
Things That
Make You Go
YUCK!

Head louse

Mystifying Mutants

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Prufrock Press Inc.
Waco, Texas

Library of Congress Cataloging-in-Publication Data

Names: Dlugos, Jenn, author. | Hatton, Charlie, author.
Title: Things that make you go yuck! : mystifying mutants/by Jenn Dlugos and Charlie Hatton.
Other titles: Mystifying mutants
Description: Waco, Texas : Prufrock Press Inc., [2017] | Audience: Ages 9-12. | Includes bibliographical references.
Identifiers: LCCN 2016035485 | ISBN 9781618215642 (pbk.)
Subjects: LCSH: Animal mutation--Juvenile literature. | Mutation (Biology)--Juvenile literature. | Animals--Abnormalities--Juvenile literature. | Variation (Biology)--Juvenile literature. | Genetics--Juvenile literature.
Classification: LCC QH390 .D5845 2017 | DDC 576.5/49--dc23
LC record available at https://lccn.loc.gov/2016035485

Edited by Lacy Compton
Cover and layout design by Raquel Trevino

ISBN-13: 978-1-61821-564-2

Printed in the United States of America.

Prufrock Press Inc.
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Waco, TX 76714-8813
Phone: (800) 998-2208
Fax: (800) 240-0333
http://www.prufrock.com

Albino hedgehog

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Welcome, Mutants!
Yes, we're talking to you!

Introduction

Mutants.

The word doesn't exactly fill you with a warm fuzzy feeling, does it? Maybe it reminds you of half-animal superhumans wreaking havoc on a city. Or man-eating insects crawling through town. Or your siblings when they wake up in the morning. In reality, mutants are not just gross critters that pop out of a science-fiction story (or the next bedroom). Real-life mutants walk, slither, and creep among us, all due to some horked-up genes.

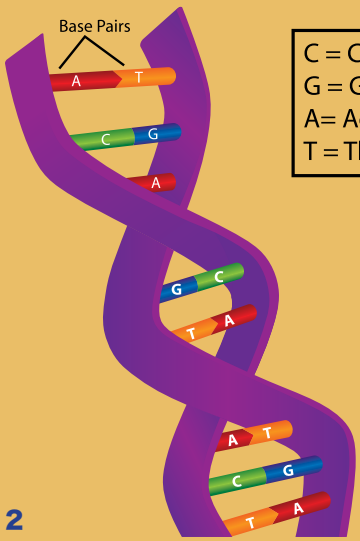
Genes: Your Personal Operating System

Just like your computer, your body comes preprogrammed. Your genes are your internal hard drive. They store all the instructions to make your traits—like hair or eye color—and the necessary programs to build and operate your human body. Your genes carry the blueprints to build the parts that allow you to talk, just like a dog's genes have blueprints to make body parts for barking. (And we're *very* glad those two blueprints never get mixed up. Otherwise, things would get pretty embarrassing when the teacher calls on you in class.)

Your Code's Written All Over Your Face (And Everywhere Else)

Unlike a computer, your genes are not stored on a central hard drive. They're actually a part of your DNA, which is stored in the nucleus of your cells. (And you have a *lot* of those—you are a living, walking machine of about 37 trillion cells.) All the DNA in one of your cells—including genes and nongene regions—is called your genome. Genes are simply sections of DNA that code for a particular trait or characteristic.

Structure of DNA
Deoxyribonucleic Acid



C = Cytosine
G = Guanine
A= Adenine
T = Thymine

DN-EH?

DNA stands for deoxyribonucleic acid (or "DEE-ox-ee-RYE-bow-new-clay-ic" acid, which is quite a mouthful, so it's always just called DNA). It looks a lot like a twisted ladder. The rungs of the ladder are made up of four bases, abbreviated as A, T, C, and G. A pairs with T to form a rung and C pairs with G. Together, these four little letters make up a super-duper long code that turns into you!

Houston, We Have a Problem

Your DNA tries really hard not to make mistakes in its code, but it isn't perfect. A mutation is any change in the DNA sequence. Sometimes an A accidentally gets paired with a C instead of a T, or a whole section of the code gets deleted. Other times a base squeezes in where it shouldn't be or a whole gene duplicates itself. Mutations can happen due to outside factors—like exposure to harmful chemicals—or when your DNA makes a mistake copying itself when your body makes new cells. Some mutations get passed down from parents to children, and children can pick up new mutations the parents didn't have, too.

The Biggest Superhero League in the World

If being a mutant was the only criterion for becoming a superhero, then we'd all need to cape up. Every single one of us—including you—has mutations in our DNA, but we don't really notice, because most mutations don't cause a significant change in our traits or body function. But some mutations can really muck things up, genetically speaking, and create some really interesting critters. Many of these outrageous oddities are lurking for you inside this book. Turn the page, if you dare . . .


