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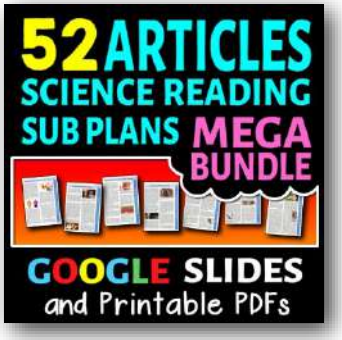

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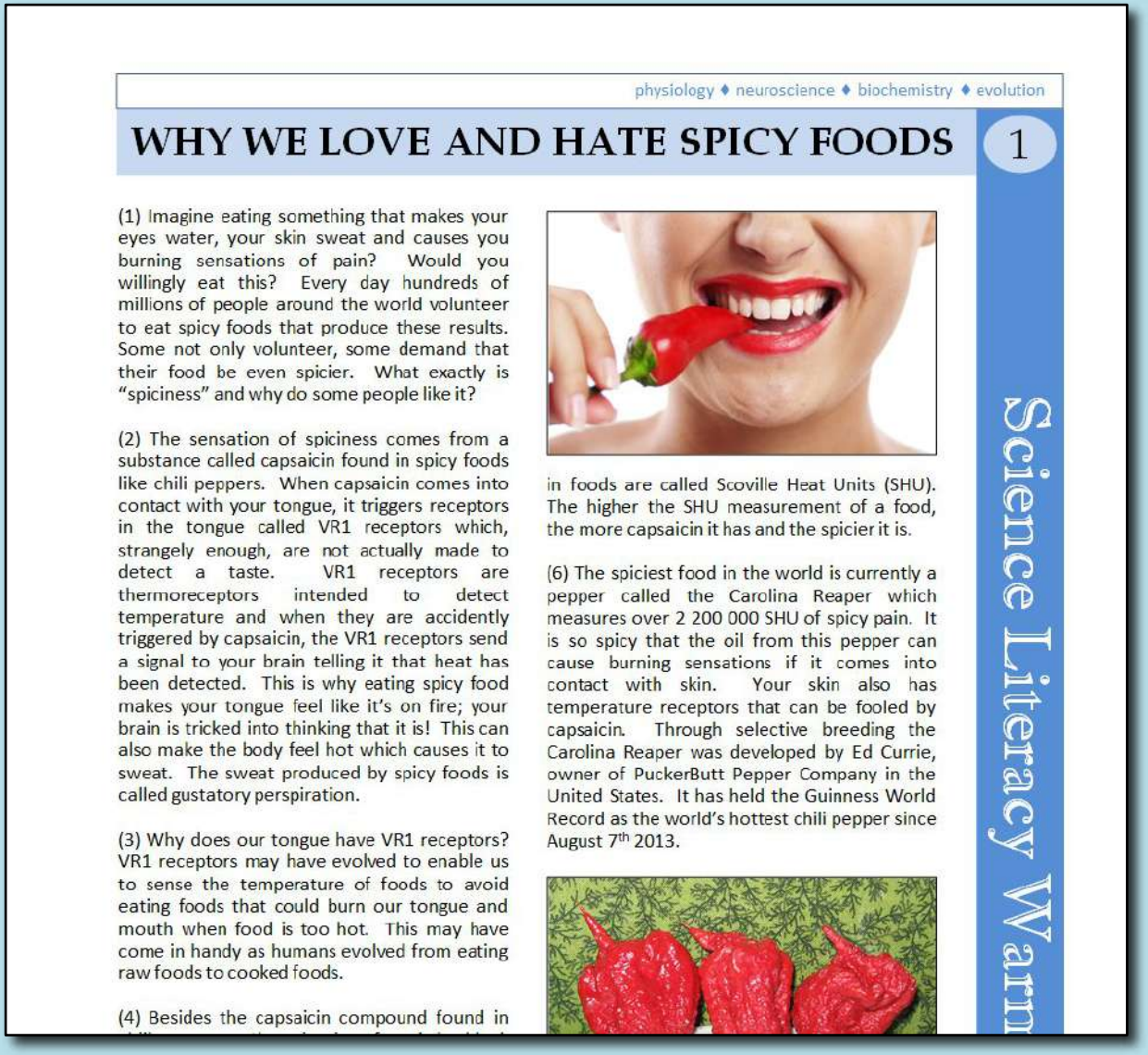
Article #3: Beyond the Appendix: Vestigial Structures (Gr.8-12)
Article #4: Dung Beetles: Where Did All the Poo Go? (Gr.7-12)
Article #5: Cancer Sniffing Dogs (Gr.7-12)
Article #6: Hyponatremia: Death by Water (Gr.9-12)
Article #7: Body Fat: The Good, The Bad and the Ugly Truth (Gr.8-12)
Article #8: Photosynthetic Animals (Gr.8-12)
Article #9: Diamonds, the Truth behind the Bling (Gr.8-12)
Article #10: Facebook Blues: Is Facebook Making you Unhappy (Gr.7-12)
Article #11: The Making of Human Hermaphrodites (Gr.9-12)
Article #12: Are Bed Bugs Keeping You Awake? (Gr.8-12)
Article #13: Miraculous Medical Maggots (Gr.7-12)
Article #14: How Anabolic Steroids Work (Gr.8-12)
Article #15: The Science of Sleep (Gr.7-12)
Article #16: Parasites Create Zombie Snails (Gr.7-12)
Article #17: Breathing and Peeing in Space (Gr.7-12)
Article #18: Is it Ironman? No, it's Alloyman! (Gr.8-12)
Article #19: Immortal Cancer Cells (Gr.9-12)
Article #20: Endangered Soil (Gr.7-12)
Article #21: Sex Changing Fish (Gr.7-12)
Article #22: Fecal Transplants (Gr.7-12)
Article #23: Human Cyborgs vs. Bionic Humans (Gr.7-12)
Article #24: Black Holes Explained (Gr.9-12)
Article #25: The Science and Evolution of Skin Color (Gr.8-12)
Article #26: Tanning, UV Radiation and Skin Cancer (Gr.7-12)
Article #27: Lobotomies: Who Needs All that Brain? (Gr.7-12)
Article #28: The Importance of Bees (Gr.7-12)
Article #29: Antibiotics: Penicillin and Beyond (Gr.7-12)
Article #30: Addicted to Sugar (Gr.7-12)
Article #31: Food Designed for Space (Gr.7-12)
Article #32: Is Life Better Without Pain? (Gr.9-12)
Article #33: Blood Doping: More Blood, More Medals (Gr.8-12)
Article #34: Hello Gastric Bypass, Goodbye Stomach (Gr.7-12)
Article #35: An Athlete's Perfect Twitch (Gr.7-12)
Article #36: The Curious Case of Caffeine (Gr.7-12)
Article #37: The Chemistry of Fireworks (Gr.7-12)
Article #38: Climate Change and Pizzly Bears (Gr.7-12)
Article #39: The Science of Self-Control (Gr.7-12)
Article #40: The Truth Behind Bottled Water (Gr.7-12)
Article #41: Natural Selection Explained (Gr.8-12)
Article #42: The Evolution of Pretty Boys (Gr.8-12)
Article #43: Living in Space Harms Your Body (Gr.7-12)
Article #44: Fossil Fuels Uncovered (Gr.7-12)
Article #45: Love and Cupid's Chemicals (Gr.7-12)
Article #46: Zika Virus Emerges (Gr.7-12)
Article #47: Fracking Facts and Fears (Gr.7-12)
Article #48: The Science of Tattoos (Gr.7-12)
Article #49: Mitochondrial Eve (Gr.9-12)
Article #50: Stem Cell Science (Gr.7-12)
Article #51: The Science of the Flu Shot (Gr.7-12)
Article #52: Concussions in Sports (Gr.7-12)

SCIENCE READING ARTICLE #1: Why We Love and Hate Spicy Foods Gr. 7-12

Article highlights include:
Students will learn about the science behind the feeling of spiciness, what chemical compound creates this sensation, the way spiciness is measured, why the desire to eat spicy foods evolved and how to cure the pain of overly spicy food.



physiology ♦ neuroscience ♦ biochemistry ♦ evolution

WHY WE LOVE AND HATE SPICY FOODS

1

Science Literacy Warm

(1) Imagine eating something that makes your eyes water, your skin sweat and causes you burning sensations of pain? Would you willingly eat this? Every day hundreds of millions of people around the world volunteer to eat spicy foods that produce these results. Some not only volunteer, some demand that their food be even spicier. What exactly is "spiciness" and why do some people like it?

(2) The sensation of spiciness comes from a substance called capsaicin found in spicy foods like chili peppers. When capsaicin comes into contact with your tongue, it triggers receptors in the tongue called VR1 receptors which, strangely enough, are not actually made to detect a taste. VR1 receptors are thermoreceptors intended to detect temperature and when they are accidently triggered by capsaicin, the VR1 receptors send a signal to your brain telling it that heat has been detected. This is why eating spicy food makes your tongue feel like it's on fire; your brain is tricked into thinking that it is! This can also make the body feel hot which causes it to sweat. The sweat produced by spicy foods is called gustatory perspiration.

(3) Why does our tongue have VR1 receptors? VR1 receptors may have evolved to enable us to sense the temperature of foods to avoid eating foods that could burn our tongue and mouth when food is too hot. This may have come in handy as humans evolved from eating raw foods to cooked foods.

(4) Besides the capsaicin compound found in

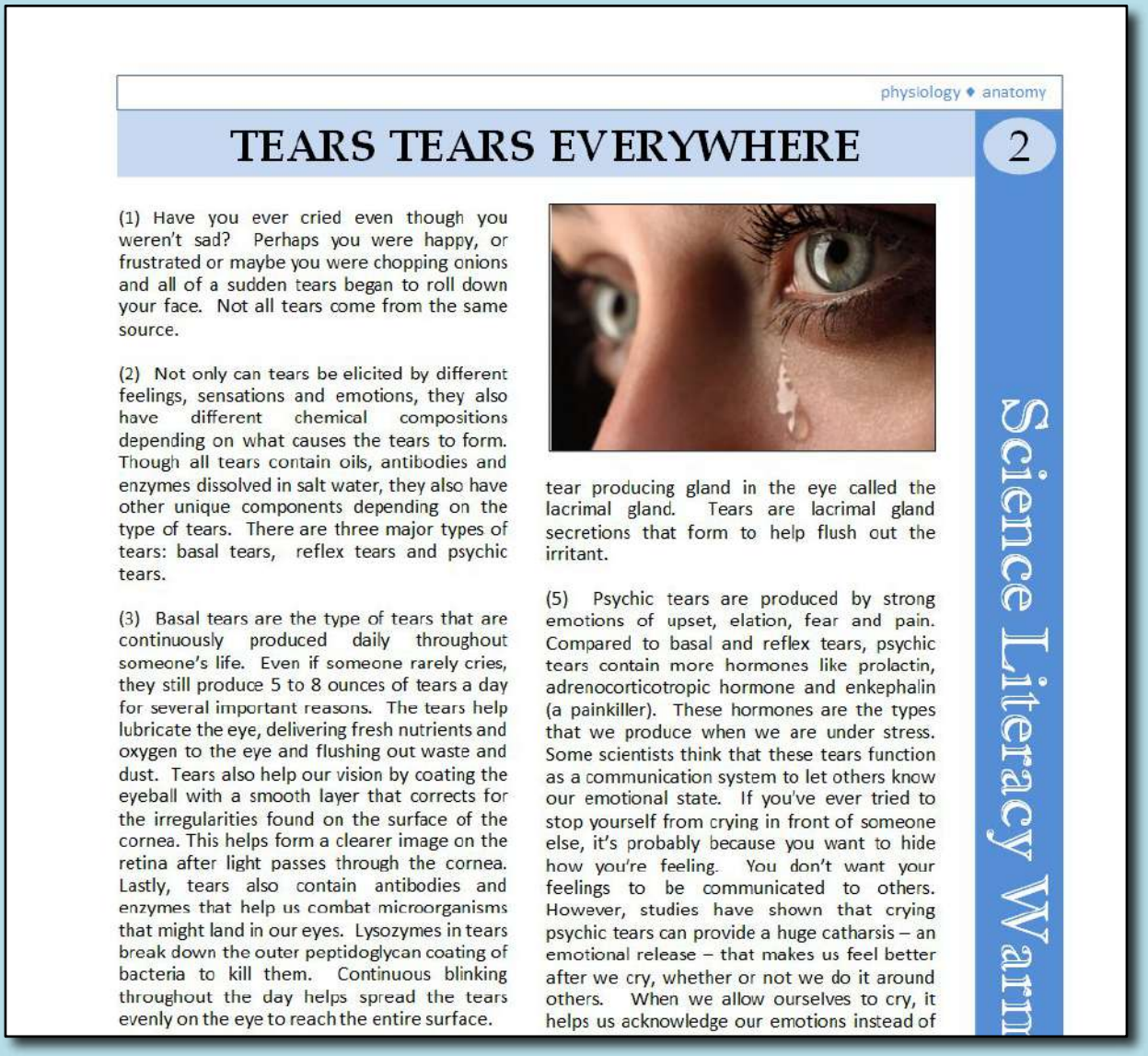
in foods are called Scoville Heat Units (SHU). The higher the SHU measurement of a food, the more capsaicin it has and the spicier it is.

(6) The spiciest food in the world is currently a pepper called the Carolina Reaper which measures over 2 200 000 SHU of spicy pain. It is so spicy that the oil from this pepper can cause burning sensations if it comes into contact with skin. Your skin also has temperature receptors that can be fooled by capsaicin. Through selective breeding the Carolina Reaper was developed by Ed Currie, owner of PuckerButt Pepper Company in the United States. It has held the Guinness World Record as the world's hottest chili pepper since August 7th 2013.

SCIENCE READING ARTICLE #2: Tears Tears Everywhere

Gr. 7-12

Article highlights include:
Students will learn about the differences in the three types of tears humans produce, the composition of these tears and their different purposes.



physiology ♦ anatomy

TEARS TEARS EVERYWHERE

2

Science Literacy Wan

(1) Have you ever cried even though you weren't sad? Perhaps you were happy, or frustrated or maybe you were chopping onions and all of a sudden tears began to roll down your face. Not all tears come from the same source.

(2) Not only can tears be elicited by different feelings, sensations and emotions, they also have different chemical compositions depending on what causes the tears to form. Though all tears contain oils, antibodies and enzymes dissolved in salt water, they also have other unique components depending on the type of tears. There are three major types of tears: basal tears, reflex tears and psychic tears.

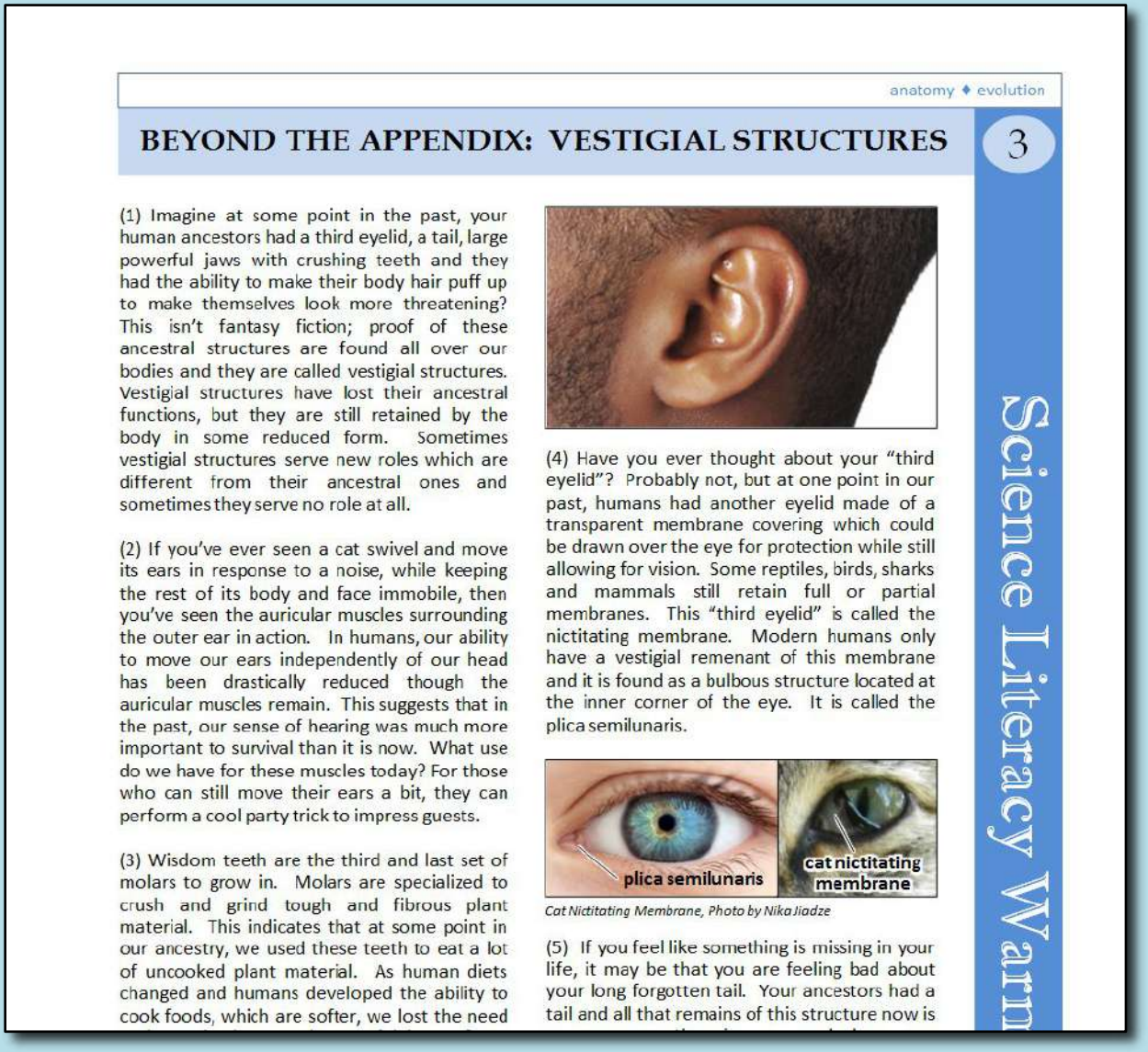
(3) Basal tears are the type of tears that are continuously produced daily throughout someone's life. Even if someone rarely cries, they still produce 5 to 8 ounces of tears a day for several important reasons. The tears help lubricate the eye, delivering fresh nutrients and oxygen to the eye and flushing out waste and dust. Tears also help our vision by coating the eyeball with a smooth layer that corrects for the irregularities found on the surface of the cornea. This helps form a clearer image on the retina after light passes through the cornea. Lastly, tears also contain antibodies and enzymes that help us combat microorganisms that might land in our eyes. Lysozymes in tears break down the outer peptidoglycan coating of bacteria to kill them. Continuous blinking throughout the day helps spread the tears evenly on the eye to reach the entire surface.

tear producing gland in the eye called the lacrimal gland. Tears are lacrimal gland secretions that form to help flush out the irritant.

(5) Psychic tears are produced by strong emotions of upset, elation, fear and pain. Compared to basal and reflex tears, psychic tears contain more hormones like prolactin, adrenocorticotropic hormone and enkephalin (a painkiller). These hormones are the types that we produce when we are under stress. Some scientists think that these tears function as a communication system to let others know our emotional state. If you've ever tried to stop yourself from crying in front of someone else, it's probably because you want to hide how you're feeling. You don't want your feelings to be communicated to others. However, studies have shown that crying psychic tears can provide a huge catharsis – an emotional release – that makes us feel better after we cry, whether or not we do it around others. When we allow ourselves to cry, it helps us acknowledge our emotions instead of

SCIENCE READING ARTICLE #3: Beyond the Appendix – Vestigial Structures Gr. 8-12

Article highlights include:
Students will learn about vestigial structures and about several different examples of human vestigial structures.



anatomy ♦ evolution

BEYOND THE APPENDIX: VESTIGIAL STRUCTURES

3

Science Literacy Warm

(1) Imagine at some point in the past, your human ancestors had a third eyelid, a tail, large powerful jaws with crushing teeth and they had the ability to make their body hair puff up to make themselves look more threatening? This isn't fantasy fiction; proof of these ancestral structures are found all over our bodies and they are called vestigial structures. Vestigial structures have lost their ancestral functions, but they are still retained by the body in some reduced form. Sometimes vestigial structures serve new roles which are different from their ancestral ones and sometimes they serve no role at all.

(2) If you've ever seen a cat swivel and move its ears in response to a noise, while keeping the rest of its body and face immobile, then you've seen the auricular muscles surrounding the outer ear in action. In humans, our ability to move our ears independently of our head has been drastically reduced though the auricular muscles remain. This suggests that in the past, our sense of hearing was much more important to survival than it is now. What use do we have for these muscles today? For those who can still move their ears a bit, they can perform a cool party trick to impress guests.

