between the two covers of the textbook and the four walls of the classroom. It focuses on "covering" decontextualized terminology and produces "bored" students. By contrast, "minds-on" biology teaching involves students in the historical and ongoing, personal and communal story of biological questions and discoveries.

While new, less encyclopedic and more involving textbooks are needed, the following "biological bafflers" can be used with any curriculum to motivate interest and instill a sense of wonder about the workings of the natural world. They may be used effectively during any phase of the teaching process: Engagement. Exploration. Explanation. Elaboration and Evaluation (Bybee & Landes 1990). Specific uses include:

1. Facts or inquiry-oriented puzzles to use at the start of a new lesson to challenge students' current conceptions or complacency
2. Analogies and comparisons to help bridge the gap between the concrete, familiar world of the student and the abstract, unfamiliar world of scientific concepts (Middleton 1991)
3. Mental "push-up type" homework questions and/or research projects for formative evaluation of learning
4. Hypotheses for lab and field-based studies of organisms (especially invertebrates)
5. Motivational games such as Nature's Trivial Pursuits (with the American Association for the Advancement of Science Project 2061 or National Science Teachers Association Scope & Sequence project conceptual themes as the categories)
6. Debate questions (Zipko 1991)
7. Test items to assess higher levels of understanding
8. Extra credit puzzles or literature reports for individual or cooperative learning groups
9. Bulletin board "believe-it-or-not" items
10. "Stump-the-teacher" items (if student-generated items are used).

The primary thing to avoid is using the items in a fashion that promotes mindless, short-term memorization of disconnected facts for regurgitation on a test. Quality science teaching helps students discover new ways of looking at their world. It helps them design their own sets of wide-angle, telephoto and close-up lenses (tools); imaging and "imagining" techniques: and conceptual filters (themes) to go exploring with, not with still photos taken from someone else's vacation. Especially note that any "answer" to a biological baffler can generate new, more refined questions, and students should be encouraged in this pursuit. The following represent a

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small subset of items that may be culled from the list of sourcebooks included.

Sample Biological Bafflers

Animal Lovemaking—Risky Business?

Question

1. Sexual reproduction has many advantages over asexual reproduction. This notwithstanding, how might the sexual drives of some animals be considered a "fatal attraction"?

Answers

1. In captivity or other times of severe stress, the female praying mantis occasionally devours the male during copulation which may continue even after she has bitten off his head and part of the upper torso.
2. The female black widow spider waits until after copulation to do the same, but may devour as many as 25 suitors in one day unless the much smaller male suitor is successful in temporarily binding her legs with web silk.
3. A female sea worm bites off the male's tail that contains testes and sperm which are swallowed, acted upon by the female's digestive juices and used to fertilize her eggs.
4. When leeches mate, the one playing the male role clings to the body of the female and deposits a sac of sperm on her skin. The sac produces flesh-deteriorating enzymes that eat a hole through the skin and fertilize the eggs within her body.
5. The Amazon molly is an all-female species. Males from another closely related species are temporarily "borrowed" for their sperm and then driven off. The sperm activate egg cell division without actually transferring genetic information. Parthenogenesis effectively counters the cannibalistic behavior of the males in the guppy family which otherwise devour the offspring.
6. A snail mates only once in its entire life, but the act of copulation may take as long as 12 hours.

Animal-Size Appetites?

Question

1. Humans consume about 1/50 their body weight in food daily whereas birds, shrews, moles and other small mammals may eat as much as half their body weight in food or more on an ongoing daily basis. Why?

Answer

1. Heat loss in animals occurs mainly through the surface area, whereas heat production occurs in all cells and varies in proportion to an animal's volume. Since volume (proportional to the cube of average length) increases faster than surface area (proportional to the square of average length), as the size of animals decreases, heat loss increases. In proportion to body weight, small animals lose more heat than humans so they need extra calories to maintain body temperature. At the other extreme, the African elephant, living in a hot climate, needs the larger surface area provided by its enormous ears to dispose of extra body heat through radiation and evaporation.

Digging for Gold?

Questions

1. Beyond its use as bait to catch fish, how does the earthworm inadvertently serve human needs?
2. What unique anatomical features help it in its work?