Orca whale

1 Sea Monsters

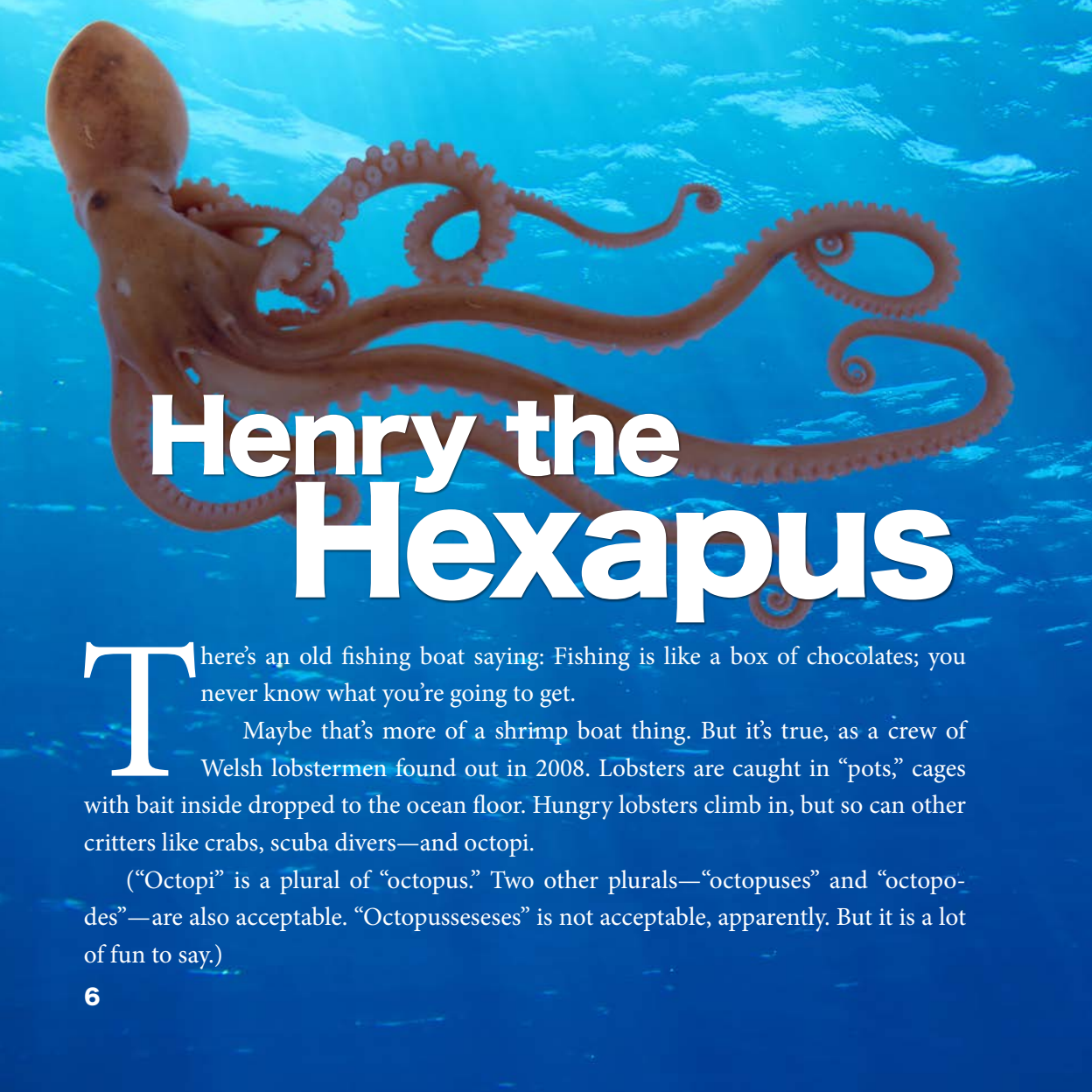
We go to the movies to see fearsome pirates battle giant Krakens or a super-shark take on a fishing boat, but we can rest easy knowing that these sea mutants came from a dark, slimy cavern in someone's imagination. Or do they? Thankfully, we don't need to worry too much about a Sharknado attacking us, but there are plenty of genetic sea monsters crawling, gliding, and oozing under the water. This chapter showcases some of the wettest and wildest mutants on Earth.

Do You Know Your Mutants?

In 2011, a one-eyed sea creature was found in Mexico. What was it?

a. An orca whale b. A hermit crab c. A dusky shark

Find out the answer at the end of the chapter!



Henry the Hexapus

There's an old fishing boat saying: Fishing is like a box of chocolates; you never know what you're going to get.

Maybe that's more of a shrimp boat thing. But it's true, as a crew of Welsh lobstermen found out in 2008. Lobsters are caught in "pots," cages with bait inside dropped to the ocean floor. Hungry lobsters climb in, but so can other critters like crabs, scuba divers—and octopi.

("Octopi" is a plural of "octopus." Two other plurals—"octopuses" and "octopodes"—are also acceptable. "Octopusseseses" is not acceptable, apparently. But it is a lot of fun to say.)

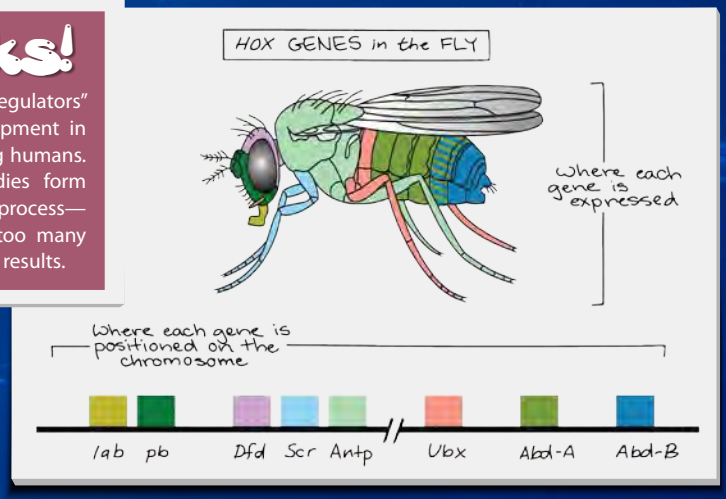
That lobster boat crew found octopi among their catch that day, but one was odd. It only had six legs. So it wasn't an "octopus" (which means "eight-footed") at all. It was a hexapus.

But this not-octopus wasn't missing limbs from an accident or because he'd left his tentacles in his other octopus pants. He'd simply grown that way. His lack of leggage was likely due to a gene mutation, possibly in a Hox gene. Other oddly-legged octopi have also been seen—some with seven legs (a septopus!), nine legs (nonopus!) or even 10. (Ahoy, decapus!)

Meanwhile, our hexapus had a happy ending. He was sent to a local aquarium, dubbed Henry the Hexapus, and spent his days munching on hermit crabs and stretching his (six) legs. Like they say: Fishing is like a pot of octopi; you never know how many legs you're going to get.

Hox Rocks!

Hox genes are called "master regulators" and are important for development in many animal species, including humans. Hox genes control how bodies form prebirth, and glitches in the process—like mutations—can lead to too many limbs, too few, or other strange results.



The Game of Cones

Nature plays more than its fair share of practical jokes. Take the cone snail, for instance. These colorful, sea-dwelling creatures carry some of the deadliest venom on the planet. Some species carry venom strong enough to kill a human, never mind a tiny sea critter. Yet, the cone snail is also as slow as . . . well, a snail. So, how dangerous can it really be? Any fish worth its sea salt could surely outswim it with one fin tied behind its back, right?

Wrong. The cone snail does have one fast-moving body part—a harpoon-like tooth that injects prey with its deadly venom. (This snail takes the term slow*poke* a bit too literally.) After its feast stops struggling, this cone-shelled assassin slows down to a snail's pace, taking its dear sweet time to swallow its prey whole.

Cone snails' venom is actually one of the most complex venoms in the world, containing more than 100 different neurotoxins (poisons that affect the nerves, brain, and spinal cord). It's so complex that scientists have not been able to make an antivenom for it yet. The genes that make this toxin for the snail are some of the fastest mutating genes in the animal kingdom. Over time the mutations have fine-tuned the toxin, so it can kill or paralyze prey efficiently.

They say bad news travels fast, but apparently not as fast as cone snail mail.

Sweet and Deadly

There are more than 500 species of cone snail, but only a few are dangerous to humans. Some snails even use a potent form of insulin in their venom. Insulin is a chemical that controls your blood sugar levels. Cone snails use this insulin to send their prey into a deadly sugar crash before they even know what hit them.

Ice(fish) Water in Their Veins

Blood, as a rule, is red. That's due to a protein called hemoglobin (he-meh-GLOW-bin), which is red in color and carries oxygen through the blood. Because oxygen is pretty important for our survival, so is hemoglobin. All vertebrates—animals with backbones, including birds, mammals, reptiles, amphibians, and many fish—depend on hemoglobin to transport oxygen.

Except. (In biology, there's always an "except.")