(3) Wisdom teeth are the third and last set of molars to grow in. Molars are specialized to crush and grind tough and fibrous plant material. This indicates that at some point in our ancestry, we used these teeth to eat a lot of uncooked plant material. As human diets changed and humans developed the ability to cook foods, which are softer, we lost the need

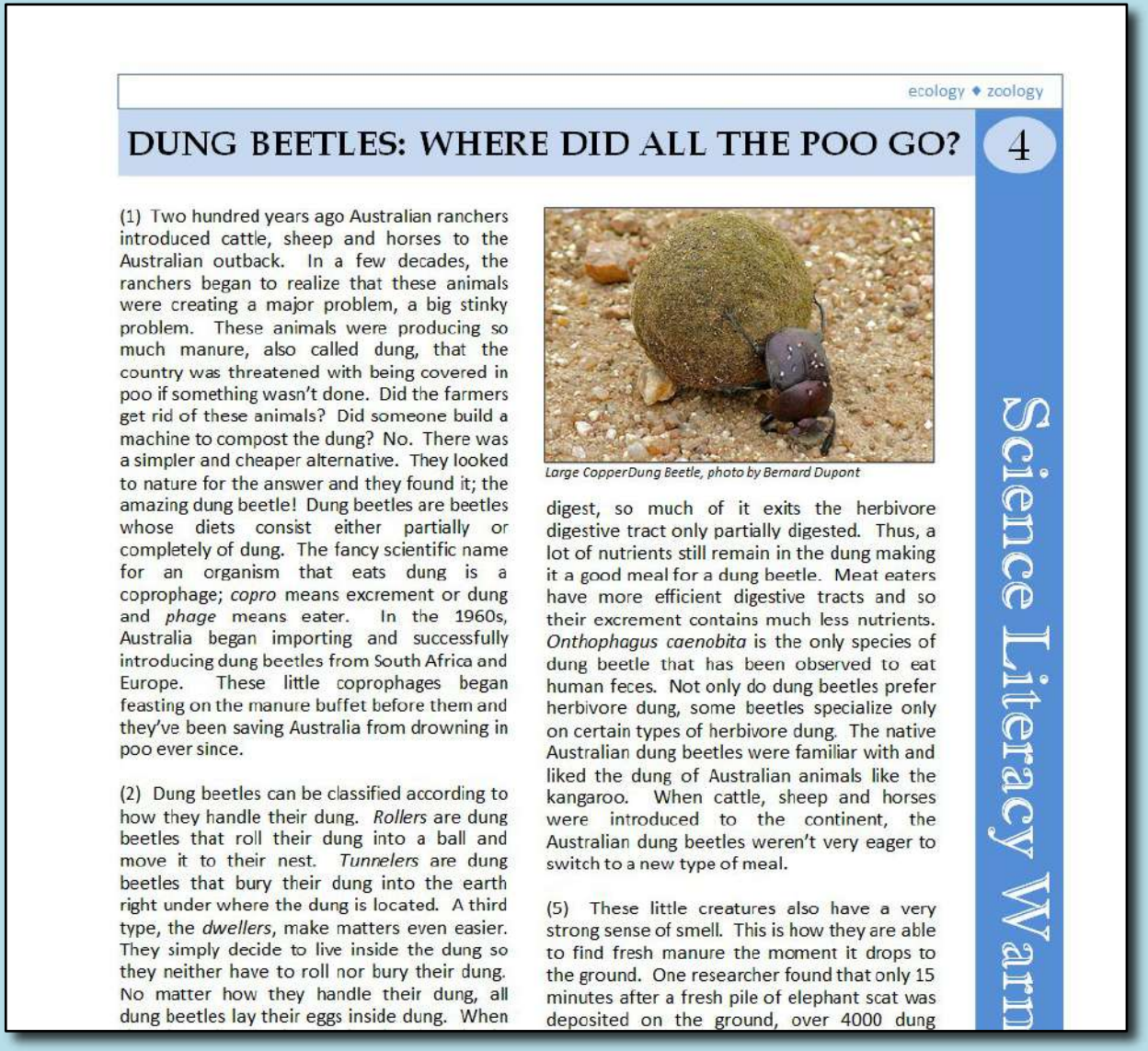
(4) Have you ever thought about your "third eyelid"? Probably not, but at one point in our past, humans had another eyelid made of a transparent membrane covering which could be drawn over the eye for protection while still allowing for vision. Some reptiles, birds, sharks and mammals still retain full or partial membranes. This "third eyelid" is called the nictitating membrane. Modern humans only have a vestigial remenant of this membrane and it is found as a bulbous structure located at the inner corner of the eye. It is called the plica semilunaris.

Cat Nictitating Membrane, Photo by Nika Jiadze

(5) If you feel like something is missing in your life, it may be that you are feeling bad about your long forgotten tail. Your ancestors had a tail and all that remains of this structure now is

SCIENCE READING ARTICLE #4: Dung Beetles – Where Did All the Poo Go? Gr. 7-12

Article highlights include:
Students will learn about the interesting habits, diets and behaviors of the dung beetle. They will also learn about why dung beetles are important to ecosystems.



ecology ♦ zoology

DUNG BEETLES: WHERE DID ALL THE POO GO?

4

Science Literacy Warm

(1) Two hundred years ago Australian ranchers introduced cattle, sheep and horses to the Australian outback. In a few decades, the ranchers began to realize that these animals were creating a major problem, a big stinky problem. These animals were producing so much manure, also called dung, that the country was threatened with being covered in poo if something wasn't done. Did the farmers get rid of these animals? Did someone build a machine to compost the dung? No. There was a simpler and cheaper alternative. They looked to nature for the answer and they found it; the amazing dung beetle! Dung beetles are beetles whose diets consist either partially or completely of dung. The fancy scientific name for an organism that eats dung is a coprophage; *copro* means excrement or dung and *phage* means eater. In the 1960s, Australia began importing and successfully introducing dung beetles from South Africa and Europe. These little coprophages began feasting on the manure buffet before them and they've been saving Australia from drowning in poo ever since.

(2) Dung beetles can be classified according to how they handle their dung. *Rollers* are dung beetles that roll their dung into a ball and move it to their nest. *Tunnelers* are dung beetles that bury their dung into the earth right under where the dung is located. A third type, the *dwellers*, make matters even easier. They simply decide to live inside the dung so they neither have to roll nor bury their dung. No matter how they handle their dung, all dung beetles lay their eggs inside dung. When

Large CopperDung Beetle, photo by Bernard Dupont

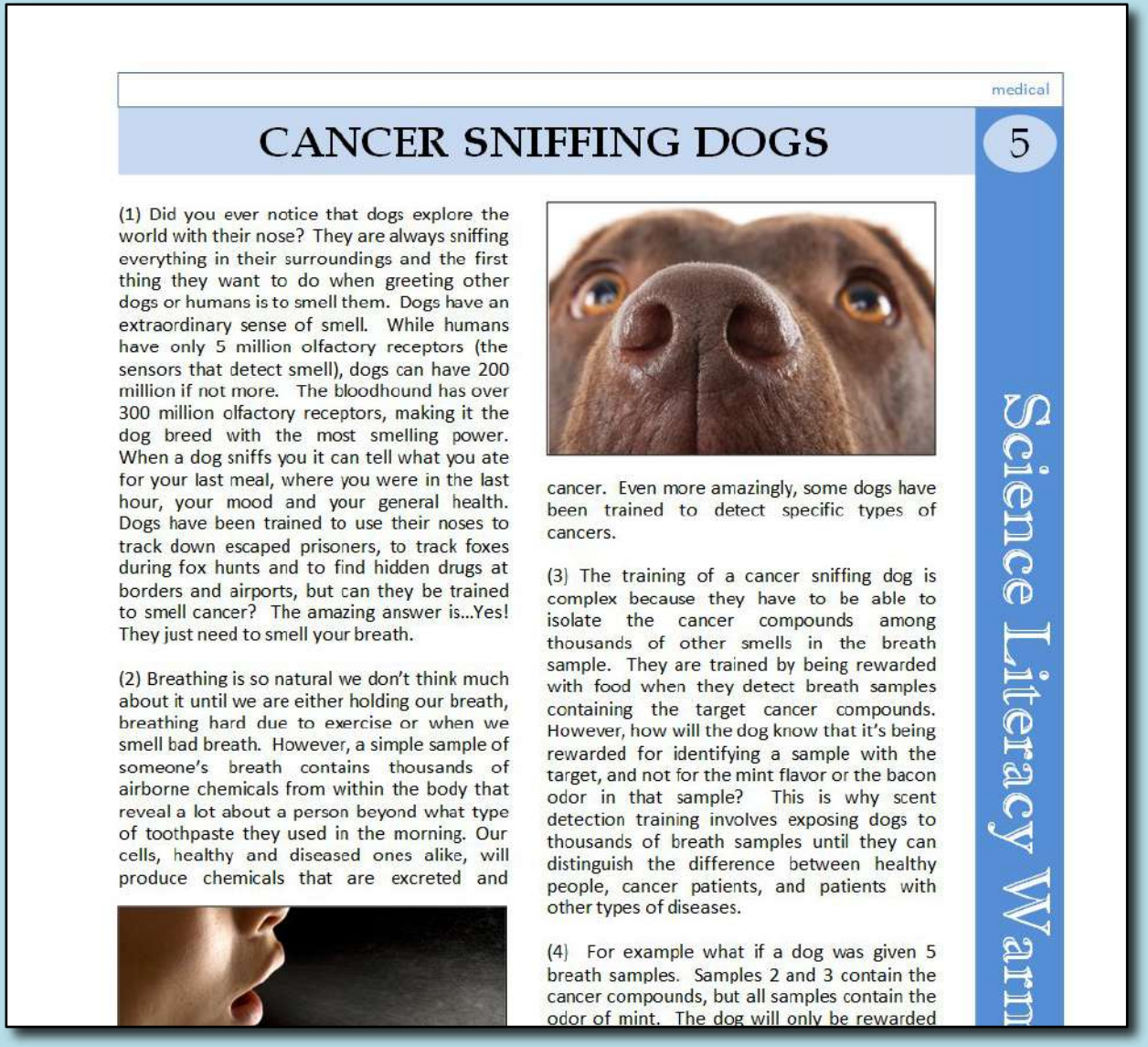
digest, so much of it exits the herbivore digestive tract only partially digested. Thus, a lot of nutrients still remain in the dung making it a good meal for a dung beetle. Meat eaters have more efficient digestive tracts and so their excrement contains much less nutrients. *Onthophagus caenobita* is the only species of dung beetle that has been observed to eat human feces. Not only do dung beetles prefer herbivore dung, some beetles specialize only on certain types of herbivore dung. The native Australian dung beetles were familiar with and liked the dung of Australian animals like the kangaroo. When cattle, sheep and horses were introduced to the continent, the Australian dung beetles weren't very eager to switch to a new type of meal.

(5) These little creatures also have a very strong sense of smell. This is how they are able to find fresh manure the moment it drops to the ground. One researcher found that only 15 minutes after a fresh pile of elephant scat was deposited on the ground, over 4000 dung

SCIENCE READING ARTICLE #5: Cancer Sniffing Dogs

Gr. 7-12

Article highlights include:
Students will learn how a sample of someone's breath can contain compounds released from cancer cells, how sensitive dogs are to scents, how dogs are trained to detect cancer compounds in samples of patients' breath and what other things a dog's sense of smell can be used for.



medical

CANCER SNIFFING DOGS

5

Science Literacy Wa

(1) Did you ever notice that dogs explore the world with their nose? They are always sniffing everything in their surroundings and the first thing they want to do when greeting other dogs or humans is to smell them. Dogs have an extraordinary sense of smell. While humans have only 5 million olfactory receptors (the sensors that detect smell), dogs can have 200 million if not more. The bloodhound has over 300 million olfactory receptors, making it the dog breed with the most smelling power. When a dog sniffs you it can tell what you ate for your last meal, where you were in the last hour, your mood and your general health. Dogs have been trained to use their noses to track down escaped prisoners, to track foxes during fox hunts and to find hidden drugs at borders and airports, but can they be trained to smell cancer? The amazing answer is...Yes! They just need to smell your breath.

(2) Breathing is so natural we don't think much about it until we are either holding our breath, breathing hard due to exercise or when we smell bad breath. However, a simple sample of someone's breath contains thousands of airborne chemicals from within the body that reveal a lot about a person beyond what type of toothpaste they used in the morning. Our cells, healthy and diseased ones alike, will produce chemicals that are excreted and

cancer. Even more amazingly, some dogs have been trained to detect specific types of cancers.

(3) The training of a cancer sniffing dog is complex because they have to be able to isolate the cancer compounds among thousands of other smells in the breath sample. They are trained by being rewarded with food when they detect breath samples containing the target cancer compounds. However, how will the dog know that it's being rewarded for identifying a sample with the target, and not for the mint flavor or the bacon odor in that sample? This is why scent detection training involves exposing dogs to thousands of breath samples until they can distinguish the difference between healthy people, cancer patients, and patients with other types of diseases.

(4) For example what if a dog was given 5 breath samples. Samples 2 and 3 contain the cancer compounds, but all samples contain the odor of mint. The dog will only be rewarded

SCIENCE READING ARTICLE #6: Hyponatremia – Death by Water Intoxication Gr. 9-12

Article highlights include:
Students will learn how water intoxication occurs as well as the symptoms of hyponatremia. They will also learn about who is most at risk for this condition and they will be given examples of people who have suffered from hyponatremia.

physiology ♦ osmosis ♦ medical

HYPONATREMIA: DEATH BY WATER INTOXICATION

6

Science Literacy Warm

(1) When we think about death by water, we usually think of drowning. This is when water floods our lungs, preventing us from breathing air. However, there is another type of death by water that might be surprising to you; it's through drinking too much water. A poison is any substance that can cause a dysfunction in the body once it is consumed in large enough quantities. You might think that water is a harmless substance, but it can be a poison when too much of it is consumed. This condition is called hyponatremia, also commonly known as water intoxication.

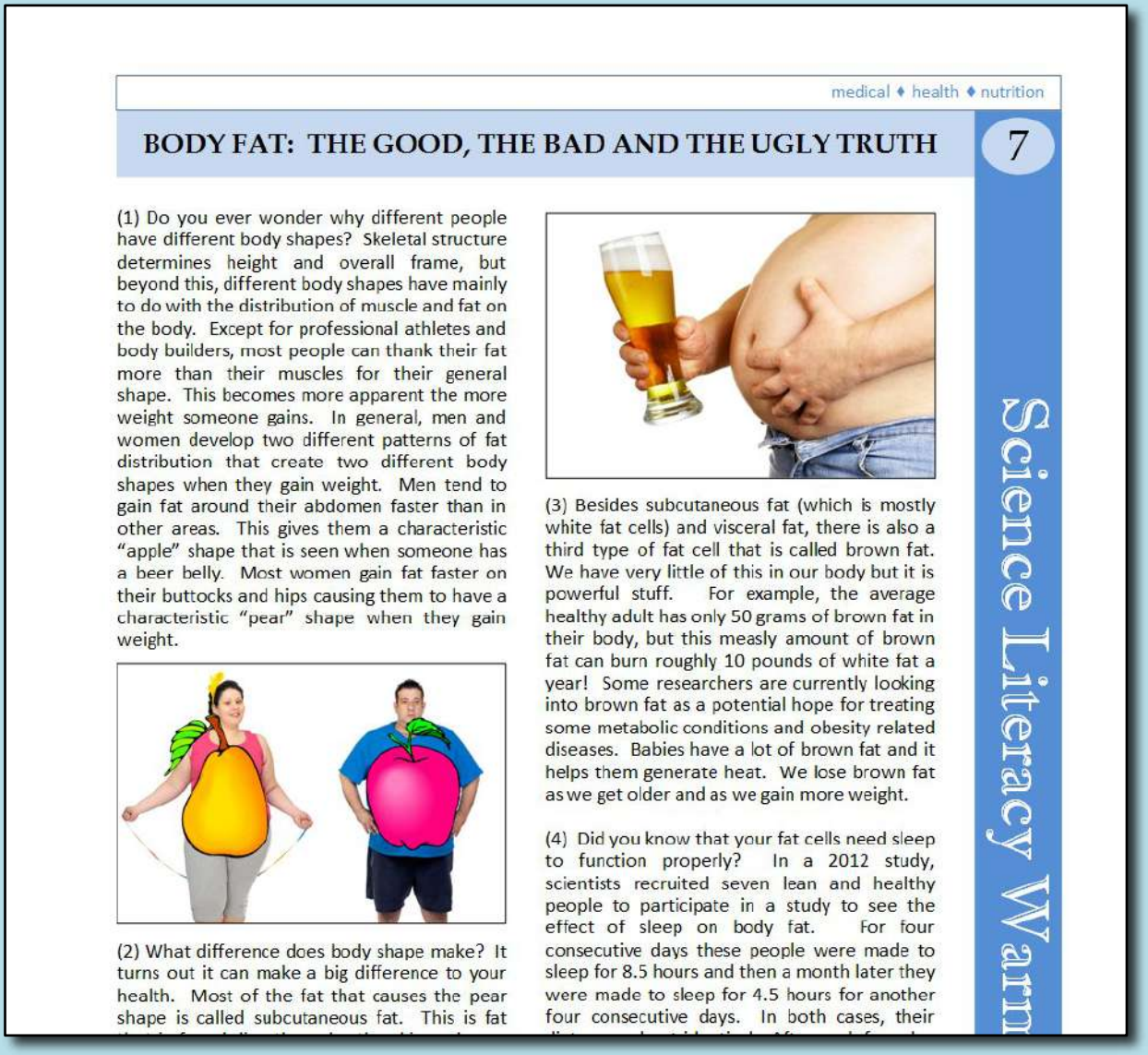
(2) The symptoms of hyponatremia include nausea, vomiting, headache, confusion, lethargy, cramps, seizures, decreased consciousness and eventually coma and death if the case is severe enough. Many of these are neurological symptoms, meaning that it affects the nervous system, which includes the brain.

(3) How does drinking too much water cause these symptoms? The key isn't actually the water, it is the salt, or electrolytes, in your body. A healthy body has a balanced concentration of electrolytes, but when excess water is added, these electrolytes become diluted in the large amount of water. Hyponatremia literally means lack of salt. Water itself likes to move from an area of low electrolyte concentration to an area of higher electrolyte concentration within the body. As more water is consumed, it first gets dumped into the blood and dilutes the electrolytes in the blood. When these electrolytes become very diluted, then the place that has a higher

(4) You might think it would be difficult to become hyponatremic. All you have to do is avoid drinking too much water to prevent this, however, every year hundreds of people accidently die of hyponatremia. The most common cases involve exercise-associated hyponatremia. When exercising, athletes lose a lot of water through sweat, and try to replace this with water or sports drinks during and after exercise. It's estimated that up to one sixth of marathon runners can become hyponatremic. Infants under 9 months old are also at risk of being hyponatremic because of their low body mass. It's easy for them to over consume liquids and if they are in distress, it's difficult for them to communicate this. People who use MDMA, a party drug commonly known as Ecstasy, can become hyponatremic. MDMA is often used

SCIENCE READING ARTICLE #7: Fat, The Good, The Bad and the Ugly Truth Gr. 8-12

Article highlights include:
Students will learn about the different types of fat in the body, their functions and the issues that can arise when fat content in the body becomes imbalanced.



medical ♦ health ♦ nutrition

BODY FAT: THE GOOD, THE BAD AND THE UGLY TRUTH

7

Science Literacy Warm

(1) Do you ever wonder why different people have different body shapes? Skeletal structure determines height and overall frame, but beyond this, different body shapes have mainly to do with the distribution of muscle and fat on the body. Except for professional athletes and body builders, most people can thank their fat more than their muscles for their general shape. This becomes more apparent the more weight someone gains. In general, men and women develop two different patterns of fat distribution that create two different body shapes when they gain weight. Men tend to gain fat around their abdomen faster than in other areas. This gives them a characteristic "apple" shape that is seen when someone has a beer belly. Most women gain fat faster on their buttocks and hips causing them to have a characteristic "pear" shape when they gain weight.