Answers

1. An earthworm can till, fertilize, drain and aerate half a pound (0.2 kg) of soil per day. There are approximately 3 million worms per acre of fertile soil.
2. The earthworm lacks lungs (and breathes through its skin), but may have as many as 10 hearts; a gizzard (for grinding); rough, bristle-like projections or setae (for anchoring); and range in size from 1/25th of an inch (1 mm) to more than 11 feet (3.3 m). If cut in half (by the "early" bird), the nocturnal earthworm may regenerate into two fully functioning organisms since it has several sets of vital organs throughout its body. If it is not cut in the middle, only one segment will live. It is also hermaphroditic and can self-fertilize or mate with another of its species.

Drinking, the Unquenchable Thirst

Question

1. Water is essential to life. Humans cannot survive without water longer than about a week and a half (the record is 11 days). What are some of the animals that can beat this record and how do they do it?

Answer

1. A camel can survive for as long as two weeks without drinking, but may make up for this by drinking as much as 28 gallons (106 l) in 10 minutes. A giraffe can go without water even longer than a camel can. But the real champion is the kangaroo rat of the American Southwest that never needs to "drink" water. Instead, it produces fluid internally from oxidation of food and from the air it breathes.

Eating: It's Enough To Make You Lose Your Appetite

Question

1. All animals obtain and digest food. But what are some of the unique ways different species go about doing this?

Answers

1. Archerfish spit water at insects sitting on branches above ponds and grab them when they hit the surface. What difficulty is encountered when trying to shoot out of water? (refraction)
2. Blue whales, the largest animal ever to live on earth (100 ft/30 m and 153.5 short tons/138 metric tons; a full-grown African elephant is about the same weight as a newborn baby blue whale), have the slowest metabolism (their hearts beat only nine times a minute) and feed on some of the smallest organisms, sea plankton. Both the blue whale and the African elephant are threatened by extinction—how is their plight different than that of dinosaurs? (human-induced extinction).
3. Chameleons which average about 6 to 7 inches/17 cm in length have tongues as long as 10 inches/25 cm for catching insects. Woodpeckers and frogs also have long, insect-catching tongues.
4. Crocodiles do not chew food, but swallow it whole. Several pounds of small stones in their stomach aid in grinding up the food. Similarly, birds, lacking teeth, routinely swallow gravel which, when agitated in the bird's stomach, grinds food—they "chew" with their stomachs.
5. Mosquitos do not bite, they stab their hosts and then suck up as much as 1 to 3 times their own weight in one sitting. While this amount of blood loss doesn't harm its prey, the stabbing mosquitos (females only) are vectors for many diseases, including malaria and typhus.
6. Snakes can go for long periods of time (some for as much as a year) without eating a single morsel of food. Pythons, like most snakes, can swallow prey several times their size, such as a rabbit. In swallowing, snakes do not use their tongues as humans do, but rather draw themselves over their prey.
7. Spiders don't eat their insect victims, they drink them. A spider covers its victim with digestive juices and then sips the dissolved tissue up its tubelike mouth. Large spiders, like the tarantula, are able to ingest an entire mouse or small bird, bones and all, in about a day and a half.
8. Starfish digestion begins when it pushes its stomach out through its mouth onto food (such as a clam which it has pried open with its arms).
9. Vampire bats of the tropics do not "suck" blood; they lap up the equivalent of their own weight in blood (about 28 g) in one night with their long tongues. As with mosquitos, the main health risk is from infection with disease organisms, such as rabies.

Hearing Is Believing?

Most animals can hear a much broader frequency range than they can produce. For example, consider: humans (receive 20-20,000 Hz/emit 80-1100 Hz), dolphins (receive 150-150,000 Hz/emit 7000-120,000 Hz) and bats (receive 1000-120,000 Hz/emit 10,000-120,000 Hz).

Questions

1. What survival advantage might this deliver?
2. How does the sense of hearing serve as a "third eye" for animals such as bats and dolphins?
3. Do all animals hear with ears?