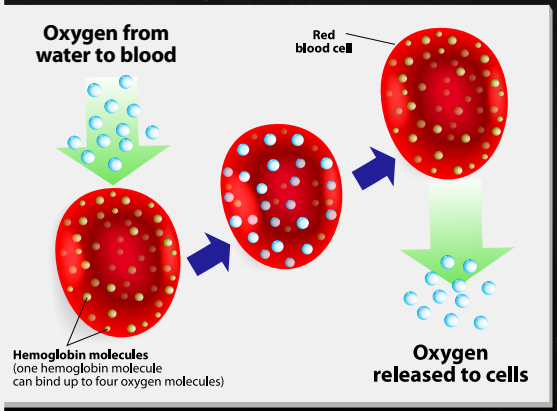
Of about 50,000 known vertebrate species, just one family (16 species total) comes up short on hemoglobin. Known as crocodile icefish, they live in the chilly waters around Antarctica. They were discovered in 1927 by sailors from a Norwegian expedition, who noted the icefish had no scales, big gaping jaws (hence the "crocodile" name), and colorless blood.

Scientists later tested icefish DNA and found that the hemoglobin genes were either missing or mutated beyond repair. Icefish still need oxygen, but without hemoglobin, they can only use the oxygen that dissolves in their blood—10 times less than other vertebrate fish get.

Most animals couldn't survive with these mutations. Luckily for icefish, the cold waters they swim in are rich in oxygen. Still, they have to work a lot harder just to get by. Icefish need 4 times more blood than other fish, and grow bigger hearts and wider blood vessels. Maybe they should invest in some tiny scuba tanks instead!

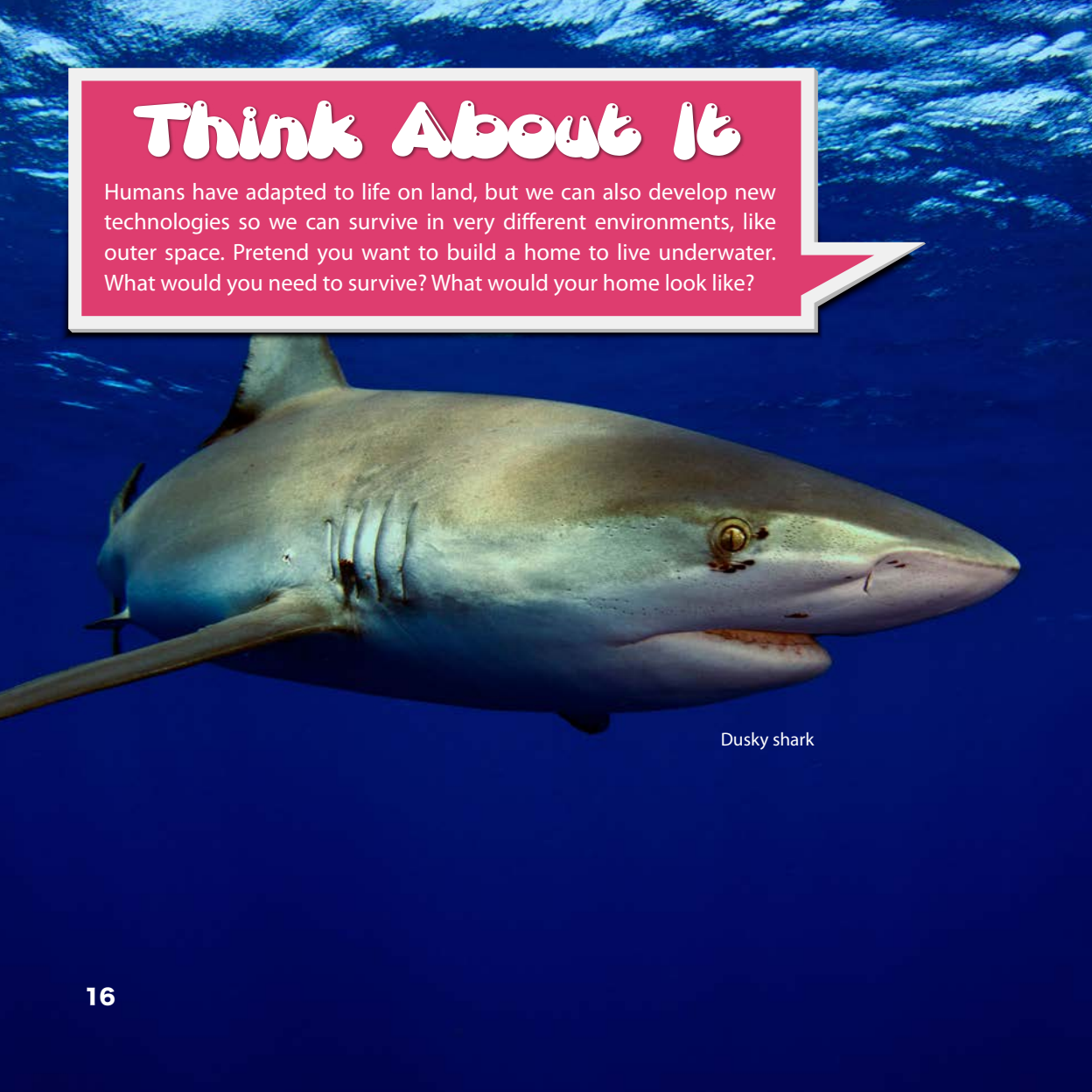
How's That Hemoglobin?

Hemoglobin is a protein in blood that carries oxygen from the lungs—or in fish, gills—to the rest of the body for energy. In mammals (like humans), hemoglobin is found in red blood cells and allows blood to carry 70 times more oxygen than could dissolve in blood directly.



Think About It

Humans have adapted to life on land, but we can also develop new technologies so we can survive in very different environments, like outer space. Pretend you want to build a home to live underwater. What would you need to survive? What would your home look like?



Dusky shark

Mutant Trivia Answer

In 2011, a one-eyed sea creature was found in Mexico. What was it?

a. An orca whale
b. A hermit crab
c. A dusky shark (correct)

It looked like something found in a horror movie, but a dusky shark fetus with one massive eye in the center of its head was found in Mexico. The condition is called *cyclopia* (sigh-CLOE-pee-uh, named after the mythical cyclops), and it is sometimes caused by a mutation that controls the SHH gene, which scientists named after Sonic the Hedgehog.

Long-haired
guinea pig

2 Man's Freaky Best Friends

Most of the mutants in this book are proof that nature does its best to make sure the wild stays . . . well, wild. But the creepy critters in this chapter are ones that we bring on ourselves. These feathered, finned, and furry mutants may make us go "Eek!", "Whaaaaaat?", or "Yuck!", but they all call our sofas and barns their homes.

Do You Know Your Mutants?

This popular pet has a color mutation that is sensitive to temperature. The animal will develop darker hair in colder areas of the body and lighter hair in warmer areas of the body. Who is this mutant?

a. A beagle b. A Siamese cat c. A long-haired guinea pig

Find out the answer at the end of the chapter!