(2) What difference does body shape make? It turns out it can make a big difference to your health. Most of the fat that causes the pear shape is called subcutaneous fat. This is fat

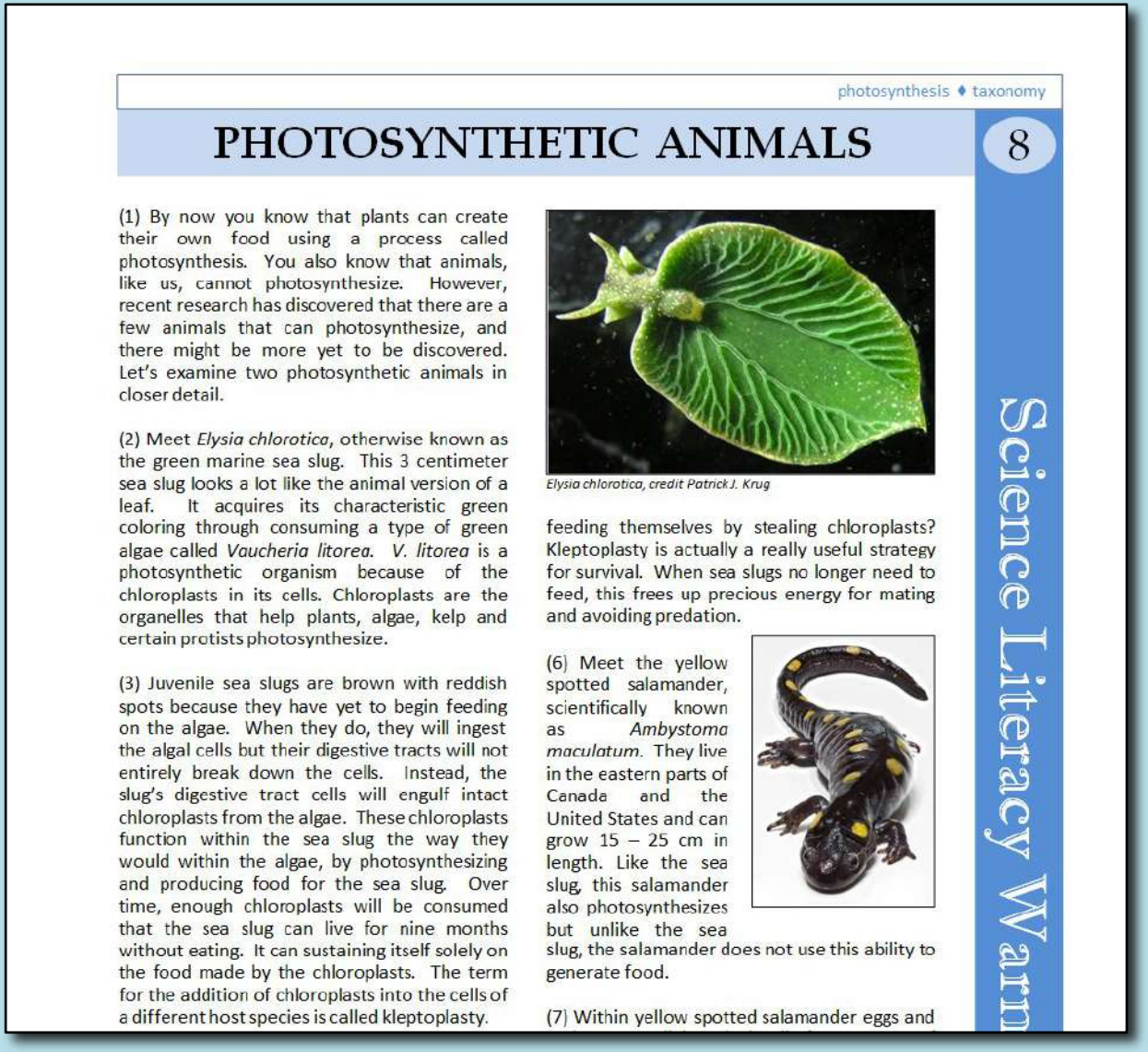
(3) Besides subcutaneous fat (which is mostly white fat cells) and visceral fat, there is also a third type of fat cell that is called brown fat. We have very little of this in our body but it is powerful stuff. For example, the average healthy adult has only 50 grams of brown fat in their body, but this measly amount of brown fat can burn roughly 10 pounds of white fat a year! Some researchers are currently looking into brown fat as a potential hope for treating some metabolic conditions and obesity related diseases. Babies have a lot of brown fat and it helps them generate heat. We lose brown fat as we get older and as we gain more weight.

(4) Did you know that your fat cells need sleep to function properly? In a 2012 study, scientists recruited seven lean and healthy people to participate in a study to see the effect of sleep on body fat. For four consecutive days these people were made to sleep for 8.5 hours and then a month later they were made to sleep for 4.5 hours for another four consecutive days. In both cases, their

SCIENCE READING ARTICLE #8: Photosynthetic Animals

Gr. 8-12

Article highlights include:
Students will learn about two animals (green sea slug and yellow spotted salamander) that can photosynthesize due to symbiotic relationships with algae.



photosynthesis ♦ taxonomy

PHOTOSYNTHETIC ANIMALS

8

Science Literacy Warm

(1) By now you know that plants can create their own food using a process called photosynthesis. You also know that animals, like us, cannot photosynthesize. However, recent research has discovered that there are a few animals that can photosynthesize, and there might be more yet to be discovered. Let's examine two photosynthetic animals in closer detail.

(2) Meet *Elysia chlorotica*, otherwise known as the green marine sea slug. This 3 centimeter sea slug looks a lot like the animal version of a leaf. It acquires its characteristic green coloring through consuming a type of green algae called *Vaucheria litorea*. *V. litorea* is a photosynthetic organism because of the chloroplasts in its cells. Chloroplasts are the organelles that help plants, algae, kelp and certain protists photosynthesize.

(3) Juvenile sea slugs are brown with reddish spots because they have yet to begin feeding on the algae. When they do, they will ingest the algal cells but their digestive tracts will not entirely break down the cells. Instead, the slug's digestive tract cells will engulf intact chloroplasts from the algae. These chloroplasts function within the sea slug the way they would within the algae, by photosynthesizing and producing food for the sea slug. Over time, enough chloroplasts will be consumed that the sea slug can live for nine months without eating. It can sustaining itself solely on the food made by the chloroplasts. The term for the addition of chloroplasts into the cells of a different host species is called kleptoplasty.

Elysia chlorotica, credit Patrick J. Krug

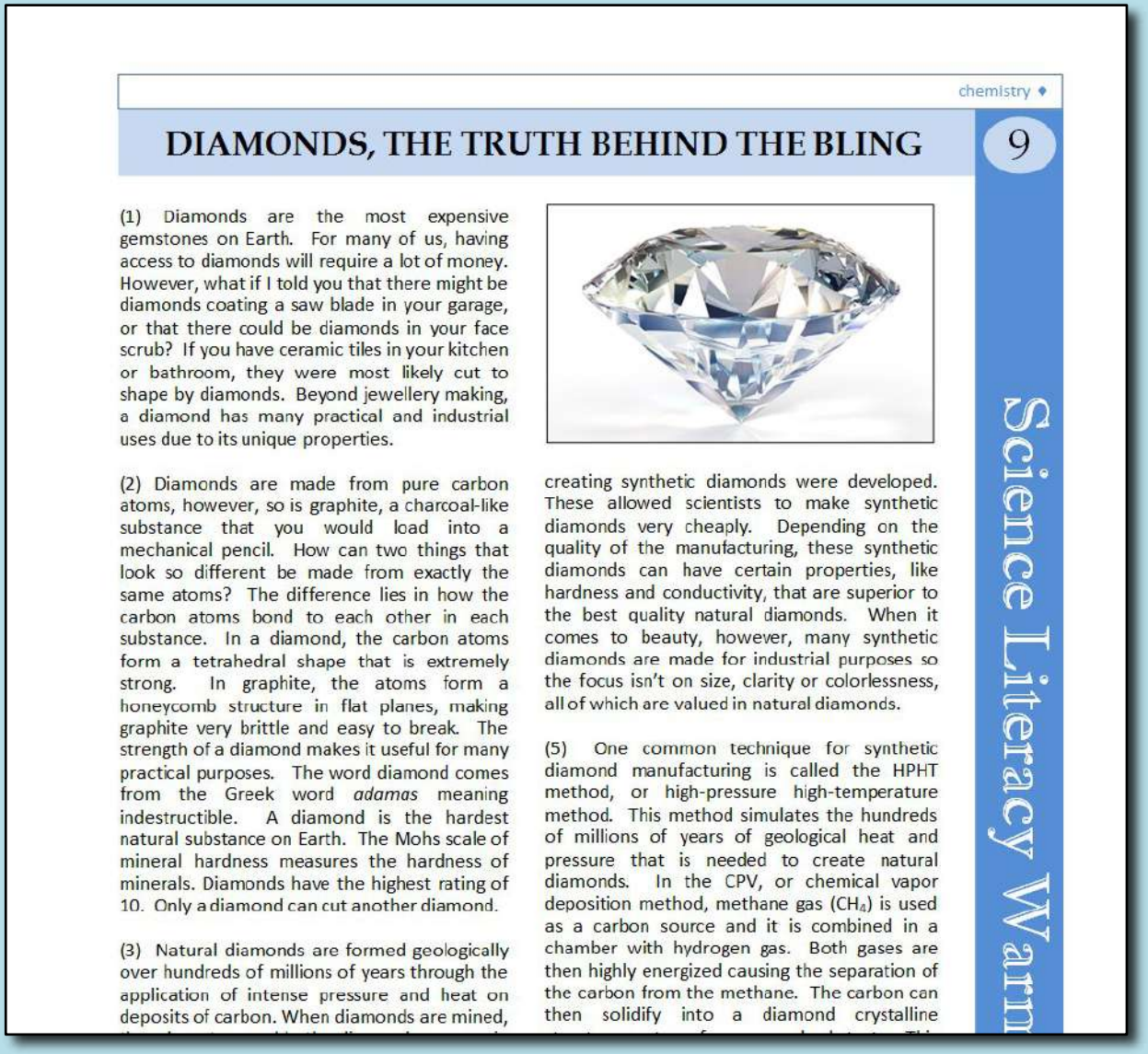
feeding themselves by stealing chloroplasts? Kleptoplasty is actually a really useful strategy for survival. When sea slugs no longer need to feed, this frees up precious energy for mating and avoiding predation.

(6) Meet the yellow spotted salamander, scientifically known as *Ambystoma maculatum*. They live in the eastern parts of Canada and the United States and can grow 15 – 25 cm in length. Like the sea slug, this salamander also photosynthesizes but unlike the sea slug, the salamander does not use this ability to generate food.

(7) Within yellow spotted salamander eggs and

SCIENCE READING ARTICLE #9: Diamonds, The Truth Behind the Bling — Gr. 8-12

Article highlights include:
Students will learn about the properties of a diamond and what makes it different from graphite, different methods of creating synthetic diamonds, and what applications these synthetic diamonds have. They will also learn about a planet in our Milky Way galaxy made up of at least one third diamond.



DIAMONDS, THE TRUTH BEHIND THE BLING

(1) Diamonds are the most expensive gemstones on Earth. For many of us, having access to diamonds will require a lot of money. However, what if I told you that there might be diamonds coating a saw blade in your garage, or that there could be diamonds in your face scrub? If you have ceramic tiles in your kitchen or bathroom, they were most likely cut to shape by diamonds. Beyond jewellery making, a diamond has many practical and industrial uses due to its unique properties.

(2) Diamonds are made from pure carbon atoms, however, so is graphite, a charcoal-like substance that you would load into a mechanical pencil. How can two things that look so different be made from exactly the same atoms? The difference lies in how the carbon atoms bond to each other in each substance. In a diamond, the carbon atoms form a tetrahedral shape that is extremely strong. In graphite, the atoms form a honeycomb structure in flat planes, making graphite very brittle and easy to break. The strength of a diamond makes it useful for many practical purposes. The word diamond comes from the Greek word *adamas* meaning indestructible. A diamond is the hardest natural substance on Earth. The Mohs scale of mineral hardness measures the hardness of minerals. Diamonds have the highest rating of 10. Only a diamond can cut another diamond.

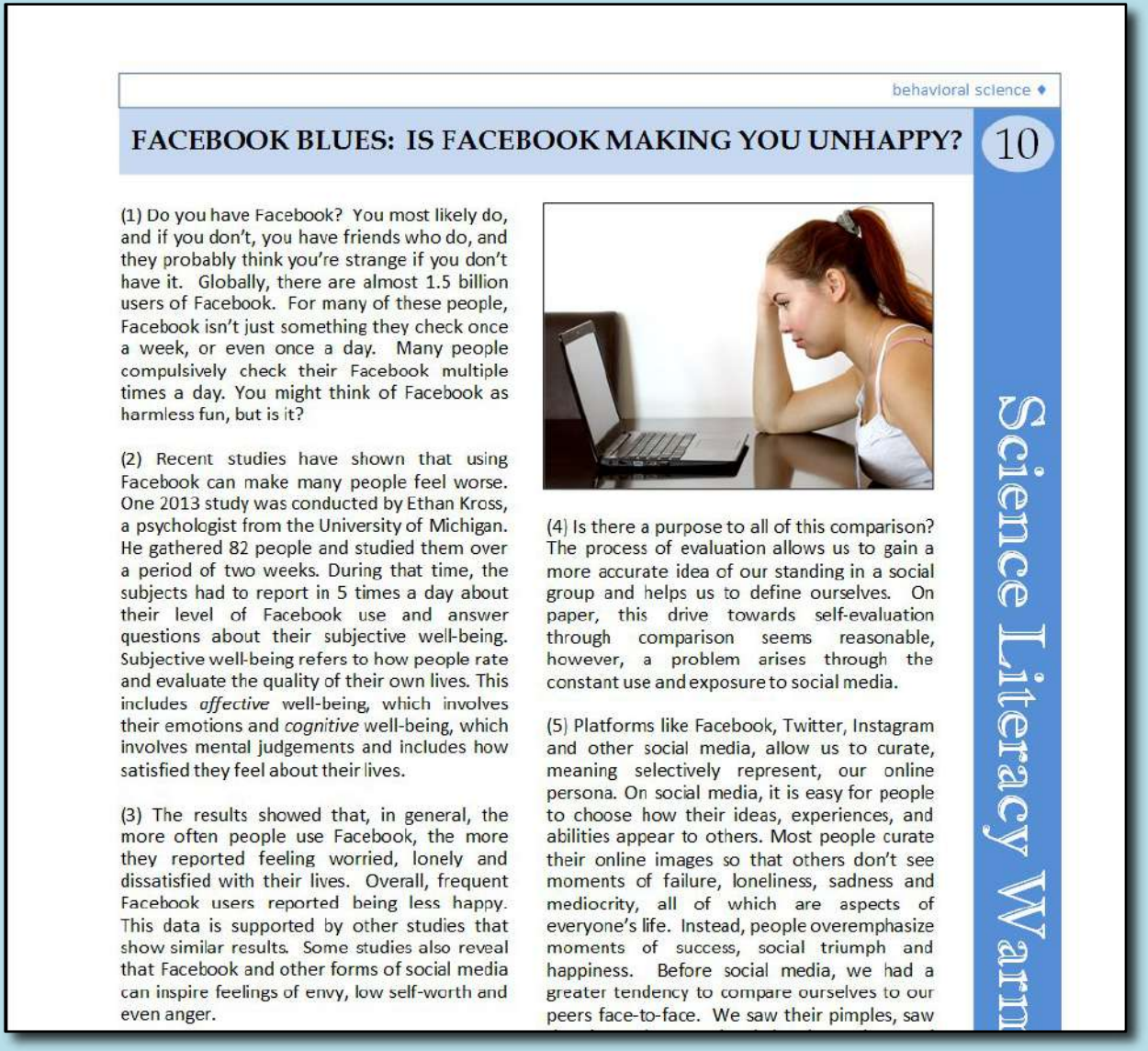
(3) Natural diamonds are formed geologically over hundreds of millions of years through the application of intense pressure and heat on deposits of carbon. When diamonds are mined,

creating synthetic diamonds were developed. These allowed scientists to make synthetic diamonds very cheaply. Depending on the quality of the manufacturing, these synthetic diamonds can have certain properties, like hardness and conductivity, that are superior to the best quality natural diamonds. When it comes to beauty, however, many synthetic diamonds are made for industrial purposes so the focus isn't on size, clarity or colorlessness, all of which are valued in natural diamonds.

(5) One common technique for synthetic diamond manufacturing is called the HPHT method, or high-pressure high-temperature method. This method simulates the hundreds of millions of years of geological heat and pressure that is needed to create natural diamonds. In the CPV, or chemical vapor deposition method, methane gas (CH_4) is used as a carbon source and it is combined in a chamber with hydrogen gas. Both gases are then highly energized causing the separation of the carbon from the methane. The carbon can then solidify into a diamond crystalline

SCIENCE READING ARTICLE #10: Is Facebook Making You Unhappy? Gr. 7-12

Article highlights include:
Students will learn about studies that show that using Facebook and other social media correlate with decreased feelings of well-being. Facebook addiction is also discussed along with a the Bergen Facebook Addiction Scale. The scale has been provided for students to diagnose their own Facebook dependency. A great class discussion can ensue from this.



behavioral science ♦

FACEBOOK BLUES: IS FACEBOOK MAKING YOU UNHAPPY?

10

Science Literacy Warm

(1) Do you have Facebook? You most likely do, and if you don't, you have friends who do, and they probably think you're strange if you don't have it. Globally, there are almost 1.5 billion users of Facebook. For many of these people, Facebook isn't just something they check once a week, or even once a day. Many people compulsively check their Facebook multiple times a day. You might think of Facebook as harmless fun, but is it?

(2) Recent studies have shown that using Facebook can make many people feel worse. One 2013 study was conducted by Ethan Kross, a psychologist from the University of Michigan. He gathered 82 people and studied them over a period of two weeks. During that time, the subjects had to report in 5 times a day about their level of Facebook use and answer questions about their subjective well-being. Subjective well-being refers to how people rate and evaluate the quality of their own lives. This includes *affective* well-being, which involves their emotions and *cognitive* well-being, which involves mental judgements and includes how satisfied they feel about their lives.

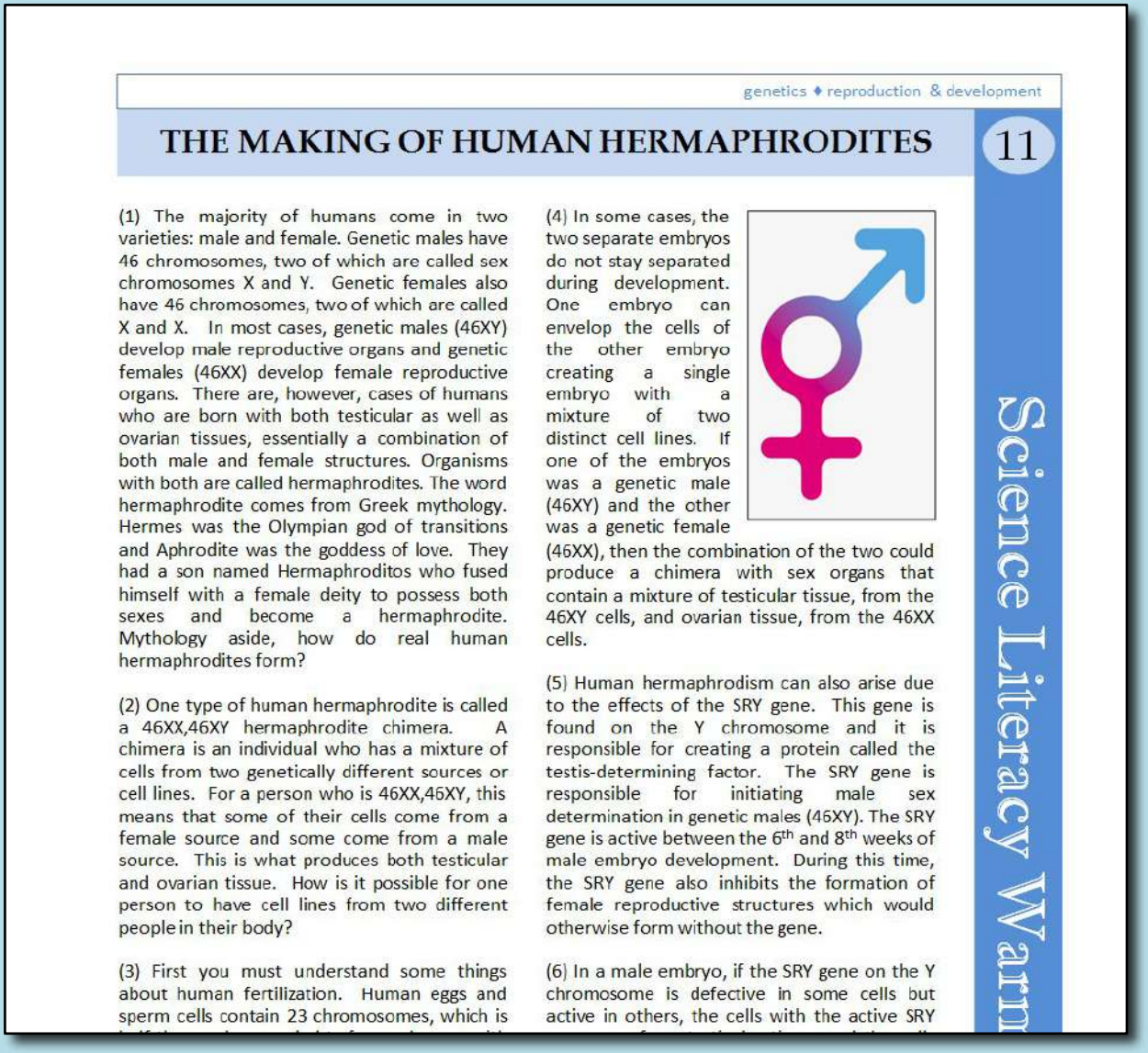
(3) The results showed that, in general, the more often people use Facebook, the more they reported feeling worried, lonely and dissatisfied with their lives. Overall, frequent Facebook users reported being less happy. This data is supported by other studies that show similar results. Some studies also reveal that Facebook and other forms of social media can inspire feelings of envy, low self-worth and even anger.

(4) Is there a purpose to all of this comparison? The process of evaluation allows us to gain a more accurate idea of our standing in a social group and helps us to define ourselves. On paper, this drive towards self-evaluation through comparison seems reasonable, however, a problem arises through the constant use and exposure to social media.