Answers

1. Although intra-species communication is not enhanced by this anomaly, the broader reception range does increase the likelihood of detecting an approaching predator.
2. In addition to their fully functional eyes, bats (and dolphins) "see" objects with echolocation by picking up the reflection of their own high-pitched squeaks. The "sound pictures" reflect back to nerves in their wing and ear membranes containing information on size, shape, distance and direction. Certain moths have developed foils to use against the bat: Some upon detecting the bat's squeaks can alter the frequency of their wing beats and others can produce sounds that mimic the bat's, thereby "jamming" their signal.
3. Cicadas have hearing organs at the base of their abdomen, in their stomachs. Crickets have hearing organs in the oval slits of their forelegs. Many insects hear with hairs located on their bodies—the cockroach hears with hairs located on its abdomen; the caterpillar has "ears" (hairs) all over its body. A snake has no ears: It picks up sounds waves by flicking its sensitive tongue.

Jumping & Lifting Contenders

Question

1. Do other animals have the jump on humans in terms of relative leaping and lifting power?

Answer

1. The longest jump recorded for men is 29 ft 2.5 in and for women, 23 ft 3.25 in. By contrast, 3 mm fleas can jump up to 13 in, frogs 17 ft 6.75 in and red kangaroos 40 or more ft. The grasshopper, which relative to its size has the greatest jumping ability of any animal, can leap over obstacles 500 times its own height or horizontal distances

of 20 times its own length. An ant can lift 50 times its own body weight—if an average man could do the same, he would be able to lift 8100 lbs; 29 percent more than the existing record weight lift. A bee can handle 300 times its own weight, the equivalent of a human pulling a 10-ton trailer.

Questions

1. Are sci-fi movie scenarios of gigantic insects terrorizing cities realistic? Why or why not? What factors limit the size of invertebrates? Why is the assumption of proportional size/strength magnification biologically invalid?

Answer

1. Some unusually large invertebrates include the South American bird-eating spider (3.5-in body, 10-in leg span), Bornea dragonfly (4.25-in body, 7.5-in wing span), African goliath beetle (6-in long), Tropical stick insect (13-in long), Andaman centipede (13-in long), African giant snail (15.5 in) and Giant South African earthworm (22 ft). An animal's weight is proportional to the cube of its length; its strength varies according to the square of its muscle-and-bone cross-section. If a flea's size were increased a thousandfold, its weight would be a billion times greater, but its strength only a million times greater; it would be crushed by its own weight.

Migrating Mania

Question

1. What are some animals that migrate and why and how do they accomplish this feat?

Answer

1. The Arctic tern holds the record for distance: 22,000 miles per year for its seasonal roundtrip from the Arctic to the Antarctic using an unknown combination of solar, celestial and electromagnetic navigation. Although not nearly as far, the 3000-mile flight of the monarch butterfly from southern Canada to Mexico is equally impressive given its apparent frailty. Other contenders include the eel (4000 mi), sea turtle (2400 mi), salmon (2000 mi) and ruby-throated hummingbird (500 mi). Weather, food shortages and mating practices are all motivating factors.

Reproduction vs the Natural Balancing Act

Question

1. In 1859, 12 pairs of rabbits were released in Australia. Within six years, there were 2 million and in less than 10 years their numbers had swollen to tens of millions and the rabbit population had become a major threat to the Australian economy. What are the underlying factors that created this ecological problem?

Answer

1. A rabbit begins to breed when it is 6 months old and can produce 4 to 8 litters of 3 to 8 baby rabbits each per year for each of the 7 to 8 years of its life. If the food supply is adequate and natural predators and disease organisms are not keeping them in check, exponential population growth can occur. Similarly, two rats can theoretically become the progenitors of 15,000 rats in less than a year.

Sight: Do You See What I See?

Question

1. Do other animals "see" the same world as humans?

Answer

1. A squirrel (like deer and many other mammals) has no color vision: It sees only in black and white. However, unlike humans whose globular eyes demand focus adjustment for varying distances, the squirrel's entire field of vision is in perfect focus. Many birds share this trait and some, especially birds of prey such as the eagle, have very acute sight; they can spot prey as far off as 2 mi/3.2 km. Bees (like most insects) can see in ultraviolet light which is beyond the range of human sight. Most insects' eyes are made up of hundreds or thousands of tiny, six-sided lenses which create a mosaic of separate images of objects within the few inches of their focal length. Many varieties of beetles can see infrared.

Sourcebooks for Biological Bafflers

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