Do You Wanna Arowana?

Which is more expensive: an aquarium fish or a new car? Usually, the answer is obvious; a Jaguar costs more than a goldfish, every time. Even if the goldfish has power steering.

But one fish family has something special up its flipper-sleeve. Arowanas (air-oh-WAH-nahs) are freshwater southern-hemisphere fish and popular with folks who keep large fish tanks. The "large" part is important, because aquarium arowanas grow up to 3 feet long. They can also leap 6 feet in the air, live 50 years or more, and come in most every color of the rainbow.

These traits make arowanas popular aquarium fish. But a few very rare arowanas are as valuable as a leather-seated luxury sedan due to a certain kind of mutation. So-called "platinum" arowanas have a genetic condition known as *leucism* (LEW-ciz-um), which leaves them pale white, with almost no pigment whatsoever. The condition also occurs in species like snakes, birds, horses, and lions.

Because of their rarity and fish-fan demand, platinum arowanas can be worth huge sums of money. In 2007, Singapore-based fish breeders brought a platinum arowana to an aquarium exhibition. They turned down offers of around $50,000 for the fish, and eventually decided to keep it. Less famous platinum arowanas aren't quite as valuable, but can cost several thousand dollars each. That's a lot of cash, just to give your aquarium that "new fish smell."

Pigments of Your Imagination

Leucistic animals are often mistaken for albinos, but there are differences. Albino creatures lack the pigment melanin, while those with leucism lack all pigment types. Albinos' eyes are pink, as red blood vessels show through in the absence of melanin. But leucistic animals have normal-colored eyes, because eye pigment is not affected by mutations causing leucism.

Not for the Faint of Goat

Many animal species have a "fight or flight" response. When threatened, they attack (fight) or they run, fly, or slither away (flight). Some goats, however, have a third option: faint.

Myotonic goats, or "fainting goats," are a little smaller than most goats, and have big, slightly bulging eyes. Other than those traits, they look like your average four-legged, hairy-chinned, tin-can-eating billy or nanny goat. Until you startle them.

Fainting goats have a hereditary genetic condition called *myotonia congenita* (my-oh-TONE-ee-uh con-GEN-it-uh). Although the exact cause isn't known, the condition in other species (including humans) is caused by mutations in genes that code

for cell membrane proteins. These mutations prevent tensed-up muscles from relaxing right away, as they normally would.

Despite the name, "fainting" goats don't actually faint when they're surprised. Instead, they tense up to run away, but all those tensed-up muscles freeze in place, and the goat can't run at all. Or walk, or stand. Startle a myotonic goat, and it'll usually stiffen up and keel over sideways. After a few seconds, its muscles will relax and the goat's as good as new.

Unless it was startled by something coming to eat it. That's where "faint" falls short of "fight" or "flight." Also, fainting goats miss the good parts of scary movies. It's a real problem.

Nor Faint of People, Either

In people, more than 100 different mutations have been identified that cause myotonia congenita. Symptoms include stiff movements, joint problems, and—like the goats—falling during sudden movements. Sometimes, making repetitive movements can relieve symptoms, in a phenomenon called the "warm-up effect." Unfortunately, no one has mentioned this to the goats.

My-Oh-Myostatin

Whippets are racing dogs descended from greyhounds. Over time, breeders noticed two unusual types of whippet puppies. Some dogs were extremely fast, even for whippets. Breeders liked these, so they often bred two "fast" whippets together, hoping for speedier pooches.

The strategy worked, but it also produced a few dogs that were very different. These dogs, called "bully whippets," look like they've been working out at the gym, bulking up with "Arnold Shih-tzu-negger" or "Bark Lesnar." The dogs' muscles bulge out of their legs, chests, and backs. But why are these muscle-bound dogs found in the litters of "fast" whippet parents?

The answer lies in the myostatin (MY-oh-stat-in) gene. The protein coded by this gene regulates muscle development. When muscles are big enough, myostatin signals growth to stop.

Like most animal genes, there are two copies of myostatin in each cell. "Fast" whippets have a mutation that affects one copy of the gene. With a little less myostatin, these dogs only grow a little more muscle—enough to make their legs stronger and give them a racing edge.

But "bully" whippets inherit mutant myostatin genes from both parents, and can't make the protein at all. With no myostatin, their muscles bulge to nearly double the usual size. In fact, these whippets—who aren't really "bullies"; they're usually very sweet—can't race at all. They're too big. But they do impress everyone with their flexing down on "Muscle-mutt Beach."

Wendy, a bully whippet

Whippets! Whippets Good!

Though whippets are smaller than their greyhound cousins, they run nearly as fast—up to 35 miles per hour—and accelerate faster than any breed. That includes greyhounds. Also Scooby Doo, being chased by a swamp monster. And all 101 Dalmatians. Whippets are seriously fast.

Bald Is Beautiful?

Some pets are man's best friend. Others are more like man's weird uncle, mostly because they desperately need a toupee. (They also make unpleasant noises at the dinner table, but scientists don't consider that a genetic mutation. Yet.) Most pooch and kitty fans love to snuggle next to a furry four-legged friend, but some dogs and cats are bred specifically for a genetic mutation that makes them bald.

Chinese crested dogs have an unusual look, with their bare skin and boy-band hair. These features are caused by genetic mutations, which make them quite a unique breed. Dogs usually pant to cool off, but Chinese crested dogs have sweat glands just like humans. Their genetic makeup can also cause them to have missing and crooked

teeth. Between their ghastly grins and their bald bodies, the hairless Chinese crested has won more World's Ugliest Dog competitions than any other breed.

Don't worry, cat lovers. There's a bald mutant for you, too! The Sphynx cat has extremely fine hairs that make it appear completely bald. These hairs give their skin a suede-like texture, and their skin color can form common cat patterns, like calico or tabby.

The Chinese crested dog "Elwood" appears at the 2007 World's Ugliest Dog Contest.

Not Quite a Sphynx

Despite its Egyptian name, the Sphynx cat breed started in Canada in 1966 from a single hairless mutant. Their large eyes and attentive ears give these cats a regal look, earning them the name Sphynx.

Siamese cat

Mutant Trivia Answer

This popular pet has a color mutation that is sensitive to temperature. The animal will develop darker hair in colder areas of the body and lighter hair in warmer areas of the body. Who is this mutant?

a. A beagle
b. A Siamese cat (correct)
c. A long-haired guinea pig

The Siamese cat has a gene mutation that causes point coloration. Colder areas of the body, like the feet, face, and tail, will have darker hair than warmer areas of the body, like the torso. Point coloration also occurs in certain horses, sheep, and rabbits.

Think About It

Bully whippets have a gene mutation that gives them super strength. If you had a pet, what super-mutant power would you want it to have? Get out your notebook or sketchpad and write a short story or draw a comic strip about you and your super-mutant pet on a dangerous superhero mission.