(5) Platforms like Facebook, Twitter, Instagram and other social media, allow us to curate, meaning selectively represent, our online persona. On social media, it is easy for people to choose how their ideas, experiences, and abilities appear to others. Most people curate their online images so that others don't see moments of failure, loneliness, sadness and mediocrity, all of which are aspects of everyone's life. Instead, people overemphasize moments of success, social triumph and happiness. Before social media, we had a greater tendency to compare ourselves to our peers face-to-face. We saw their pimples, saw

SCIENCE READING ARTICLE #11: The Making of Human Hermaphrodites Gr. 9-12

Article highlights include:
Students will learn about human hermaphrodites, the etymology of the word hermaphrodite, the two major causes of human hermaphrodism (46XX/46XY chimeras, the SRY gene) and other organisms that are hermaphroditic.



genetics ♦ reproduction & development

THE MAKING OF HUMAN HERMAPHRODITES

11

Science Literacy Warm

(1) The majority of humans come in two varieties: male and female. Genetic males have 46 chromosomes, two of which are called sex chromosomes X and Y. Genetic females also have 46 chromosomes, two of which are called X and X. In most cases, genetic males (46XY) develop male reproductive organs and genetic females (46XX) develop female reproductive organs. There are, however, cases of humans who are born with both testicular as well as ovarian tissues, essentially a combination of both male and female structures. Organisms with both are called hermaphrodites. The word hermaphrodite comes from Greek mythology. Hermes was the Olympian god of transitions and Aphrodite was the goddess of love. They had a son named Hermaphroditos who fused himself with a female deity to possess both sexes and become a hermaphrodite. Mythology aside, how do real human hermaphrodites form?

(2) One type of human hermaphrodite is called a 46XX,46XY hermaphrodite chimera. A chimera is an individual who has a mixture of cells from two genetically different sources or cell lines. For a person who is 46XX,46XY, this means that some of their cells come from a female source and some come from a male source. This is what produces both testicular and ovarian tissue. How is it possible for one person to have cell lines from two different people in their body?

(3) First you must understand some things about human fertilization. Human eggs and sperm cells contain 23 chromosomes, which is

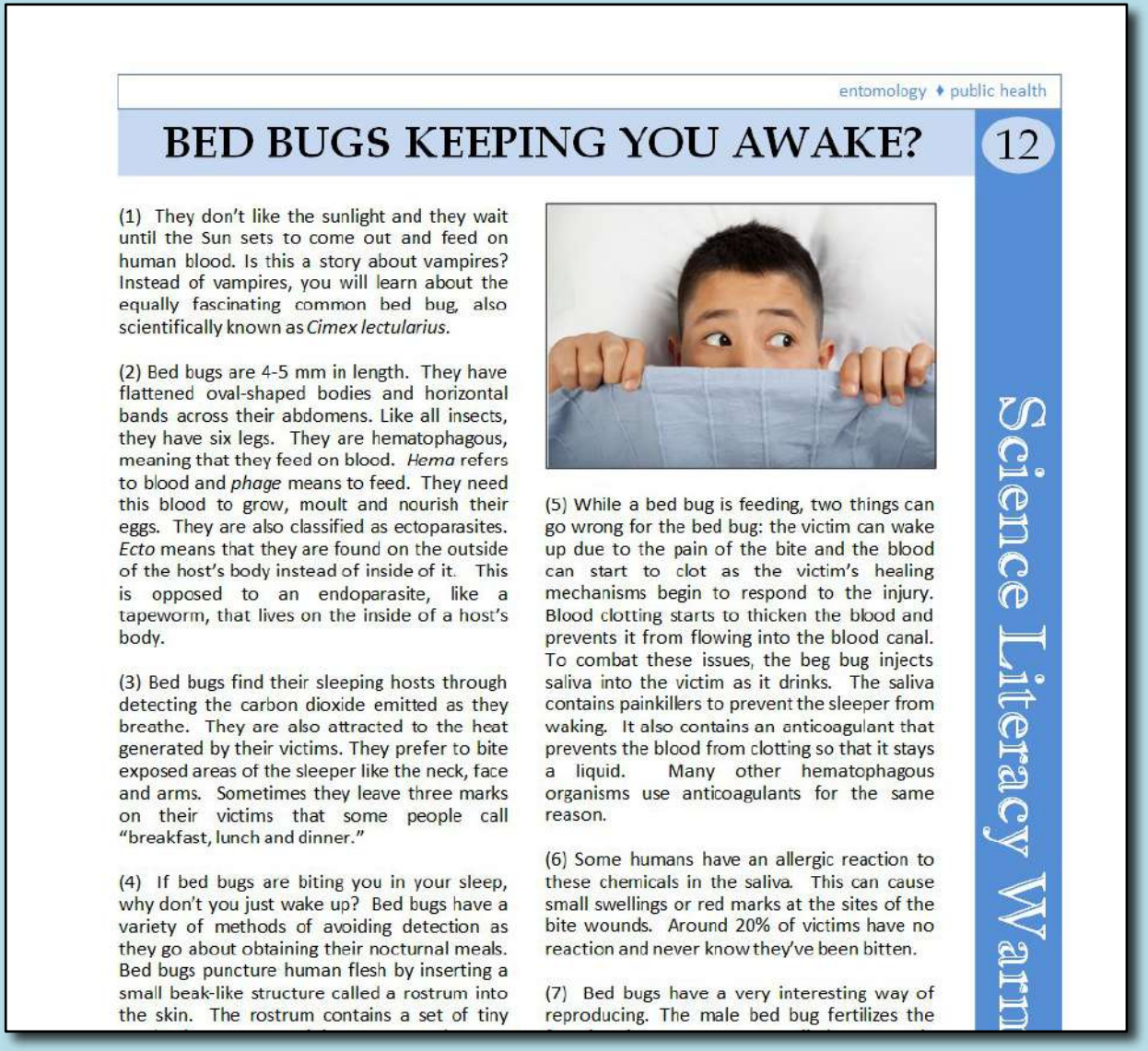
(4) In some cases, the two separate embryos do not stay separated during development. One embryo can envelop the cells of the other embryo creating a single embryo with a mixture of two distinct cell lines. If one of the embryos was a genetic male (46XY) and the other was a genetic female (46XX), then the combination of the two could produce a chimera with sex organs that contain a mixture of testicular tissue, from the 46XY cells, and ovarian tissue, from the 46XX cells.

(5) Human hermaphrodism can also arise due to the effects of the SRY gene. This gene is found on the Y chromosome and it is responsible for creating a protein called the testis-determining factor. The SRY gene is responsible for initiating male sex determination in genetic males (46XY). The SRY gene is active between the 6th and 8th weeks of male embryo development. During this time, the SRY gene also inhibits the formation of female reproductive structures which would otherwise form without the gene.

(6) In a male embryo, if the SRY gene on the Y chromosome is defective in some cells but active in others, the cells with the active SRY

SCIENCE READING ARTICLE #12: Are Bed Bugs Keeping You Awake? Gr. 8-12

Article highlights include:
Students will learn about beg bugs, their physical and behavioral characteristics, how they reproduce, their effects on human hosts, why cases of infestation in developed countries has risen in the last few decades and what methods do and don't work in attempts to eradicate them.



entomology ♦ public health

BED BUGS KEEPING YOU AWAKE?

12

Science Literacy Warm

(1) They don't like the sunlight and they wait until the Sun sets to come out and feed on human blood. Is this a story about vampires? Instead of vampires, you will learn about the equally fascinating common bed bug, also scientifically known as *Cimex lectularius*.

(2) Bed bugs are 4-5 mm in length. They have flattened oval-shaped bodies and horizontal bands across their abdomens. Like all insects, they have six legs. They are hematophagous, meaning that they feed on blood. *Hema* refers to blood and *phage* means to feed. They need this blood to grow, moult and nourish their eggs. They are also classified as ectoparasites. *Ecto* means that they are found on the outside of the host's body instead of inside of it. This is opposed to an endoparasite, like a tapeworm, that lives on the inside of a host's body.

(3) Bed bugs find their sleeping hosts through detecting the carbon dioxide emitted as they breathe. They are also attracted to the heat generated by their victims. They prefer to bite exposed areas of the sleeper like the neck, face and arms. Sometimes they leave three marks on their victims that some people call "breakfast, lunch and dinner."

(4) If bed bugs are biting you in your sleep, why don't you just wake up? Bed bugs have a variety of methods of avoiding detection as they go about obtaining their nocturnal meals. Bed bugs puncture human flesh by inserting a small beak-like structure called a rostrum into the skin. The rostrum contains a set of tiny

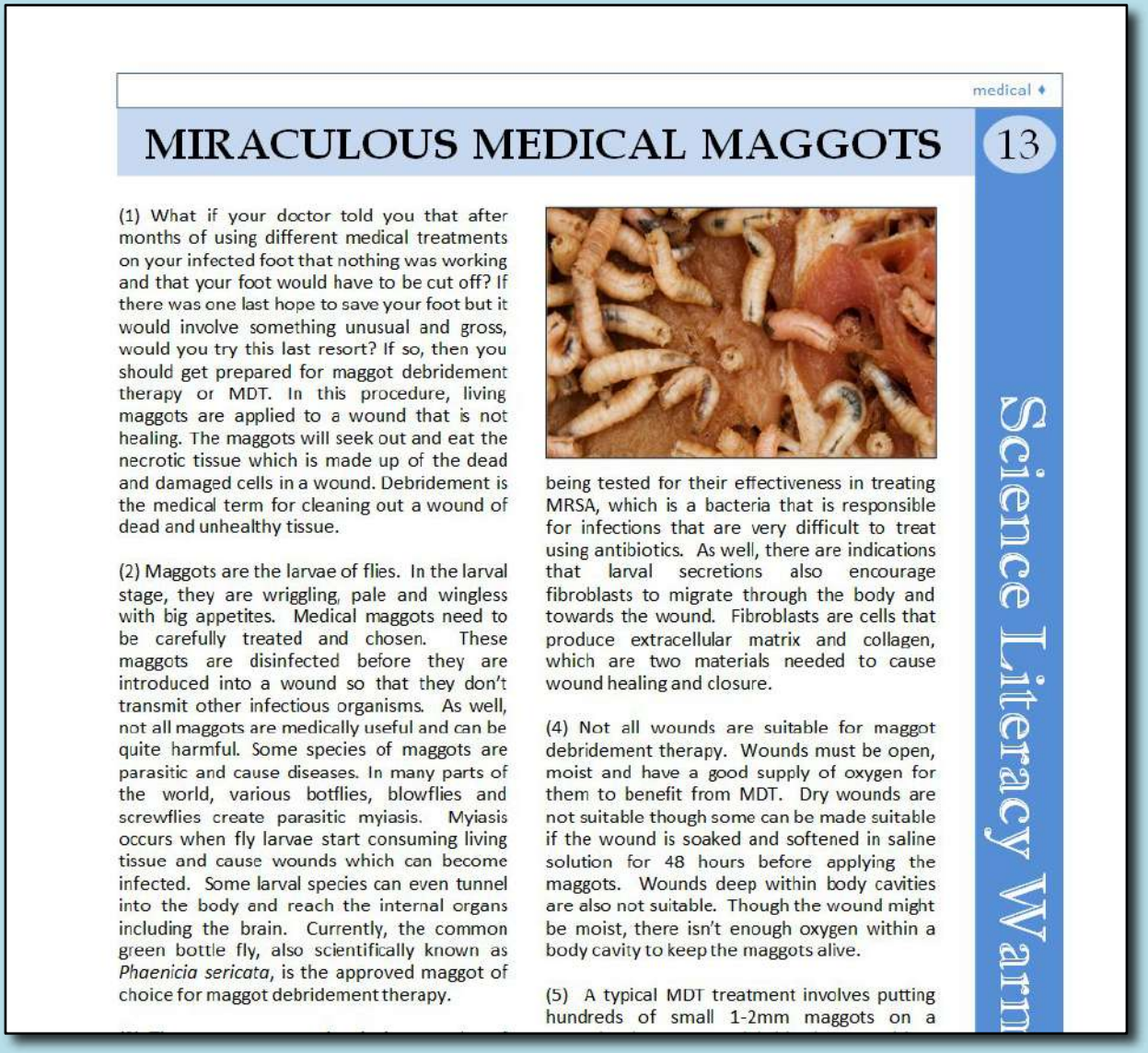
(5) While a bed bug is feeding, two things can go wrong for the bed bug: the victim can wake up due to the pain of the bite and the blood can start to clot as the victim's healing mechanisms begin to respond to the injury. Blood clotting starts to thicken the blood and prevents it from flowing into the blood canal. To combat these issues, the beg bug injects saliva into the victim as it drinks. The saliva contains painkillers to prevent the sleeper from waking. It also contains an anticoagulant that prevents the blood from clotting so that it stays a liquid. Many other hematophagous organisms use anticoagulants for the same reason.

(6) Some humans have an allergic reaction to these chemicals in the saliva. This can cause small swellings or red marks at the sites of the bite wounds. Around 20% of victims have no reaction and never know they've been bitten.

(7) Bed bugs have a very interesting way of reproducing. The male bed bug fertilizes the

SCIENCE READING ARTICLE #13: Miraculous Medical Maggots — Gr. 7-12

Article highlights include:
Students will learn about how maggot debridement therapy (MDT) is used to heal wounds and stave off infection, why the common green bottle fly larva is the maggot of choice, what type of wounds are best suited to MDT and the rise, fall and re-emergence of MDT as a popular medical treatment.



MIRACULOUS MEDICAL MAGGOTS

(1) What if your doctor told you that after months of using different medical treatments on your infected foot that nothing was working and that your foot would have to be cut off? If there was one last hope to save your foot but it would involve something unusual and gross, would you try this last resort? If so, then you should get prepared for maggot debridement therapy or MDT. In this procedure, living maggots are applied to a wound that is not healing. The maggots will seek out and eat the necrotic tissue which is made up of the dead and damaged cells in a wound. Debridement is the medical term for cleaning out a wound of dead and unhealthy tissue.

(2) Maggots are the larvae of flies. In the larval stage, they are wriggling, pale and wingless with big appetites. Medical maggots need to be carefully treated and chosen. These maggots are disinfected before they are introduced into a wound so that they don't transmit other infectious organisms. As well, not all maggots are medically useful and can be quite harmful. Some species of maggots are parasitic and cause diseases. In many parts of the world, various botflies, blowflies and screwflies create parasitic myiasis. Myiasis occurs when fly larvae start consuming living tissue and cause wounds which can become infected. Some larval species can even tunnel into the body and reach the internal organs including the brain. Currently, the common green bottle fly, also scientifically known as *Phaenicia sericata*, is the approved maggot of choice for maggot debridement therapy.

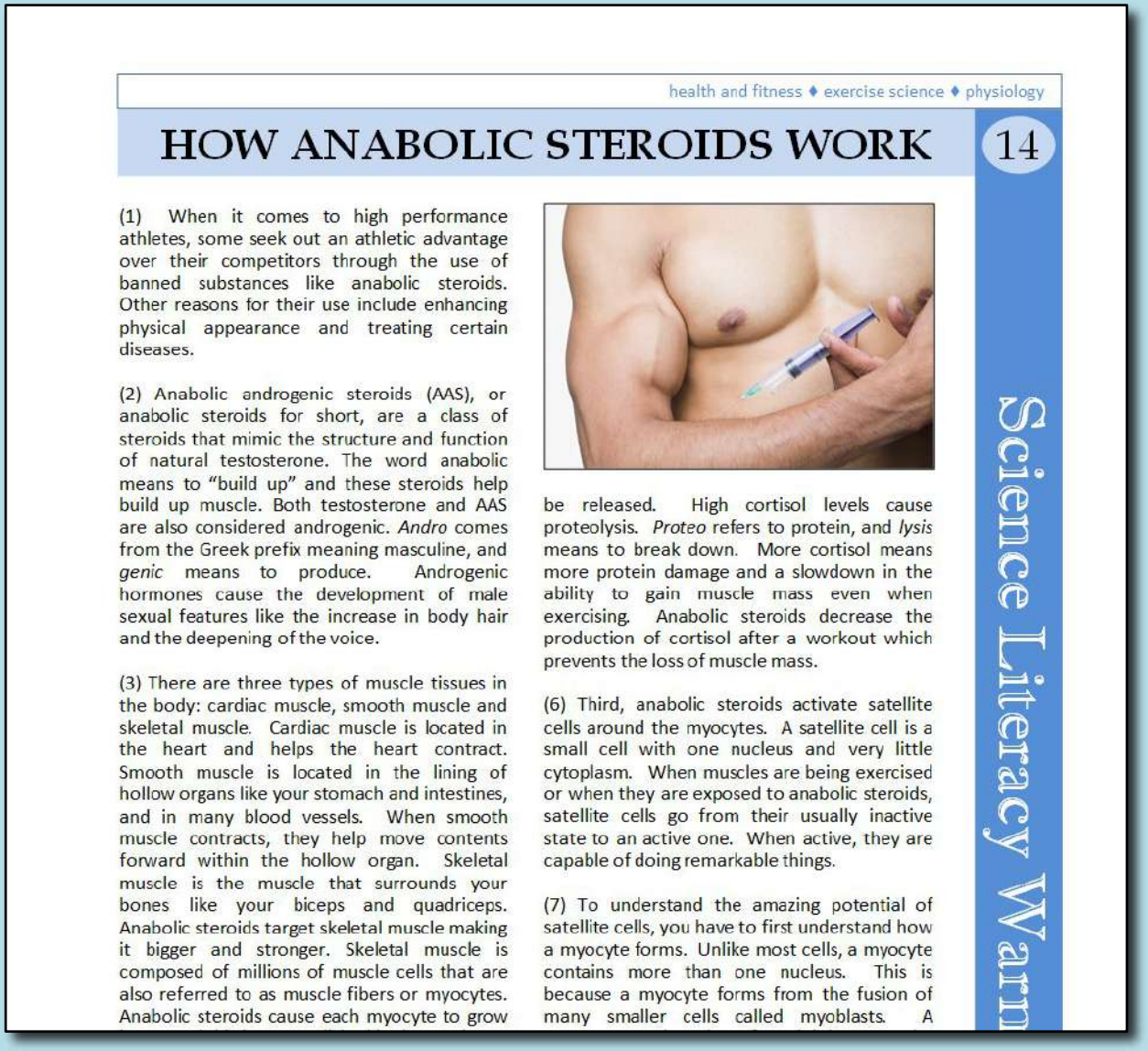
being tested for their effectiveness in treating MRSA, which is a bacteria that is responsible for infections that are very difficult to treat using antibiotics. As well, there are indications that larval secretions also encourage fibroblasts to migrate through the body and towards the wound. Fibroblasts are cells that produce extracellular matrix and collagen, which are two materials needed to cause wound healing and closure.

(4) Not all wounds are suitable for maggot debridement therapy. Wounds must be open, moist and have a good supply of oxygen for them to benefit from MDT. Dry wounds are not suitable though some can be made suitable if the wound is soaked and softened in saline solution for 48 hours before applying the maggots. Wounds deep within body cavities are also not suitable. Though the wound might be moist, there isn't enough oxygen within a body cavity to keep the maggots alive.

(5) A typical MDT treatment involves putting hundreds of small 1-2mm maggots on a

SCIENCE READING ARTICLE #14: How Anabolic Steroids Work — Gr. 8-12

Article highlights include:
Students will learn about how steroids build muscle by building proteins, preventing the breakdown of proteins and by activating satellite cells that help produce more and bigger muscle cells. Side effects of anabolic steroid use is also discussed.



health and fitness ♦ exercise science ♦ physiology

HOW ANABOLIC STEROIDS WORK

14

Science Literacy Warm

(1) When it comes to high performance athletes, some seek out an athletic advantage over their competitors through the use of banned substances like anabolic steroids. Other reasons for their use include enhancing physical appearance and treating certain diseases.

(2) Anabolic androgenic steroids (AAS), or anabolic steroids for short, are a class of steroids that mimic the structure and function of natural testosterone. The word anabolic means to "build up" and these steroids help build up muscle. Both testosterone and AAS are also considered androgenic. *Andro* comes from the Greek prefix meaning masculine, and *genic* means to produce. Androgenic hormones cause the development of male sexual features like the increase in body hair and the deepening of the voice.

(3) There are three types of muscle tissues in the body: cardiac muscle, smooth muscle and skeletal muscle. Cardiac muscle is located in the heart and helps the heart contract. Smooth muscle is located in the lining of hollow organs like your stomach and intestines, and in many blood vessels. When smooth muscle contracts, they help move contents forward within the hollow organ. Skeletal muscle is the muscle that surrounds your bones like your biceps and quadriceps. Anabolic steroids target skeletal muscle making it bigger and stronger. Skeletal muscle is composed of millions of muscle cells that are also referred to as muscle fibers or myocytes. Anabolic steroids cause each myocyte to grow

be released. High cortisol levels cause proteolysis. *Proteo* refers to protein, and *lysis* means to break down. More cortisol means more protein damage and a slowdown in the ability to gain muscle mass even when exercising. Anabolic steroids decrease the production of cortisol after a workout which prevents the loss of muscle mass.

(6) Third, anabolic steroids activate satellite cells around the myocytes. A satellite cell is a small cell with one nucleus and very little cytoplasm. When muscles are being exercised or when they are exposed to anabolic steroids, satellite cells go from their usually inactive state to an active one. When active, they are capable of doing remarkable things.