Australian redback spider, a type of widow spider

3 Mutants Underfoot

From rats to spiders, there are plenty of critters that scamper, scurry, and slither their way into our nightmares. None of the animals in this chapter need any help to give people a bad case of the willies, but they all have gene mutations that make them creepier, scarier, or deadlier.

Do You Know Your Mutants?

A scientist kept a group of these critters in complete darkness for more than 50 years to study how their genes changed in extreme living conditions. What were they?

a. Rats b. Fruit flies c. Black widow spiders

Find out the answer at the end of the chapter!

A Really, REALLY Bad Hair Day

How do you do your hairdo? Are you a mousse-and-gel-er? A blowdry-and-brush-er? A wash-and-out-the-door-er? Hopefully, you're not a let-blood-sucking-bugs-crawl-on-your-head-er, but for those of us with luxurious locks, it's always a risk. Head lice are tiny wingless bugs that live in human hair and suck blood from your scalp. If that's not gross enough, these itchy insects have developed a genetic mutation that makes them resistant to lice-killing drugs, turning them into a real head-scratcher for doctors.

Lice are parasites, because they live at the expense of a host (meaning, you). They're like siblings who barge into your room uninvited, eat all your food, and borrow your stuff without asking. Head lice only affect humans, so you can't give them to—or get them from—your pets. (And Fido probably wouldn't be too disgusted if you did come home with a lice-covered skull. It's hard to gross out a critter that smells its own poop.)

A special insecticide medication usually kills them, but a population of "superlice" have popped up that are resistant to some of these drugs. These hair-wreckers are confirmed in 25 states already, and the actual numbers are probably higher. Fortunately, prescription medications can help treat these lice, so you don't have to split hairs with these notorious 'do-destroyers.

The Name Is Bond, Lice Bond

Lice can't fly, hop, or teleport like Captain Kirk, so they can only get to your head by crawling. Once they find a delicious-looking noggin, they use special hook-like claws to climb up your hair like super spies and they set up their not-so-secret base on your scalp.

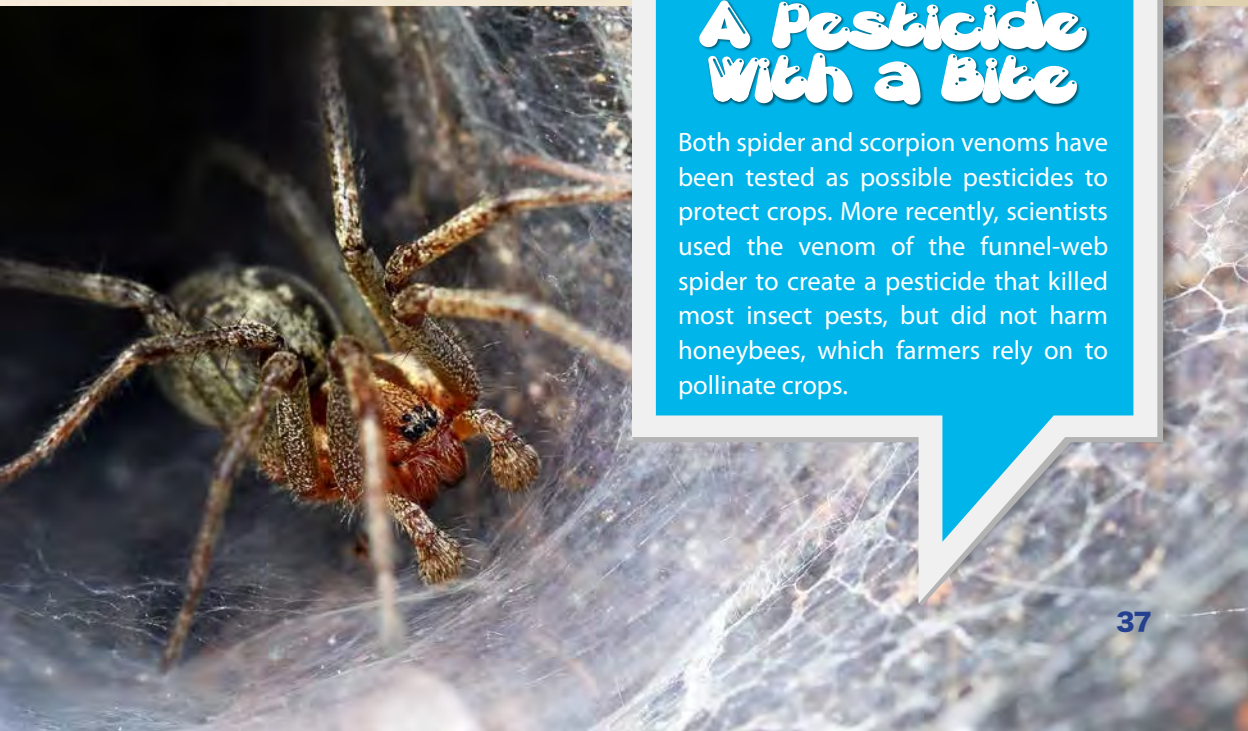
The Lord of the Stings

Whether they're making you scream in a horror movie or just scaring the suds off you in the shower, spiders usually take the Number 1 spot on the Atrocious Arachnid list. Scorpions are probably a bit annoyed by this. With powerful pincers and a venomous whip-like tail, scorpions are both formidable foes and fearsome predators. Recently, a group of scientists compared scorpion and insect genes and found an answer to how scorpions developed their deadly sting.

Insects have a substance called *defensin* that protects them from bacteria, viruses, and other harmful germs. Scientists discovered that just one tiny gene mutation can

turn certain insects' defensins into the scorpion venom. This suggests that these insects and scorpions evolved from a common ancestor, but a genetic mutation way back in the past turned these protective substances into deadly weapons for scorpions.

It takes a very brave (or very dumb) predator to grab a scorpion by its venom-filled tail, but scientists discovered that some species have a back-up line of defense—they can snap their tails off and run away. Unfortunately, this daredevil stunt leaves the scorpion with a pretty unsavory problem—it can't poop for the rest of its life. Despite this, these scorpions can continue to eat and can even mate for months. Just don't ever let these scorpions take the wheel on a long road trip. They're definitely *not* stopping at the next rest stop.



A Pesticide with a Bite

Both spider and scorpion venoms have been tested as possible pesticides to protect crops. More recently, scientists used the venom of the funnel-web spider to create a pesticide that killed most insect pests, but did not harm honeybees, which farmers rely on to pollinate crops.

One Predator's Poison Is Another's Brunch

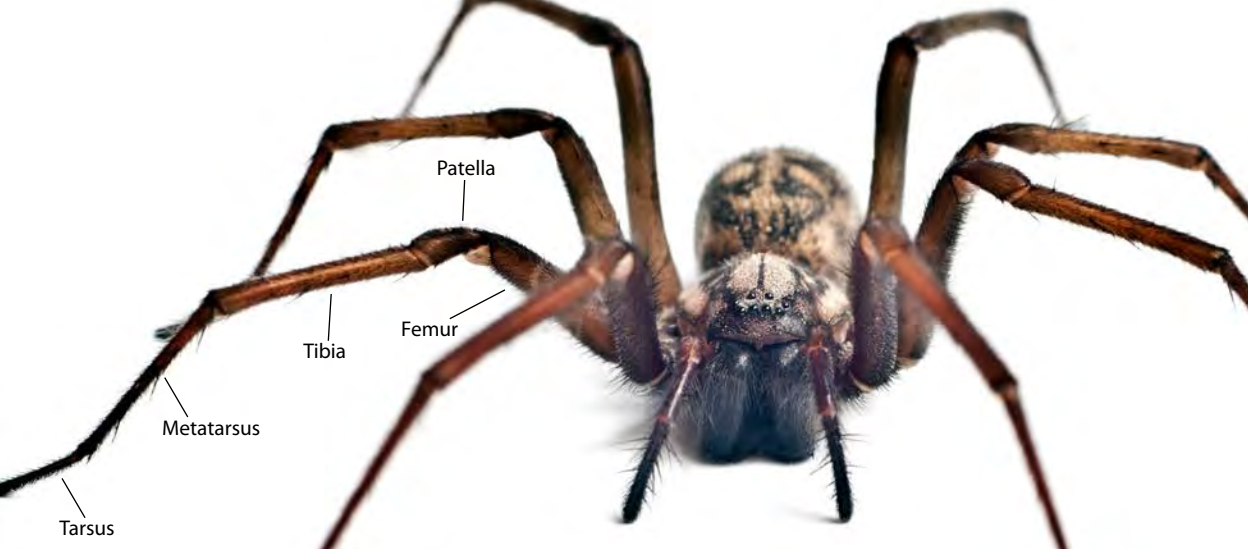
Life in the wild is a lot like a head-to-head duel in a video game. You pick a character who chucks ninja stars and your friend picks a character with a sword, and then you punch, kick, and combo your way to victory. (Unless your friend is winning. Then you "accidentally" hit the reset button and claim a power glitch, because the wild is also unfair.) Like video game characters, animals also have specialized defenses for the inevitable fight to the death.

Take the rough-skinned newt, for example. Its bright orange belly secretes an extremely potent toxin that kills almost anything that tries to swallow it. The newts try to warn predators of their poison first by showing them their bright orange underbelly. To do this, the newt arches his head toward his back feet. Scientists call it the *unkenreflex*. (It's an appropriate name. If we tried to bend our heads back to touch our feet, we'd be crying "unken!" too.) Often, this display convinces the predators to pass on the noxious newt, and they slither, scamper, or waddle on to rustle up some less toxic takeout.

Except for the garter snake. It has a gene mutation that makes it resistant to the newt's toxin. The newt can still try to trick it by flashing its "I'm poisonous!" belly, but if the snake calls its bluff, the newt's out of luck. Maybe the newts should look into a whole new weapon of defense. We're voting for ninja stars.

GPS (Garter Positioning System)

Garter snakes don't need a GPS to get to another snake's home, because they can use their tongues to detect chemicals that other snakes leave. Even baby garter snakes can read these signals and follow chemical trails left by other snakes.



Knee Deep in Mutant Spiders

Nothing sends a chill up your spine faster than eight hairy legs scampering toward you (unless, of course, they are attached to two puppies). But if you're brave enough to look at a spider's legs, they are actually quite fascinating. Each leg has seven joints, which give them a lot of flexibility, but that's a lot of joints to coordinate just to move around.

Your kneecap bone is called the *patella*. Spiders do not have bones, but scientists use the word patella to describe the main "knee" joint that connects two sections of the

spider's leg, the tibia and femur (which are also the names of the two large bones in your legs connected by your knee joint). Scientists recently discovered that spiders developed this patella from a duplication of the *dac* gene, short for the dachshund gene. (Yep, the gene that gave spiders "knees" is named after wiener dogs with short, stumpy legs.) When researchers deleted this double gene, the patella and tibia in spiders became one large leg segment. Without knees, these spiders walked stiffly, like little Frankenstein monsters. Well done, scientists. You managed to make spiders even creepier.

Hydraulic Spiders

Spiders don't have complex muscle systems like humans do, so they flex their legs using hydraulics. Hydraulic engines are powered by the flow of pressurized fluid. Spiders have an open circulatory system, so their blood mixes with other fluids in their bodies. The pressure created by all of this fluid pushes the joint outward to flex. After death, this pressure releases, which is why spider legs curl up when they die.

Fruit fly

Mutant Trivia Answer

A scientist kept a group of these critters in complete darkness for more than 50 years to study how their genes changed in extreme living conditions. What were they?

a. Rats
b. Fruit flies (correct)
c. Black widow spiders

In 1954, a Japanese scientist named Syuiti Mori put a group of fruit flies in a dark cave to see how the genes in the population would change over time. The flies stayed in the cave for more than 50 years, producing 1,400 generations of offspring. Although the changes to the fly were not as profound as expected, Syuiti's team did find mutations in a couple of key genes that may have increased the flies' survival in the dark, including one mutation that damaged the flies' natural light receptors.

Think About It

Your favorite actor or actress calls you up. He or she wants to make a horror movie about a mutant critter, and they want you to write it. What creepy crawly will you pick? How will you mutate it? Draw your scariest movie poster for your mutant-a-rific masterpiece!

Attack of the CLAVATA Tomatoes

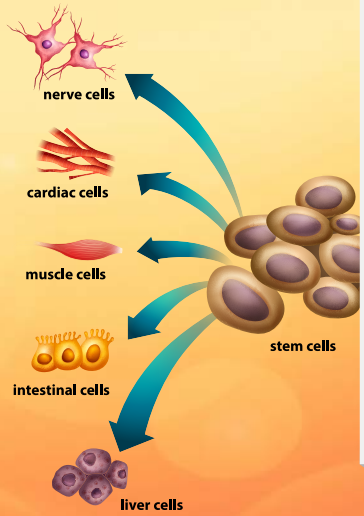
Beefsteak tomatoes look like mutants. Misshapen, lumpy, and much bigger than normal, they can weigh a pound or more. They're like the Quasimodos of tomatoes. Quasimatoes.

Although beefsteak tomatoes have been around since at least the 1500s, no one knew why they grew that way—until 2015, when scientists looked at a different set of weird tomatoes. These plants grew more flowers and fruit than usual, which

the researchers traced back to mutations affecting the behavior of CLAVATA proteins. In plants, proteins encoded by CLAVATA genes act within stem cells to slow growth during development. These proteins balance the growth process, so the plant doesn't grow too large for the food and energy available.