(7) To understand the amazing potential of satellite cells, you have to first understand how a myocyte forms. Unlike most cells, a myocyte contains more than one nucleus. This is because a myocyte forms from the fusion of many smaller cells called myoblasts. A

SCIENCE READING ARTICLE #15: The Science of Sleep

Gr. 7-12

Article highlights include:
Students will learn the differences between REM and nonREM sleep, how much sleep is needed for individuals, why sleep is important, what happens when someone experiences sleep deprivation and insomnia and how other mammals exhibit different sleep patterns and habits when compared to us.

THE SCIENCE OF SLEEP

(1) Imagine the following changes happening to your body: your muscles go limp, your body temperature decreases by 1-2°F, you become much less responsive to stimuli, you produce less urine but your body increases its ability to heal itself. Should you be worried about these unusual changes? No, because these changes happen to you every day and they aren't unusual at all; they occur when you sleep.

(2) Though most animals sleep, scientists are just beginning to understand the science behind it. Sleep and wakefulness can be considered two vastly different mental and physiological states that humans experience each day. Wakefulness involves consciousness and the ability to respond to stimuli. Sleep involves unconsciousness and a greatly reduced ability to respond to stimuli. Sleep itself can be broken down into two states. One sleep state is called rapid eye movement (REM) sleep and the other is called non-rapid eye movement (NREM) sleep.

(3) During REM sleep, the sleeper's eyes move quickly under their closed eyelids and their brain is very active. REM sleep is characterized by increased heart rate and blood pressure and less regular breathing. Many of the features of REM sleep are similar to wakefulness, however, the body is paralysed during this time. Vivid and strange dreams happen during REM sleep and nightmares can occur in this state of sleep. Newborns spend about 9 hours a day in REM sleep. The amount of REM sleep decreases rapidly over time and by the age of 5, they only spend 2 hours a day in REM sleep.

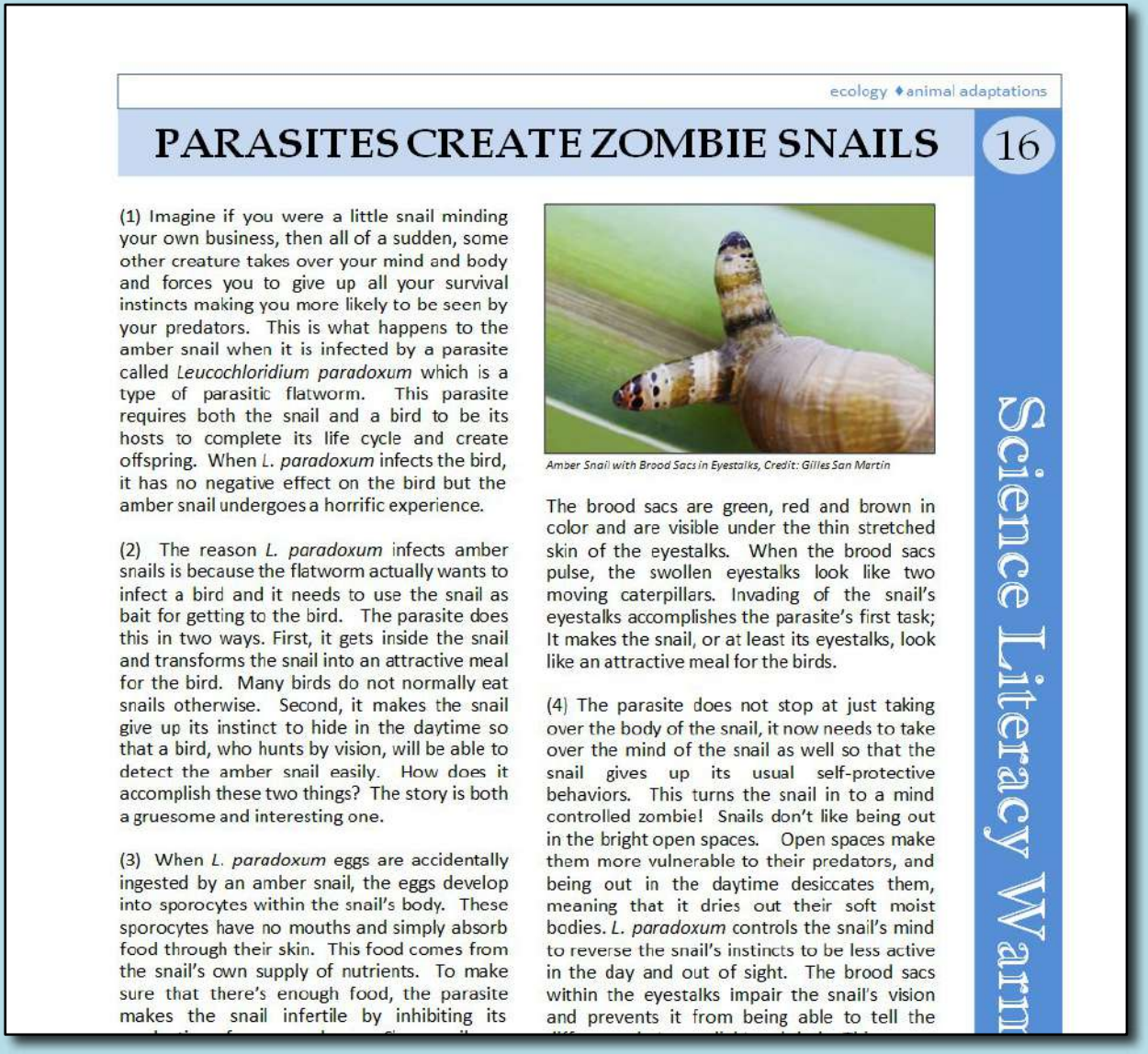
and even crying during sleep and it is difficult to wake up the sleeper. Night terrors are typically experienced by children.

(5) Most humans experience monophasic sleep, meaning that they sleep once a day. Some experience biphasic sleep if they have a habit of taking a nap during the day. In one night of monophasic sleep, a sleeper may go through 4 or 5 sleep cycles. Each cycle lasts for roughly 90 minutes and starts with NREM sleep and ends with REM sleep before starting again.

(6) The optimal amount of sleep a person needs differs for each individual depending on age, genetics and the presence of diseases. Usually a newborn needs to sleep for 14-17 hours a day, preteens and teens need 8-11 hours a day and adults need 7-9 hours a day. The length of sleep needed is also determined by a gene called DEC2. People with a mutation in this gene need two hours less sleep than the average person. Though they sleep less, they show no signs of lowered energy or impaired functioning when awake.

SCIENCE READING ARTICLE #16: Parasites Create Zombie Snails — Gr. 7-12

Article highlights include:
Students will learn about the L. paradoxum parasite that infects snails. The parasite takes over the snail's body and mind to turn it into an organism that will attract birds, the parasite's second host. This gruesome tale will enthrall your students and teach them about animal adaptations and parasitism at the same time.



ecology ♦ animal adaptations

PARASITES CREATE ZOMBIE SNAILS

16

(1) Imagine if you were a little snail minding your own business, then all of a sudden, some other creature takes over your mind and body and forces you to give up all your survival instincts making you more likely to be seen by your predators. This is what happens to the amber snail when it is infected by a parasite called *Leucochloridium paradoxum* which is a type of parasitic flatworm. This parasite requires both the snail and a bird to be its hosts to complete its life cycle and create offspring. When *L. paradoxum* infects the bird, it has no negative effect on the bird but the amber snail undergoes a horrific experience.

(2) The reason *L. paradoxum* infects amber snails is because the flatworm actually wants to infect a bird and it needs to use the snail as bait for getting to the bird. The parasite does this in two ways. First, it gets inside the snail and transforms the snail into an attractive meal for the bird. Many birds do not normally eat snails otherwise. Second, it makes the snail give up its instinct to hide in the daytime so that a bird, who hunts by vision, will be able to detect the amber snail easily. How does it accomplish these two things? The story is both a gruesome and interesting one.

(3) When *L. paradoxum* eggs are accidentally ingested by an amber snail, the eggs develop into sporocytes within the snail's body. These sporocytes have no mouths and simply absorb food through their skin. This food comes from the snail's own supply of nutrients. To make sure that there's enough food, the parasite makes the snail infertile by inhibiting its

Amber Snail with Brood Sacs in Eyestalks, Credit: Gilles San Martin

The brood sacs are green, red and brown in color and are visible under the thin stretched skin of the eyestalks. When the brood sacs pulse, the swollen eyestalks look like two moving caterpillars. Invading of the snail's eyestalks accomplishes the parasite's first task; It makes the snail, or at least its eyestalks, look like an attractive meal for the birds.

(4) The parasite does not stop at just taking over the body of the snail, it now needs to take over the mind of the snail as well so that the snail gives up its usual self-protective behaviors. This turns the snail in to a mind controlled zombie! Snails don't like being out in the bright open spaces. Open spaces make them more vulnerable to their predators, and being out in the daytime desiccates them, meaning that it dries out their soft moist bodies. *L. paradoxum* controls the snail's mind to reverse the snail's instincts to be less active in the day and out of sight. The brood sacs within the eyestalks impair the snail's vision and prevents it from being able to tell the

Science Literacy Warm

SCIENCE READING ARTICLE #17: Breathing and Peeing in Space — Gr. 7-12

Article highlights include:
Students will learn about the challenges of supporting human life in a space craft. The focus will be on the technologies that are used to constantly supply the crew with oxygen and that help get rid of liquid and solid waste in a microgravity environment.

astronomy ♦ technology ♦ chemistry

BREATHING AND PEEING IN SPACE

17

Science Literacy Warm

(1) Supporting human life inside of a spacecraft is challenging. A spacecraft is small and air and food need to be provided, waste needs to be removed and everything must stay clean. All of this is made more challenging due to the zero gravity or microgravity experienced within different spacecrafts.

(2) Earth's air is made up of mostly 78% nitrogen gas and 21% oxygen gas. In a space station, there isn't a lot of room to store a large amount of air. The oxygen is quickly used up by the astronauts if no further oxygen is supplied. The International Space Station (ISS) was put into orbit around the Earth in 1998 and was designed for long-term missions. The original oxygen on board has long disappeared. In space crafts, there needs to be ways to generate oxygen and three main methods are used: 1) pressurized oxygen air tanks, 2) oxygen generators using electrolysis and 3) solid fuel oxygen generators (SFOG).

(3) The pressurized oxygen air tanks on board the ISS are constantly resupplied with oxygen when supply ships arrive from Earth. These supply ships also pump nitrogen gas into other tanks. The space station's atmosphere control system mixes the two gases together to imitate the mixture of air found on Earth. It then circulates this air mixture through the spacecraft.

(4) Oxygen generators can also use the process of electrolysis to make oxygen. During electrolysis, water molecules are broken down into oxygen gas and hydrogen gas. See the

This water, along with the water reclaimed from the astronauts' urine, can be used for electrolysis. The electrolysis of water is the main way that oxygen is provided on a spacecraft.

(5) The solid fuel oxygen generator (SFOG) is the backup method for making oxygen in case of emergencies. SFOG contains two powders: sodium chlorate ($NaClO_3$) powder and iron (Fe) powder. A chemical reaction happens between these two powders to form water. Take at look at the equation for this reaction:

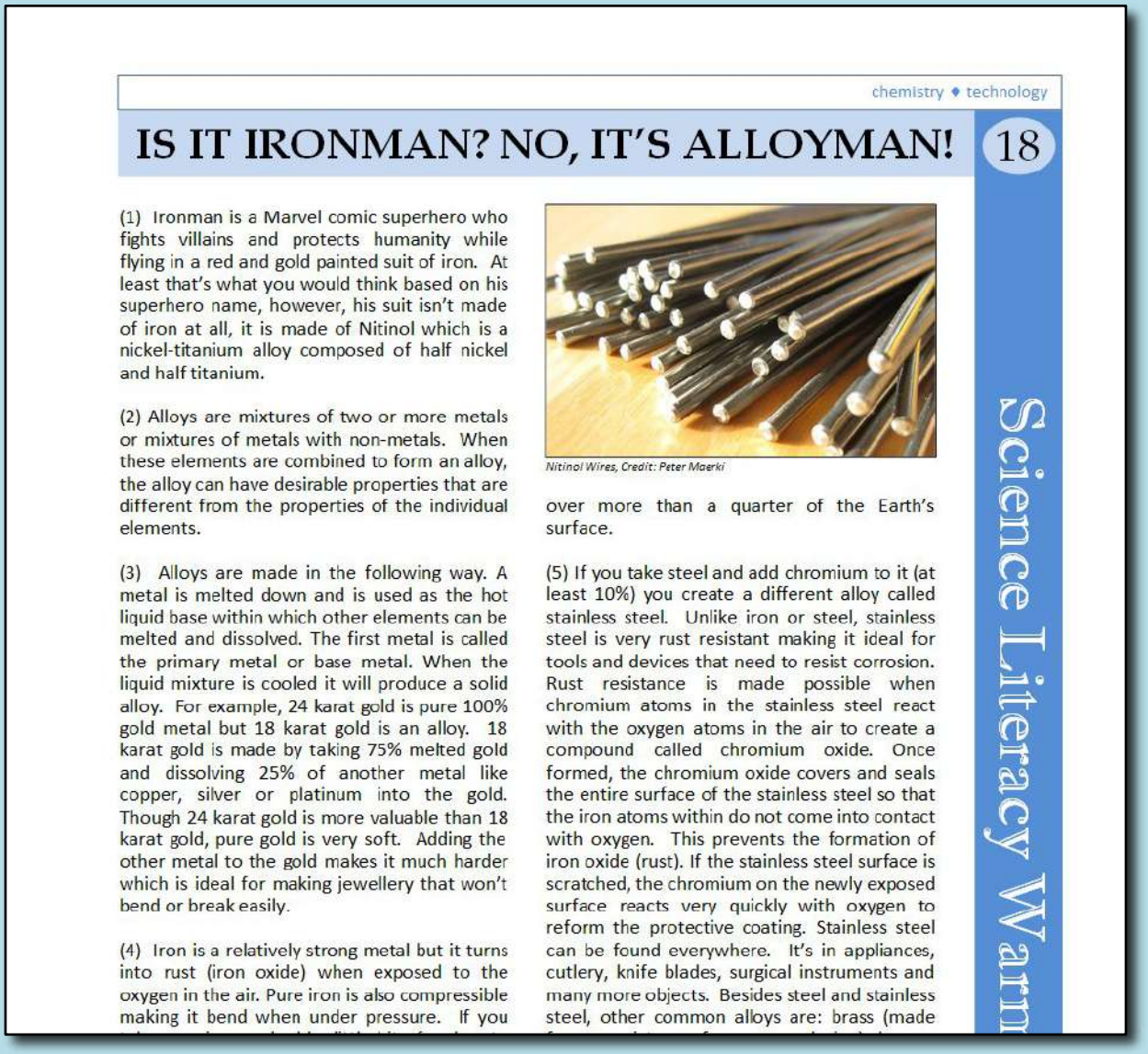
$$NaClO_3 + Fe \rightarrow 3O_2 + NaCl + FeO$$

In addition to producing oxygen gas, salt (NaCl) and iron oxide (FeO) are also produced. Every kilogram of the SFOG powdered mixture can produce enough oxygen for 6.5 hours of breathing.

(6) Not only is oxygen strictly controlled on a spacecraft, so is waste production and waste storage. On Earth, water easily pours and

SCIENCE READING ARTICLE #18: Is it Ironman? No it's Alloyman! Gr. 8-12

Article highlights include:
Students will learn about alloys, how they are made, how steel and stainless steel are made and about Nitinol, the amazing super-elastic alloy that makes up Ironman's suit.



chemistry ♦ technology

IS IT IRONMAN? NO, IT'S ALLOYMAN!

18

Science Literacy Warm

(1) Ironman is a Marvel comic superhero who fights villains and protects humanity while flying in a red and gold painted suit of iron. At least that's what you would think based on his superhero name, however, his suit isn't made of iron at all, it is made of Nitinol which is a nickel-titanium alloy composed of half nickel and half titanium.

(2) Alloys are mixtures of two or more metals or mixtures of metals with non-metals. When these elements are combined to form an alloy, the alloy can have desirable properties that are different from the properties of the individual elements.

(3) Alloys are made in the following way. A metal is melted down and is used as the hot liquid base within which other elements can be melted and dissolved. The first metal is called the primary metal or base metal. When the liquid mixture is cooled it will produce a solid alloy. For example, 24 karat gold is pure 100% gold metal but 18 karat gold is an alloy. 18 karat gold is made by taking 75% melted gold and dissolving 25% of another metal like copper, silver or platinum into the gold. Though 24 karat gold is more valuable than 18 karat gold, pure gold is very soft. Adding the other metal to the gold makes it much harder which is ideal for making jewellery that won't bend or break easily.

(4) Iron is a relatively strong metal but it turns into rust (iron oxide) when exposed to the oxygen in the air. Pure iron is also compressible making it bend when under pressure. If you

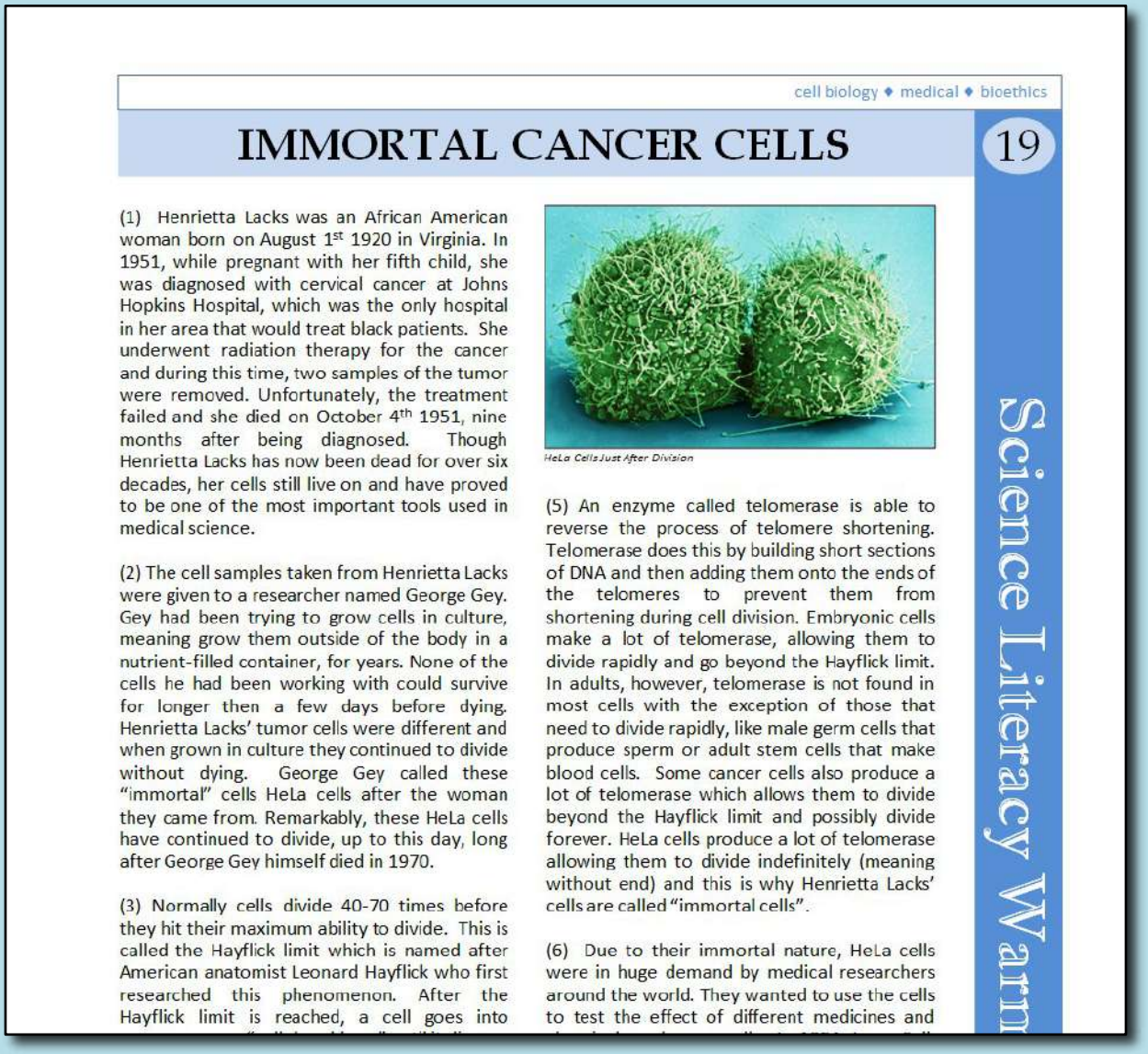
Nitinol Wires, Credit: Peter Maerki

over more than a quarter of the Earth's surface.