When the CLAVATA proteins are disrupted, though, growth goes all higgledy-piggledy. In the mutants the scientists began studying, this meant more flowers and fruit per plant. But when they looked at the genes of other tomatoes, they found a similar mutation in a particular gene, CLAVATA3, that leads to bigger, brawnier, bulbous tomatoes. Like the beefsteaks.

Because CLAVATA genes are in all plants, we might someday be able to fine-tune them to grow all sorts of bigger crops. So keep an eye out for beefsteak beets, beefsteak blueberries, or maybe even beefsteak broccoli. Now there's a veggie even Quasimodo would be afraid of.



The Secret Life of Stem Cells

Stem cells are cells in all plants and animals—including humans—that don't know what they want to be when they "grow up." Whereas a skin cell can only produce more skin cells or a hair cell more hair cells, stem cells can develop into many different types of cells—or into more stem cells. So they're very important during development and throughout an organism's life.

Red salamander

5 Color Me Mutated

You can't always spot a mutant just by looking at it, but organisms with color mutations definitely stand out from the crowd. From red to purple, two-toned to no-toned, mutants come in every color of the rainbow. Here are a few of the weirdest and freakiest ones out there.

Do You Know Your Mutants?

Albinism is a gene mutation characterized by a lack of pigment in the skin and eyes. Which animal is most likely an albino?

a. A red salamander

b. A pink dolphin

c. An all-black zebra

Find out the answer at the end of the chapter!

On Hopperdays, We Wear Pink

When it comes to fashion, you can either choose to blend into the crowd or turn heads. Grasshoppers have the same quandary. Although many have a green or brown color to camouflage from predators, there is always that fashion-forward grasshopper that leaves its home decked head-to-wing in hot pink.

Hot pink grasshoppers don't choose to be fashionistas. Their coloring is most likely caused by a gene mutation that causes *erythrism* (ih-RITH-rizz-um), in which the organism produces an unusual amount of red pigment. If you happen to spot an adult pink grasshopper in the wild, you're quite lucky indeed. Many do not survive long enough to make it to adulthood, because their bright pink color makes them an easy-to-find meal for predators.

Erythrism exists in other animals, including raccoons, salamanders, and coyotes, but it's not common. And it may occur in even more species than we think. In 2013, a photographer in South Africa snapped a picture of a leopard with a pink tint to its coat, which people now call the Pink Panther. It's not known what precisely caused its unique coloring, but erythrism is one possibility.

Color Me Toxic

Some species of grasshopper have bright colors to warn predators. Multicolored African variegated grasshoppers feed on poisonous plants and store chemicals from the plants in their bodies. Their bright, multicolored bodies warn predators that they are packed with deadly toxin.

Piebaldism: When Some Little Pigments Stay Home

Commerson's dolphins, also referred to as piebald dolphins

If you were painting a fence, you'd want to do a good job. That means covering all of it evenly with paint, and not leaving any colorless spots. If Tom Sawyer were painting a fence, he'd get someone else to do all the work, take a nap, and the job probably wouldn't get done very well. That fence might have irregular splotches of paint, with bare spots willy-nilly throughout.

In other words, the fence might look piebald. Piebaldism is a genetic disorder in humans and other animals that creates the same look as that half-painted fence. The condition is often caused by a mutation in the gene KIT, or the gene SNAI2. Some areas

of the body are colored, usually black or brown, and others are white, with no color at all. The specific patterns are unpredictable, with islands of color and white appearing all over.

Piebaldism is a hereditary condition, which means it's passed down from mothers and fathers to their children. In addition to white patches of skin, piebald mammals also lose color in their hair, while birds lose feather coloring, and some snakes and fish grow white, colorless scales. But the exact coloration is distinct to each individual; even identical twins inheriting the same genetic mutation from their parents would develop different patterns of color and white.

Just like every Tom Sawyer-painted fence looks different. But never quite finished.

Passing Down the Piebald

Our cells contain two copies of every gene, one inherited from our mother and the other from our father. Piebaldism is a "dominant" trait, which means if one of those copies—from mother or father—has the right mutation, the individual will be piebald. Other traits, like sickle cell anemia, are "recessive," meaning both copies must be mutated before the effect is seen.

Pass the Pepper, Hold the Salt

A flock of black moths in a horror movie symbolizes doom and gloom, but for one little moth, rocking an all-black wardrobe actually helps it to survive. Found in temperate climates, the peppered moth is true to its name. Its white coloring peppered with black spots gives it a near-perfect camouflage from predators as it rests amongst the white lichens that grow on tree bark. Or it did, before humans screwed it up.

In the 1800s, the Industrial Revolution was in full swing. Big machines performed work that was once done by hand, factories sprouted up left and right, and cities grew

larger. In industrialized areas where peppered moths lived, black soot from factories coated the trees and killed the lichens, making the white moths easy targets for predators. But a few moths had no problem surviving in this soot-filled environment, because they carried a gene mutation that made them almost completely black. Against light-colored lichens, their coloring would make them easy pickings for predators, but against the blackened trees, their color was an advantage. Over time, most of the moths found in industrialized areas were black.

In recent decades, improved pollution standards and cleaner fuel sources have allowed lichens to return, so the classic white peppered moth has made a big comeback in some regions. And that's the truth about the wild—sometimes it really is black and white.

Just Wanna Have Fun(gi)