(5) If you take steel and add chromium to it (at least 10%) you create a different alloy called stainless steel. Unlike iron or steel, stainless steel is very rust resistant making it ideal for tools and devices that need to resist corrosion. Rust resistance is made possible when chromium atoms in the stainless steel react with the oxygen atoms in the air to create a compound called chromium oxide. Once formed, the chromium oxide covers and seals the entire surface of the stainless steel so that the iron atoms within do not come into contact with oxygen. This prevents the formation of iron oxide (rust). If the stainless steel surface is scratched, the chromium on the newly exposed surface reacts very quickly with oxygen to reform the protective coating. Stainless steel can be found everywhere. It's in appliances, cutlery, knife blades, surgical instruments and many more objects. Besides steel and stainless steel, other common alloys are: brass (made

SCIENCE READING ARTICLE #19: Immortal Cancer Cells — Gr. 9-12

Article highlights include:
Students will learn about Henrietta Lacks and how cancer cells from her body, called HeLa cells, have been dividing for over six decades to produce immortal cell lines that have been used in medical and commercial research all over the world. Students will learn about the limits of cell division and how cancer cells circumvent these limits.



cell biology ♦ medical ♦ bioethics

IMMORTAL CANCER CELLS

19

Science Literacy Warm

(1) Henrietta Lacks was an African American woman born on August 1st 1920 in Virginia. In 1951, while pregnant with her fifth child, she was diagnosed with cervical cancer at Johns Hopkins Hospital, which was the only hospital in her area that would treat black patients. She underwent radiation therapy for the cancer and during this time, two samples of the tumor were removed. Unfortunately, the treatment failed and she died on October 4th 1951, nine months after being diagnosed. Though Henrietta Lacks has now been dead for over six decades, her cells still live on and have proved to be one of the most important tools used in medical science.

(2) The cell samples taken from Henrietta Lacks were given to a researcher named George Gey. Gey had been trying to grow cells in culture, meaning grow them outside of the body in a nutrient-filled container, for years. None of the cells he had been working with could survive for longer then a few days before dying. Henrietta Lacks' tumor cells were different and when grown in culture they continued to divide without dying. George Gey called these "immortal" cells HeLa cells after the woman they came from. Remarkably, these HeLa cells have continued to divide, up to this day, long after George Gey himself died in 1970.

(3) Normally cells divide 40-70 times before they hit their maximum ability to divide. This is called the Hayflick limit which is named after American anatomist Leonard Hayflick who first researched this phenomenon. After the Hayflick limit is reached, a cell goes into

HeLa Cells Just After Division

(5) An enzyme called telomerase is able to reverse the process of telomere shortening. Telomerase does this by building short sections of DNA and then adding them onto the ends of the telomeres to prevent them from shortening during cell division. Embryonic cells make a lot of telomerase, allowing them to divide rapidly and go beyond the Hayflick limit. In adults, however, telomerase is not found in most cells with the exception of those that need to divide rapidly, like male germ cells that produce sperm or adult stem cells that make blood cells. Some cancer cells also produce a lot of telomerase which allows them to divide beyond the Hayflick limit and possibly divide forever. HeLa cells produce a lot of telomerase allowing them to divide indefinitely (meaning without end) and this is why Henrietta Lacks' cells are called "immortal cells".

(6) Due to their immortal nature, HeLa cells were in huge demand by medical researchers around the world. They wanted to use the cells to test the effect of different medicines and

SCIENCE READING ARTICLE #20: Endangered Soil

Gr. 7-12

Article highlights include:
Students will learn about soil, what it is made of, why it is so important to our survival and what factors are causing soil to be endangered throughout our planet. A great article for discussing ecological and environmental issues.

ecology ♦ environmental issues

ENDANGERED SOIL

20

(1) The United Nations declared 2015 *The International Year of Soils*. There has been a growing awareness that soil isn't only important for healthy ecosystems, but that soil is also critical to our ability to make enough food to feed the world. Food security, which is the access that humans have to healthy food, is threatened when soil is threatened.

(2) The way we have been conducting intensive modern agriculture, polluting our lands and expanding urban cities has had a huge effect on the Earth's soil for the last two centuries. These things, along with the effects of climate change, have made soil endangered and has increased concerns over food security.

(3) Let's first examine the soil itself. If you think that soil is just simply dirt, then you are mistaken. Dirt isn't alive while soil is brimming with life. Besides minerals, water and decomposing organic matter, soil also contains thousands of species of small insects, worms, fungi and microorganisms. A handful of soil contains more microorganisms than there are people on Earth! One key to healthy soil is numerous and diverse soil organisms.

(4) There are two main branches of soil science: pedology and edaphology. Pedology is concerned with how soil forms. Edaphology is the study of how soil conditions affect organisms, like the plants, living in the soil.

(5) We take for granted that soil has always been here and will always be here, but pedology tells us something different. Soil

through contact with the forces of nature. Once weathering forms the initial cracks in the rock, the eroding actions of water, chemical reactions and living organisms (like plants) can start to erode and break apart the rock even further. This process takes a long time causing topsoil to form very slowly.

(7) Edaphology helps us study and examine how altering our soil affects the plants grown in it. Proper soil conditions are vital for healthy plant growth. Over the last two centuries, not only have we seen a decrease in the amount of topsoil on Earth, we've also seen a huge decrease in soil quality and fertility.

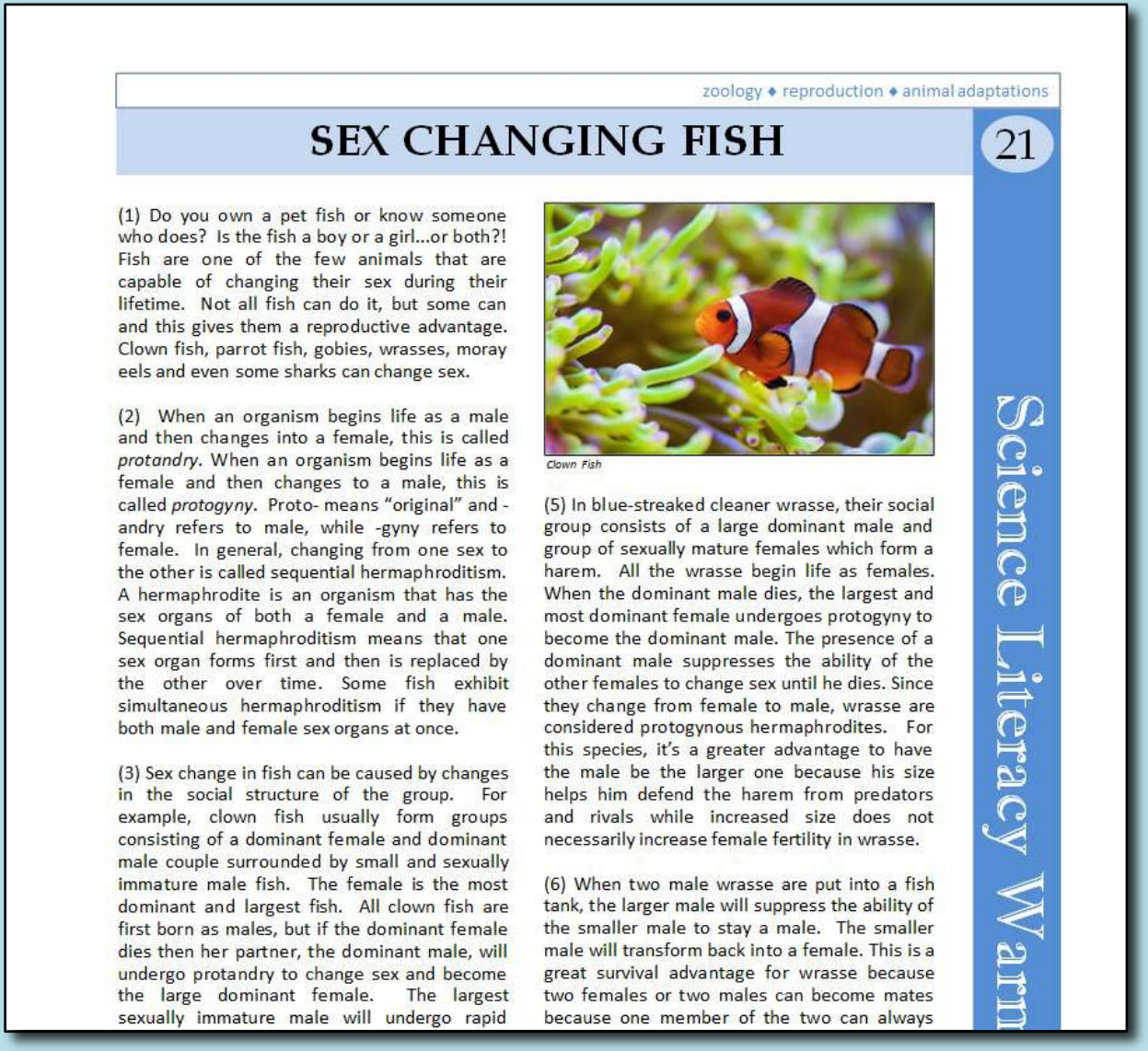
(8) Every time a crop is grown in soil, the crop absorbs nutrients from the soil to help it grow. Nutrients like nitrogen, potassium, phosphorus, calcium, magnesium, sulfur and many other nutrients are sucked up by crops which are then transported to markets for sale. In natural ecosystems, like forests, plants suck up nutrients as well, but when the plants die and

Science Literacy Warm

SCIENCE READING ARTICLE #21: Sex Changing Fish

Gr. 7-12

Article highlights include:
Students will learn about how some fish are able to change sex from male to female or from female to male. They will find out what type of reproductive advantages this gives the fish and what conditions trigger sex changes.



zoology ♦ reproduction ♦ animal adaptations

SEX CHANGING FISH

21

Science Literacy Warm

(1) Do you own a pet fish or know someone who does? Is the fish a boy or a girl...or both?! Fish are one of the few animals that are capable of changing their sex during their lifetime. Not all fish can do it, but some can and this gives them a reproductive advantage. Clown fish, parrot fish, gobies, wrasses, moray eels and even some sharks can change sex.

(2) When an organism begins life as a male and then changes into a female, this is called *protandry*. When an organism begins life as a female and then changes to a male, this is called *protogyny*. Proto- means "original" and -andry refers to male, while -gyny refers to female. In general, changing from one sex to the other is called sequential hermaphroditism. A hermaphrodite is an organism that has the sex organs of both a female and a male. Sequential hermaphroditism means that one sex organ forms first and then is replaced by the other over time. Some fish exhibit simultaneous hermaphroditism if they have both male and female sex organs at once.

(3) Sex change in fish can be caused by changes in the social structure of the group. For example, clown fish usually form groups consisting of a dominant female and dominant male couple surrounded by small and sexually immature male fish. The female is the most dominant and largest fish. All clown fish are first born as males, but if the dominant female dies then her partner, the dominant male, will undergo protandry to change sex and become the large dominant female. The largest sexually immature male will undergo rapid

Clown Fish

(5) In blue-streaked cleaner wrasse, their social group consists of a large dominant male and group of sexually mature females which form a harem. All the wrasse begin life as females. When the dominant male dies, the largest and most dominant female undergoes protogyny to become the dominant male. The presence of a dominant male suppresses the ability of the other females to change sex until he dies. Since they change from female to male, wrasse are considered protogynous hermaphrodites. For this species, it's a greater advantage to have the male be the larger one because his size helps him defend the harem from predators and rivals while increased size does not necessarily increase female fertility in wrasse.

(6) When two male wrasse are put into a fish tank, the larger male will suppress the ability of the smaller male to stay a male. The smaller male will transform back into a female. This is a great survival advantage for wrasse because two females or two males can become mates because one member of the two can always

SCIENCE READING ARTICLE #22: Fecal Transplants

Gr. 7-12

Article highlights include:
Students will learn about how fecal microbiota transplants help treat intestinal diseases like C. diff infections. They will learn how the fecal transplant helps get rid of the infection, how fecal samples are obtained and how they are administered into the body.

digestive system ♦ medical

FECAL TRANSPLANTS

22

Science Literacy Warm

(1) Though we make feces all the time, this waste material isn't something we often enjoy talking or thinking about, but what if feces could be the cure to a dangerous and even potentially deadly disease? Fecal microbiota transplant (FMT) is a type of therapy used to treat *Clostridium difficile (C. diff)* infections which are difficult to treat and affect over half a million North Americans, killing approximately 30 000 of them each year.

(2) FMT therapy involves taking the feces from one healthy person and transplanting it into the intestines of a person infected with *C. diff*. Feces contains billions of microorganisms (microbiota) that come from your digestive tract. The majority of the microorganisms living in your intestines are beneficial bacteria that exist in harmony with your body. There are an estimated 300-1000 species of bacteria that colonize your gut to create a healthy colon (large intestine). These bacteria help manufacture vitamins, they help train the immune system of the intestines and they help keep the numbers of disease-causing microorganisms low.

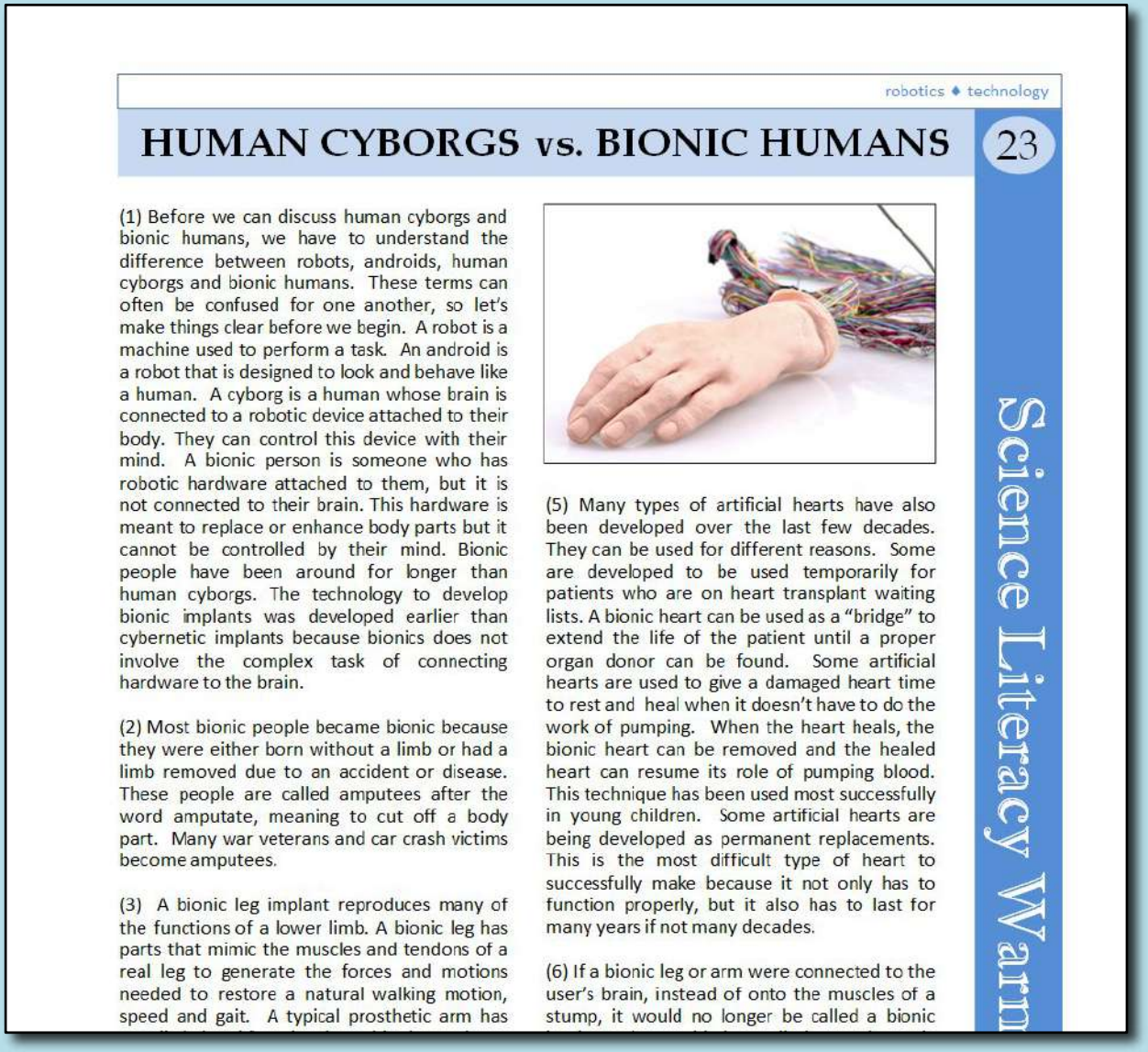
(3) To understand how FMT helps treat *C. diff* infections, we should first understand a little about this organism. Some strains of the *C. diff* bacteria are pathogenic (disease-causing) and can create intestinal infections that lead to a large production of watery diarrhea, nausea, abdominal pain, fever and in some cases, a life-threatening inflammation of the colon. These symptoms occur when *C. diff* produces enterotoxin and cytotoxin that inflame the

(5) The use of antibiotics is the main cause of *C. diff* infections. Using antibiotics, especially broad spectrum antibiotics that kill a wide range of bacteria, threaten the beneficial bacteria in your intestines. This is not the intended effect, but most of this good bacteria can be wiped out by some types of antibiotics. *C. diff* , unfortunately, is quite resistant to most antibiotics so it doesn't get killed along with its bacterial neighbours. Without the inhibiting influence of the beneficial bacteria, *C. diff* can take the opportunity to multiply quickly and cause a life-threatening infection.

(6) This is where fecal microbiota transplants come in. After years of trying to treat *C. diff* patients with stronger and stronger antibiotics, an easier, more effective and cheaper answer was found using FMT therapy. When feces containing healthy microbiota are introduced to a *C. diff* patient, the new bacteria establishes itself in the recipient's colon and starts to multiply. New colonies of beneficial bacteria will take over the colon and supress

SCIENCE READING ARTICLE #23: Human Cyborgs vs. Bionic Humans Gr. 7-12

Article highlights include:
Students will learn about the differences between a bionic implant and a cybernetic implant and how the two function differently and can achieve different results. The last part of the article turns to the idea of using human cyborgs in the military and can lead into a class discussion about the bioethics of this and other cybernetic applications.



HUMAN CYBORGS vs. BIONIC HUMANS

(1) Before we can discuss human cyborgs and bionic humans, we have to understand the difference between robots, androids, human cyborgs and bionic humans. These terms can often be confused for one another, so let's make things clear before we begin. A robot is a machine used to perform a task. An android is a robot that is designed to look and behave like a human. A cyborg is a human whose brain is connected to a robotic device attached to their body. They can control this device with their mind. A bionic person is someone who has robotic hardware attached to them, but it is not connected to their brain. This hardware is meant to replace or enhance body parts but it cannot be controlled by their mind. Bionic people have been around for longer than human cyborgs. The technology to develop bionic implants was developed earlier than cybernetic implants because bionics does not involve the complex task of connecting hardware to the brain.

(2) Most bionic people became bionic because they were either born without a limb or had a limb removed due to an accident or disease. These people are called amputees after the word amputate, meaning to cut off a body part. Many war veterans and car crash victims become amputees.

(3) A bionic leg implant reproduces many of the functions of a lower limb. A bionic leg has parts that mimic the muscles and tendons of a real leg to generate the forces and motions needed to restore a natural walking motion, speed and gait. A typical prosthetic arm has

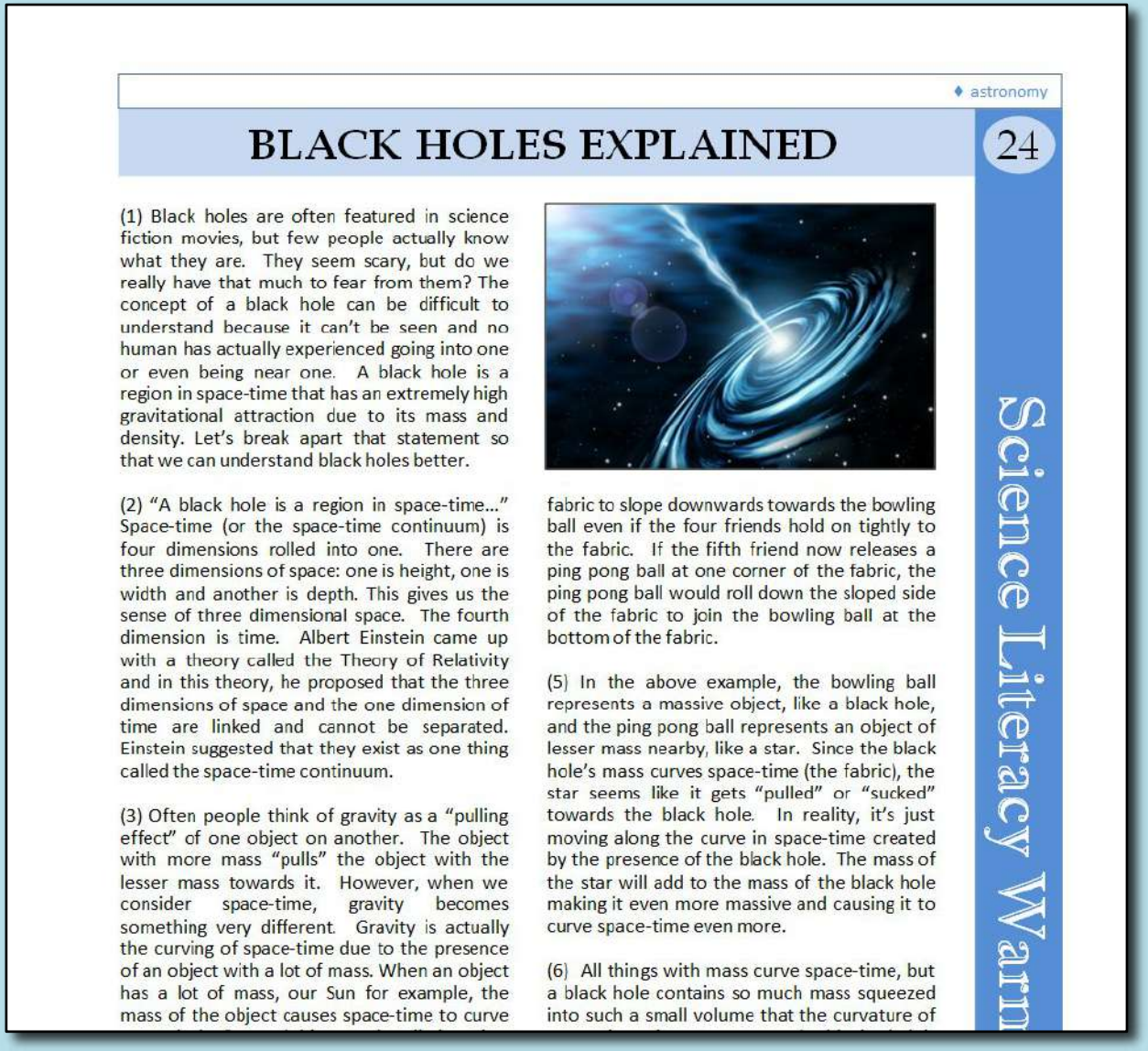
(5) Many types of artificial hearts have also been developed over the last few decades. They can be used for different reasons. Some are developed to be used temporarily for patients who are on heart transplant waiting lists. A bionic heart can be used as a "bridge" to extend the life of the patient until a proper organ donor can be found. Some artificial hearts are used to give a damaged heart time to rest and heal when it doesn't have to do the work of pumping. When the heart heals, the bionic heart can be removed and the healed heart can resume its role of pumping blood. This technique has been used most successfully in young children. Some artificial hearts are being developed as permanent replacements. This is the most difficult type of heart to successfully make because it not only has to function properly, but it also has to last for many years if not many decades.