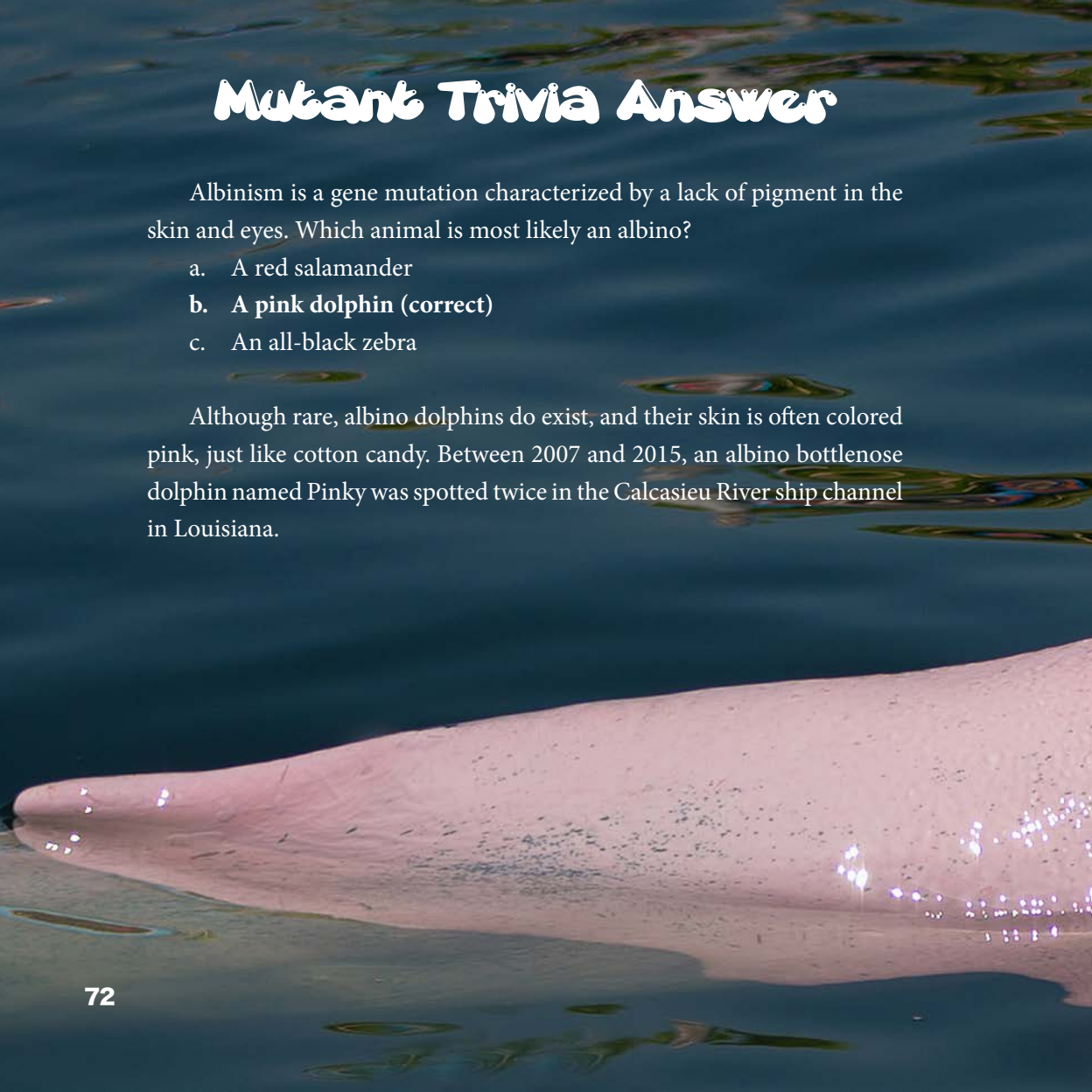
Lichens look like moss, but they are actually a combination of two organisms—fungi and algae. The algae create energy through photosynthesis, which feeds the fungus, and the fungus provides a moist, protected environment for the algae to grow.

Mutant Trivia Answer

Albinism is a gene mutation characterized by a lack of pigment in the skin and eyes. Which animal is most likely an albino?

a. A red salamander
b. A pink dolphin (correct)
c. An all-black zebra

Although rare, albino dolphins do exist, and their skin is often colored pink, just like cotton candy. Between 2007 and 2015, an albino bottlenose dolphin named Pinky was spotted twice in the Calcasieu River ship channel in Louisiana.



Think About It

Come up with a video game starring one of the color mutants in this chapter (or one that you research on your own). What is the goal of your game? How does the animal's color help or hurt it? Who or what are the villains?

Pink dolphin

A Big Problem Needs a Pig Solution

There's a problem with pig poop.

Actually, there are several problems with pig poop, beginning with the smell. But one problem affects the environment in an unusual way. Like all organisms, pigs need the element phosphorus to live. On farms, pigs are fed grain containing phosphorus, but more than half is in a form the pigs can't digest. So most of it slides right through and comes out in the pigs' waste.

This phosphorus can then contaminate nearby lakes and ponds. Some algae species thrive on phosphorus and grow out of control, reducing oxygen levels and killing fish and other life.

One fix is to pull the phosphorus out of the pig poop before it can disrupt the environment. Because nobody wants to do that directly—again, the smell—scientists have found a way to genetically engineer pigs to reduce the phosphorus output. Better yet, it helps the pigs.

The key is a gene found in bacteria that produces a protein called *phytase* (FIE-tays), which breaks down the hard-to-digest form of phosphorus. When that gene is inserted into a pig's genome, the pig digests more of the phosphorus in the feed. Which means more phosphorus for the pig to use, and far less in the waste products. Happier pigs, a healthier environment, and improved pig poop. Now if only they could do something about the smell.

Fed Up With Phytase?

Some farms solve the phosphorus pig poop problem without genetic engineering, by mixing phytase protein directly in the pigs' feed. Once eaten and in the pigs' digestive system, the phytase protein can break down phosphorus, just as before. But adding phytase to feed can be expensive and must be treated carefully before it's given to pigs or it may not function properly.

Let There Be . . . Mutants!

Bioluminescent mushrooms

Many creatures can produce light through chemical processes inside their bodies. These organisms—which include insect, bacteria, fungus, and jellyfish species, among others—are said to be "bioluminescent" (where "bio-" means "living" and "luminescent" means "glowing" or "light"). Some light up to signal danger or find a mate, while others glow steadily in the dark.

But why should those critters have all the fun? Scientists have identified many of the genes that allow bioluminescent species to light their own way and have inserted some of those genes into other plants and animals, allowing them to glow. Why? For science!

One common use for bioluminescent genes is to include them along with other genes engineered into an organism—like a gene providing disease resistance, for instance. Here, the light-enabling genes act as "reporters"; if cells contain the bioluminescent genes and light up, then the other genes have likely been incorporated into the genome, too. This technique has been used in species including plants, fish, frogs, mice, rabbits, pigs, sheep, cats, monkeys, and more.

Not all bioluminescent engineering projects are strictly scientific, however. Glowing fish are available from pet stores in a rainbow of colors, and some people have discussed engineering trees with bioluminescent genes to replace street lights in cities. What a bright idea!

Seeing Green

The bioluminescent gene most often used in genetic engineering originally comes from jellyfish. Called *green fluorescent protein*, or GFP, the protein encoded by the gene absorbs blue light and emits green light in response. In 2008, a team of scientists was awarded the Nobel Prize in chemistry for their discovery and early work with GFP.

Zebrafish

Mutant Trivia Answer

Scientists sometimes give goofy names to their lab mutants. This common research animal is named Casanova when it is born with a gene mutation that gives it two hearts.

a. White rat
b. Zebrafish (correct)
c. Nematode worm

Researchers love to use zebrafish to study genes, because they are vertebrates (like humans) and they have transparent embryos, which are easy to study. Mutant zebrafish have plenty of goofy names, including Spock (born with pointed ears) and Dracula (born with a mutation that makes them sensitive to light).

Think About It

Humans have always looked to nature to develop some of our best inventions. We make digging tools that look like animal claws and airplanes that look like magnificent birds. Think of your favorite plant or animal. What invention would you make that's inspired by its traits or behaviors? How would your invention benefit humankind?


Blue lobster

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Chapter 1

Sea Monsters

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Chapter 2

Man's Freaky Best Friends

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Moon Jellyfish

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Jenn and Charlie are Boston-based science nerds who met through stand-up comedy. By day, Jenn writes science textbooks and Charlie slings data for a cancer research company. By night, they make comedy films and stay up past their bedtime e-mailing pictures of weird animals to each other.

Albino Egyptian fruit bat

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