(6) If a bionic leg or arm were connected to the user's brain, instead of onto the muscles of a stump, it would no longer be called a bionic

SCIENCE READING ARTICLE #24: Black Holes Explained

Gr. 9-12

Article highlights include:
Students will learn about black holes and how they are related to the space-time continuum and gravity. An analogy is used for easy understanding. The event horizon and singularity is also explained as well as the classification of three types of black holes.



♦ astronomy

BLACK HOLES EXPLAINED

24

Science Literacy Warm

(1) Black holes are often featured in science fiction movies, but few people actually know what they are. They seem scary, but do we really have that much to fear from them? The concept of a black hole can be difficult to understand because it can't be seen and no human has actually experienced going into one or even being near one. A black hole is a region in space-time that has an extremely high gravitational attraction due to its mass and density. Let's break apart that statement so that we can understand black holes better.

(2) "A black hole is a region in space-time..." Space-time (or the space-time continuum) is four dimensions rolled into one. There are three dimensions of space: one is height, one is width and another is depth. This gives us the sense of three dimensional space. The fourth dimension is time. Albert Einstein came up with a theory called the Theory of Relativity and in this theory, he proposed that the three dimensions of space and the one dimension of time are linked and cannot be separated. Einstein suggested that they exist as one thing called the space-time continuum.

(3) Often people think of gravity as a "pulling effect" of one object on another. The object with more mass "pulls" the object with the lesser mass towards it. However, when we consider space-time, gravity becomes something very different. Gravity is actually the curving of space-time due to the presence of an object with a lot of mass. When an object has a lot of mass, our Sun for example, the mass of the object causes space-time to curve

fabric to slope downwards towards the bowling ball even if the four friends hold on tightly to the fabric. If the fifth friend now releases a ping pong ball at one corner of the fabric, the ping pong ball would roll down the sloped side of the fabric to join the bowling ball at the bottom of the fabric.

(5) In the above example, the bowling ball represents a massive object, like a black hole, and the ping pong ball represents an object of lesser mass nearby, like a star. Since the black hole's mass curves space-time (the fabric), the star seems like it gets "pulled" or "sucked" towards the black hole. In reality, it's just moving along the curve in space-time created by the presence of the black hole. The mass of the star will add to the mass of the black hole making it even more massive and causing it to curve space-time even more.

(6) All things with mass curve space-time, but a black hole contains so much mass squeezed into such a small volume that the curvature of

SCIENCE READING ARTICLE #25: The Science and Evolution of Skin Color Gr. 8-12

Article highlights include:
Students will learn about the pigment melanin, its function and how the skin produces and distributes this substance to produce different levels of skin pigmentation. They will also learn about albinism and about how changing environmental conditions and determine the level of skin pigmentation in evolving populations. Also discussed is the reason why women, in general, are less pigmented then men.

evolution ♦ cell biology ♦ anatomy & physiology

THE SCIENCE AND EVOLUTION OF SKIN COLOR

25

Science Literacy Warm

(1) Have you ever wondered why humans have so many different skin colors? Skin color is affected by the presence of various substances but the most important one is a pigment called melanin. Melanin comes in various colors. Eumelanin is the most common type of melanin and it is a brownish-black pigment. Eumelanin is the pigment that darkens hair, skin and eyes (the irises). Pheomelanin is a pinkish to reddish pigment and can be found in red hair, lips, and nipples. In light skinned people, there is less melanin and so other factors like the circulating red blood cells and the bluish-white connective tissue under the skin play a significant role in determining the specific shade of light skin a person possesses.

(2) To highlight how much melanin contributes to skin color, let's consider people who cannot produce melanin. A person with albinism is unable to produce melanin. This pigment is lacking in their skin, hair and eyes due to the absence of an enzyme called tyrosinase. Tyrosinase helps create melanin as well as other pigments. For example, it is tyrosinase that is responsible for the darkening of an apple or potato after it is sliced. Without melanin, albinos have white hair as well as pink skin and pink eyes because the blood vessels in these areas are not covered by any pigments.

(3) Skin is mostly made up of two types of cells, melanocytes and keratinocytes. Melanocytes are the skin cells that make up 5%-10% of the skin and they are the pigment producing cells that make melanin. Within melanocytes are organelles called melanosomes which

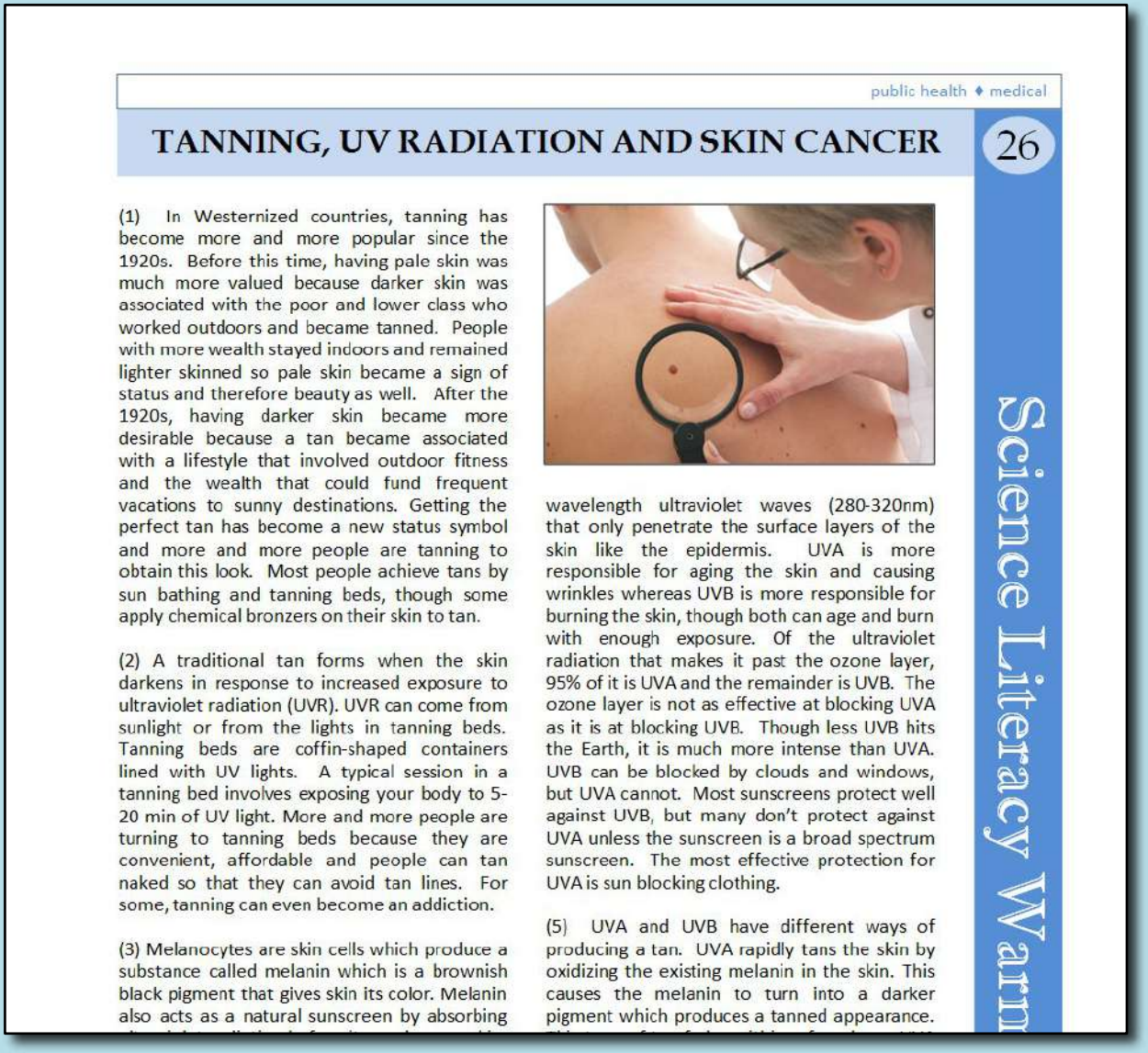
(4) Melanin serves a very important function. This pigment is excellent at absorbing ultraviolet radiation (UVR). It can absorb 99.9% of the UVR that lands on it. This blocks UVR from reaching the DNA within skin cells. Intense and long-term exposure to UVR can result in sunburns as well as skin cancer. Melanin is the body's natural sunscreen and the more you have the more protected you are against UVR.

(5) Our pre-human ancestors had body hair. Among other functions, the body hair protected them from exposure to UVR. Our earliest human ancestors came from sub-Saharan Africa and as they began to lose their body hair, they also began to develop dark skin to shield themselves from the damaging effects of the intense equatorial sunlight.

(6) When some humans began to migrate away from Africa to areas of the world that were further north, like parts of Europe and East Asia, they began to produce less melanin

SCIENCE READING ARTICLE #26: Tanning, UV Radiation and Skin Cancer Gr. 7-12

Article highlights include:
Students will learn about why tanning has become popular, the differences between UVA and UVB and how both cause a different type of tanning response in the skin and health consequences of each, and finally, students will learn about skin cancer with a focus on melanoma and risk factors for developing skin cancer.



public health ♦ medical

TANNING, UV RADIATION AND SKIN CANCER

26

Science Literacy Warm

(1) In Westernized countries, tanning has become more and more popular since the 1920s. Before this time, having pale skin was much more valued because darker skin was associated with the poor and lower class who worked outdoors and became tanned. People with more wealth stayed indoors and remained lighter skinned so pale skin became a sign of status and therefore beauty as well. After the 1920s, having darker skin became more desirable because a tan became associated with a lifestyle that involved outdoor fitness and the wealth that could fund frequent vacations to sunny destinations. Getting the perfect tan has become a new status symbol and more and more people are tanning to obtain this look. Most people achieve tans by sun bathing and tanning beds, though some apply chemical bronzers on their skin to tan.

(2) A traditional tan forms when the skin darkens in response to increased exposure to ultraviolet radiation (UVR). UVR can come from sunlight or from the lights in tanning beds. Tanning beds are coffin-shaped containers lined with UV lights. A typical session in a tanning bed involves exposing your body to 5-20 min of UV light. More and more people are turning to tanning beds because they are convenient, affordable and people can tan naked so that they can avoid tan lines. For some, tanning can even become an addiction.

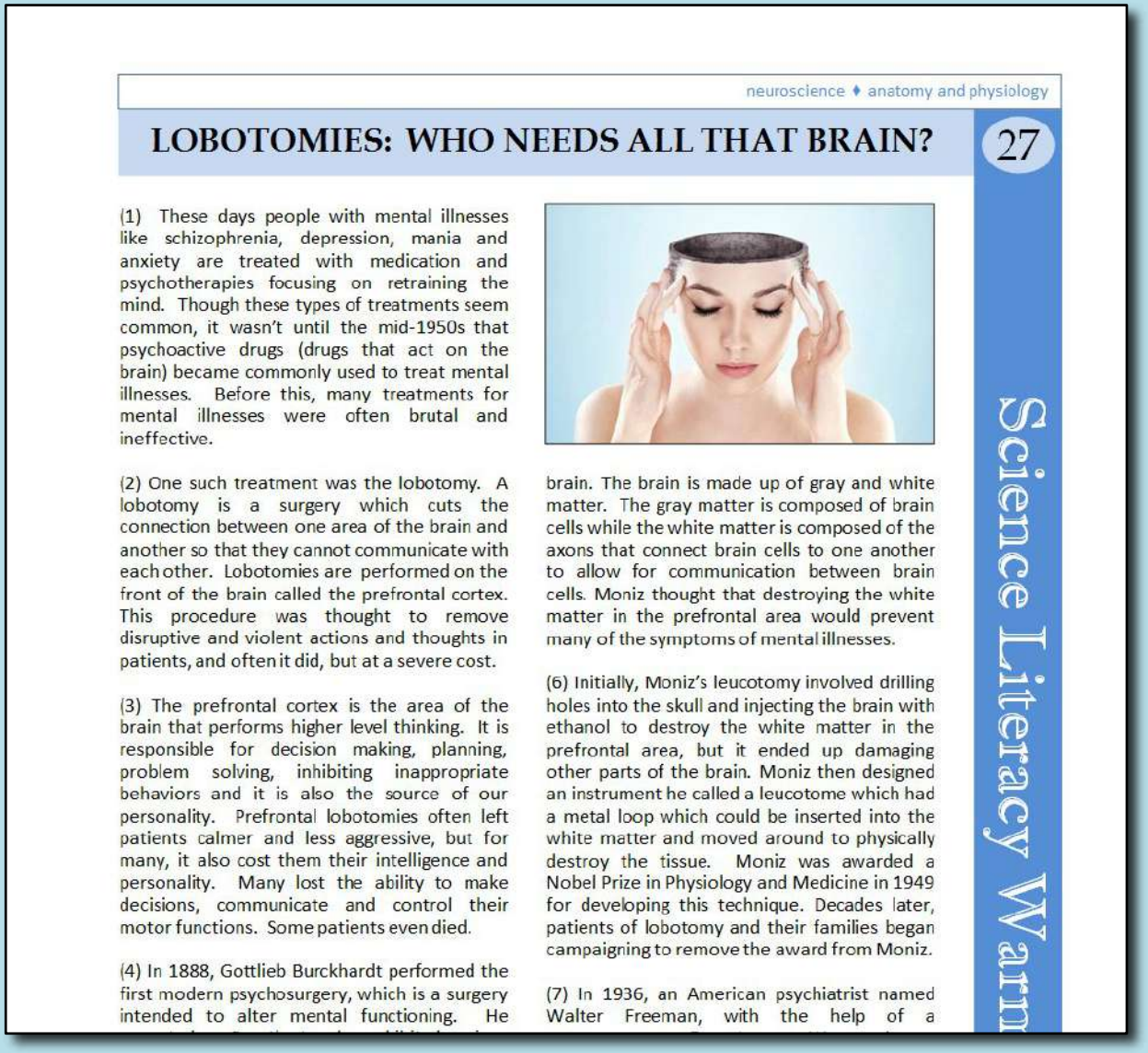
(3) Melanocytes are skin cells which produce a substance called melanin which is a brownish black pigment that gives skin its color. Melanin also acts as a natural sunscreen by absorbing

wavelength ultraviolet waves (280-320nm) that only penetrate the surface layers of the skin like the epidermis. UVA is more responsible for aging the skin and causing wrinkles whereas UVB is more responsible for burning the skin, though both can age and burn with enough exposure. Of the ultraviolet radiation that makes it past the ozone layer, 95% of it is UVA and the remainder is UVB. The ozone layer is not as effective at blocking UVA as it is at blocking UVB. Though less UVB hits the Earth, it is much more intense than UVA. UVB can be blocked by clouds and windows, but UVA cannot. Most sunscreens protect well against UVB, but many don't protect against UVA unless the sunscreen is a broad spectrum sunscreen. The most effective protection for UVA is sun blocking clothing.

(5) UVA and UVB have different ways of producing a tan. UVA rapidly tans the skin by oxidizing the existing melanin in the skin. This causes the melanin to turn into a darker pigment which produces a tanned appearance.

SCIENCE READING ARTICLE #27: Lobotomies: Who Needs All that Brain? Gr. 7-12

Article highlights include:
Students will learn about lobotomies, why they were used, how they were performed, the people who helped develop the procedure (António Egas Moniz, and Walter Freeman), the effect lobotomies had on patients and why the technique is no longer widely used to treat mental illnesses.



neuroscience ♦ anatomy and physiology

LOBOTOMIES: WHO NEEDS ALL THAT BRAIN?

27

Science Literacy Warm

(1) These days people with mental illnesses like schizophrenia, depression, mania and anxiety are treated with medication and psychotherapies focusing on retraining the mind. Though these types of treatments seem common, it wasn't until the mid-1950s that psychoactive drugs (drugs that act on the brain) became commonly used to treat mental illnesses. Before this, many treatments for mental illnesses were often brutal and ineffective.

(2) One such treatment was the lobotomy. A lobotomy is a surgery which cuts the connection between one area of the brain and another so that they cannot communicate with each other. Lobotomies are performed on the front of the brain called the prefrontal cortex. This procedure was thought to remove disruptive and violent actions and thoughts in patients, and often it did, but at a severe cost.

(3) The prefrontal cortex is the area of the brain that performs higher level thinking. It is responsible for decision making, planning, problem solving, inhibiting inappropriate behaviors and it is also the source of our personality. Prefrontal lobotomies often left patients calmer and less aggressive, but for many, it also cost them their intelligence and personality. Many lost the ability to make decisions, communicate and control their motor functions. Some patients even died.

(4) In 1888, Gottlieb Burckhardt performed the first modern psychosurgery, which is a surgery intended to alter mental functioning. He

brain. The brain is made up of gray and white matter. The gray matter is composed of brain cells while the white matter is composed of the axons that connect brain cells to one another to allow for communication between brain cells. Moniz thought that destroying the white matter in the prefrontal area would prevent many of the symptoms of mental illnesses.

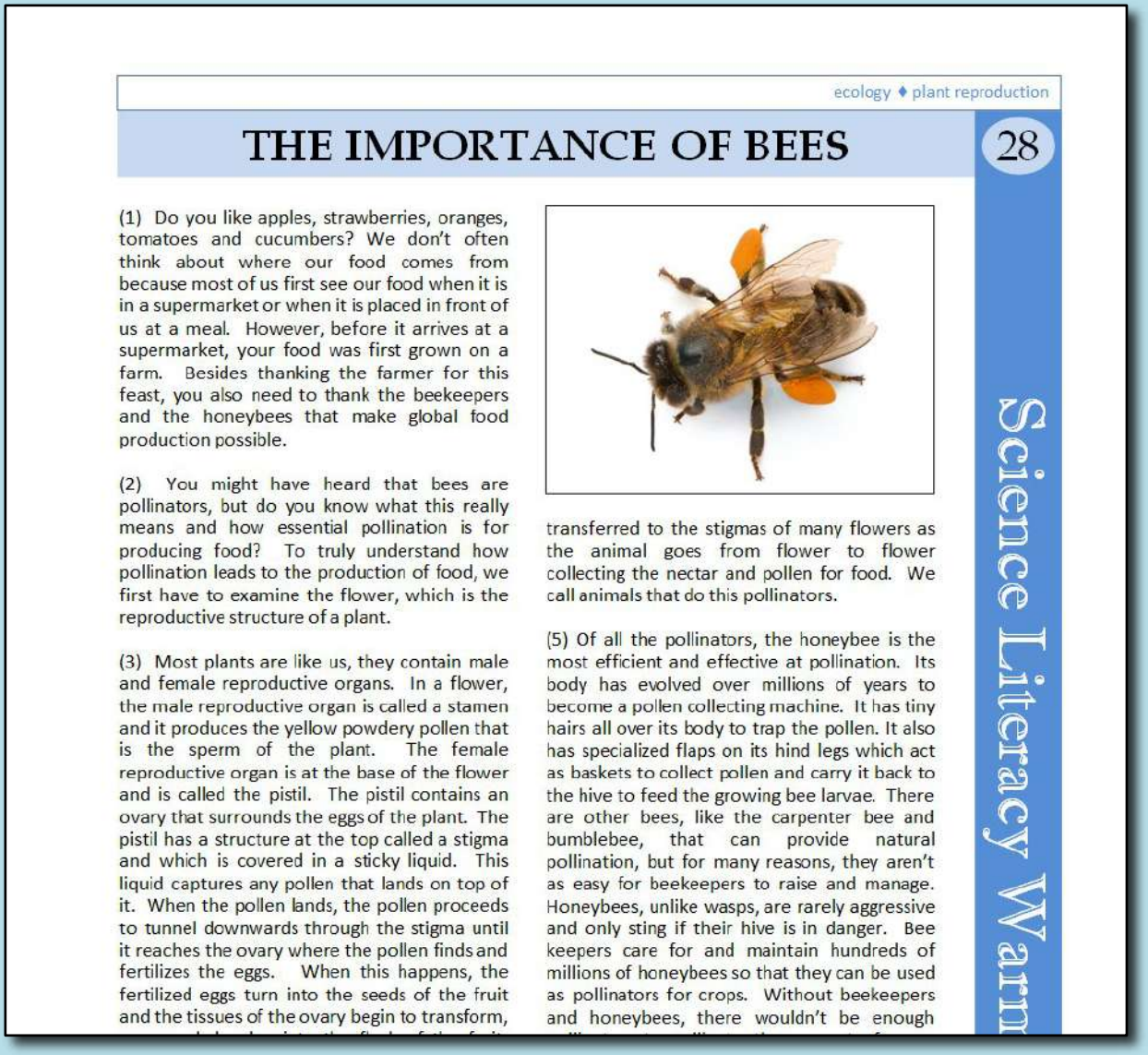
(6) Initially, Moniz's leucotomy involved drilling holes into the skull and injecting the brain with ethanol to destroy the white matter in the prefrontal area, but it ended up damaging other parts of the brain. Moniz then designed an instrument he called a leucotome which had a metal loop which could be inserted into the white matter and moved around to physically destroy the tissue. Moniz was awarded a Nobel Prize in Physiology and Medicine in 1949 for developing this technique. Decades later, patients of lobotomy and their families began campaigning to remove the award from Moniz.

(7) In 1936, an American psychiatrist named Walter Freeman, with the help of a

SCIENCE READING ARTICLE #28: The Importance of Bees

Gr. 7-12

Article highlights include:
Students will learn how pollination occurs, how the honeybee is specialized to collect pollen, why the honeybee is used by beekeepers over other pollinators and how critical bees are for global food production.



ecology ♦ plant reproduction

THE IMPORTANCE OF BEES

28

Science Literacy Warm

(1) Do you like apples, strawberries, oranges, tomatoes and cucumbers? We don't often think about where our food comes from because most of us first see our food when it is in a supermarket or when it is placed in front of us at a meal. However, before it arrives at a supermarket, your food was first grown on a farm. Besides thanking the farmer for this feast, you also need to thank the beekeepers and the honeybees that make global food production possible.

(2) You might have heard that bees are pollinators, but do you know what this really means and how essential pollination is for producing food? To truly understand how pollination leads to the production of food, we first have to examine the flower, which is the reproductive structure of a plant.

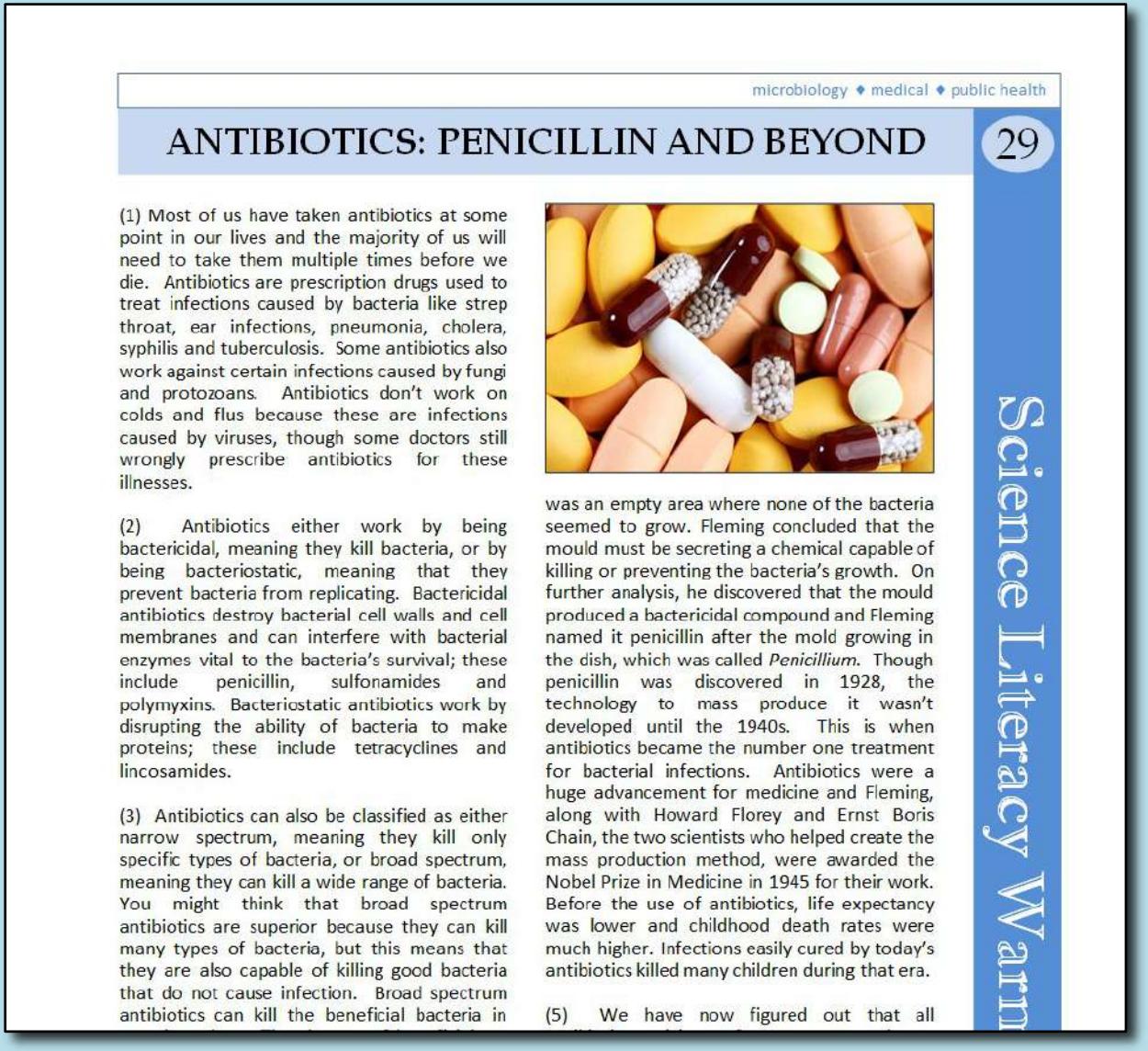
(3) Most plants are like us, they contain male and female reproductive organs. In a flower, the male reproductive organ is called a stamen and it produces the yellow powdery pollen that is the sperm of the plant. The female reproductive organ is at the base of the flower and is called the pistil. The pistil contains an ovary that surrounds the eggs of the plant. The pistil has a structure at the top called a stigma and which is covered in a sticky liquid. This liquid captures any pollen that lands on top of it. When the pollen lands, the pollen proceeds to tunnel downwards through the stigma until it reaches the ovary where the pollen finds and fertilizes the eggs. When this happens, the fertilized eggs turn into the seeds of the fruit and the tissues of the ovary begin to transform,

transferred to the stigmas of many flowers as the animal goes from flower to flower collecting the nectar and pollen for food. We call animals that do this pollinators.

(5) Of all the pollinators, the honeybee is the most efficient and effective at pollination. Its body has evolved over millions of years to become a pollen collecting machine. It has tiny hairs all over its body to trap the pollen. It also has specialized flaps on its hind legs which act as baskets to collect pollen and carry it back to the hive to feed the growing bee larvae. There are other bees, like the carpenter bee and bumblebee, that can provide natural pollination, but for many reasons, they aren't as easy for beekeepers to raise and manage. Honeybees, unlike wasps, are rarely aggressive and only sting if their hive is in danger. Bee keepers care for and maintain hundreds of millions of honeybees so that they can be used as pollinators for crops. Without beekeepers and honeybees, there wouldn't be enough

SCIENCE READING ARTICLE #29: Antibiotics: Penicillin and Beyond Gr. 7-12

Article highlights include:
Students will learn about bactericidal vs. bacteriostatic antibiotics, narrow vs. broad spectrum antibiotics, what antibiotics are effective in treating, how penicillin was discovered by Alexander Fleming and how the misuse, overprescription and use of subtherapeutic antibiotics in livestock feed has contributed to the growing antibiotic resistance seen in bacteria. How antibiotic resistance develops is also discussed.



microbiology ♦ medical ♦ public health

ANTIBIOTICS: PENICILLIN AND BEYOND

29

Science Literacy Warm

(1) Most of us have taken antibiotics at some point in our lives and the majority of us will need to take them multiple times before we die. Antibiotics are prescription drugs used to treat infections caused by bacteria like strep throat, ear infections, pneumonia, cholera, syphilis and tuberculosis. Some antibiotics also work against certain infections caused by fungi and protozoans. Antibiotics don't work on colds and flus because these are infections caused by viruses, though some doctors still wrongly prescribe antibiotics for these illnesses.

(2) Antibiotics either work by being bactericidal, meaning they kill bacteria, or by being bacteriostatic, meaning that they prevent bacteria from replicating. Bactericidal antibiotics destroy bacterial cell walls and cell membranes and can interfere with bacterial enzymes vital to the bacteria's survival; these include penicillin, sulfonamides and polymyxins. Bacteriostatic antibiotics work by disrupting the ability of bacteria to make proteins; these include tetracyclines and lincosamides.

(3) Antibiotics can also be classified as either narrow spectrum, meaning they kill only specific types of bacteria, or broad spectrum, meaning they can kill a wide range of bacteria. You might think that broad spectrum antibiotics are superior because they can kill many types of bacteria, but this means that they are also capable of killing good bacteria that do not cause infection. Broad spectrum antibiotics can kill the beneficial bacteria in

was an empty area where none of the bacteria seemed to grow. Fleming concluded that the mould must be secreting a chemical capable of killing or preventing the bacteria's growth. On further analysis, he discovered that the mould produced a bactericidal compound and Fleming named it penicillin after the mold growing in the dish, which was called *Penicillium*. Though penicillin was discovered in 1928, the technology to mass produce it wasn't developed until the 1940s. This is when antibiotics became the number one treatment for bacterial infections. Antibiotics were a huge advancement for medicine and Fleming, along with Howard Florey and Ernst Boris Chain, the two scientists who helped create the mass production method, were awarded the Nobel Prize in Medicine in 1945 for their work. Before the use of antibiotics, life expectancy was lower and childhood death rates were much higher. Infections easily cured by today's antibiotics killed many children during that era.

(5) We have now figured out that all

SCIENCE READING ARTICLE #30: Addicted to Sugar

Gr. 7-12

Article highlights include:
Students will learn about the health impacts of sugar, research showing that sugar can be more addictive than cocaine or heroine, the effect of sugar on the brain, how available sugar was to our ancestors, the effects of high-fructose corn syrup, an example of how hidden added sugars can be found in "healthy" meals and how to read food labels appropriately so that the sugar content can be better understood.

neuroscience ♦ health & nutrition

ADDICTED TO SUGAR

30

Science Literacy Warm

(1) When people think of addictions they think of substances like alcohol, cigarettes and illegal drugs like cocaine and heroine. However, what if there's a more addictive substance that is more common, found in all of our homes and aggressively marketed and even legally sold to children? This substance exists and it is sugar.

(2) Over the last few years, more and more research points to sugar as a major contributor to health problems like cardiovascular disease, obesity, diabetes, liver disease, some cancers and even lowered mental functioning. We all know we shouldn't eat too much sugar, but most of us don't realize how much sugar we're actually consuming and how it's affecting our health. Many of us might say that we have a "sweet tooth" but very few of us would think that we have a sugar addiction.

(3) Research is beginning to show that many of us exhibit signs of sugar addiction. Signs like cravings for sugar, loss of self control around sweets and feelings of withdrawal (feeling bad or unhappy) when not eating it. Studies have been done on rats to investigate the addictive properties of sugar versus other addictive drugs. In these studies, rats were given cocaine or heroine until they become addicted. After drug addiction was established, the rats were introduced to sugar along with the drug. Over a short period of time, over 90% of the rats began to choose sugar over the drug they were already addicted to and developed a stronger sugar addiction than drug addiction. Research like this shows the powerful addictive capacity of sugar.

not adapted to the overload of pleasure that occurs when we consume sweets. Sugar triggers the same pleasure, reward, and habit formation pathways in the brain as cocaine and heroine. This pleasure ensures continued sugar consumption that can lead to addiction.

(5) Not only are fruits sweeter and more available than ever before, we are also consuming a greater amount of added sugars in other foods. High fructose corn syrup (HFCS) was developed in the 1970s and since then it has become a very common sweetener in sodas, sugary drinks, and many processed foods. Unlike sucrose (cane sugar) which is already very sweet, HFCS is even sweeter and more rapidly absorbed by the body to provide a very quick reward for the brain. Many children in Westernized countries will consume 2 beverages a day containing HFCS and this is a major contributor to childhood obesity, diabetes and sugar addiction.

(6) The majority of us consume too much sugar

SCIENCE READING ARTICLE #31: Food Designed for Space — Gr. 7-12

Article highlights include:
Students will learn about the challenges of designing food for astronauts, the requirements that space food must meet (like taking up very little space and having a long shelf-life at room temperatures), the different categories of space foods, how different equipment must be made for eating a meal in microgravity environments, and why food in space doesn't taste as good as it would on Earth.

astronomy ♦ food science

FOOD DESIGNED FOR SPACE

31

Science Literacy Warm

(1) Have you ever had a desire to eat toothpaste from the tube? Imagine squeezing the contents of the tube directly into your mouth and instead of tasting mint toothpaste you taste chocolate sauce. This is what Yuri Gagarin, a Russian cosmonaut, tasted in April 1961 when he became the first human to travel into outer space. He ate one tube of chocolate sauce and two tubes of meat sauce. Until Gagarin, scientists were unsure if food could be swallowed in space with little to no gravity. It turns out that the process of peristalsis, which is the involuntary wave-like contractions of the esophagus, pushes food from the throat to the stomach even when gravity is unavailable to aid in the transport.

(2) As you can imagine, food in a tube was not very delicious and soon new space foods were designed. Designing space food is tricky because it has to meet specific requirements for space. It has to be nutritious for the astronauts, take up very little space, be easy to clean up, produce very little waste and be easy to eat without leaving crumbs behind. Another vital requirement is that the food has to last a long time without spoiling at room temperature since most ships lack refrigeration capabilities. There are various types of foods typically used for space missions.

(3) One of the most important types is the *rehydratable food*. Most food is up to 90% water so dehydrating food is a great way to save space. Dehydrated foods have the water removed from them, leaving only the solid components behind. The food can be easily

ISS Space Food on a Tray, credit: NASA

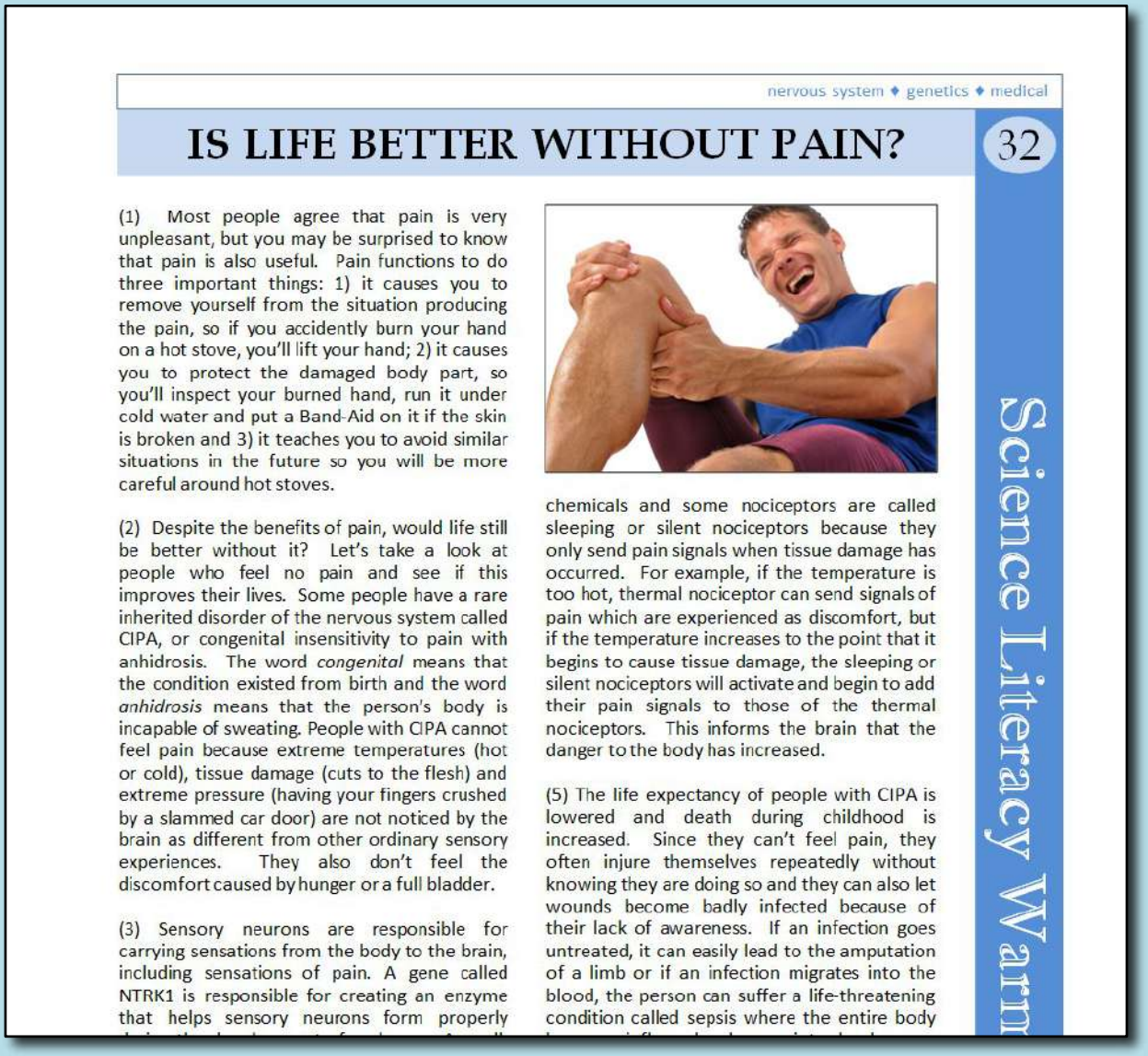
(5) Even astronauts miss their sodas so eventually some were allowed on board ships, however, fizzy drinks with carbonation proved to be problematic. Microgravity conditions caused "wet burps" that resulted in a bit of vomiting for some astronauts. Though sodas are still allowed, they are not the best type of space beverage and are kept to a minimum.

(6) There's another type of space food called *immediate moisture foods*. These foods do not require added water or reheating in order to eat them. These foods contain a bit of water, but not enough to cause quick spoilage at room temperature. Examples include dried fruits and beef jerky. *Natural form foods* have even less water content and these include nuts, cookies and granola bars.

(7) Food can also be heated or exposed to

SCIENCE READING ARTICLE #32: Is Life Better Without Pain? Gr. 9-12

Article highlights include:
Students will learn about the usefulness of pain to survival and about CIPA (congenital insensitivity to pain with anhidrosis). They will learn about the difficulties people with CIPA face because they cannot feel pain, the different types of nociceptors (pain neurons) that exist in humans, how mutations in a gene destroys nociceptors in people with CIPA, the concerns parents need to have if their child has CIPA and how CIPA is genetically inherited.



nervous system ♦ genetics ♦ medical

IS LIFE BETTER WITHOUT PAIN?

32

Science Literacy Warm

(1) Most people agree that pain is very unpleasant, but you may be surprised to know that pain is also useful. Pain functions to do three important things: 1) it causes you to remove yourself from the situation producing the pain, so if you accidently burn your hand on a hot stove, you'll lift your hand; 2) it causes you to protect the damaged body part, so you'll inspect your burned hand, run it under cold water and put a Band-Aid on it if the skin is broken and 3) it teaches you to avoid similar situations in the future so you will be more careful around hot stoves.

(2) Despite the benefits of pain, would life still be better without it? Let's take a look at people who feel no pain and see if this improves their lives. Some people have a rare inherited disorder of the nervous system called CIPA, or congenital insensitivity to pain with anhidrosis. The word *congenital* means that the condition existed from birth and the word *anhidrosis* means that the person's body is incapable of sweating. People with CIPA cannot feel pain because extreme temperatures (hot or cold), tissue damage (cuts to the flesh) and extreme pressure (having your fingers crushed by a slammed car door) are not noticed by the brain as different from other ordinary sensory experiences. They also don't feel the discomfort caused by hunger or a full bladder.

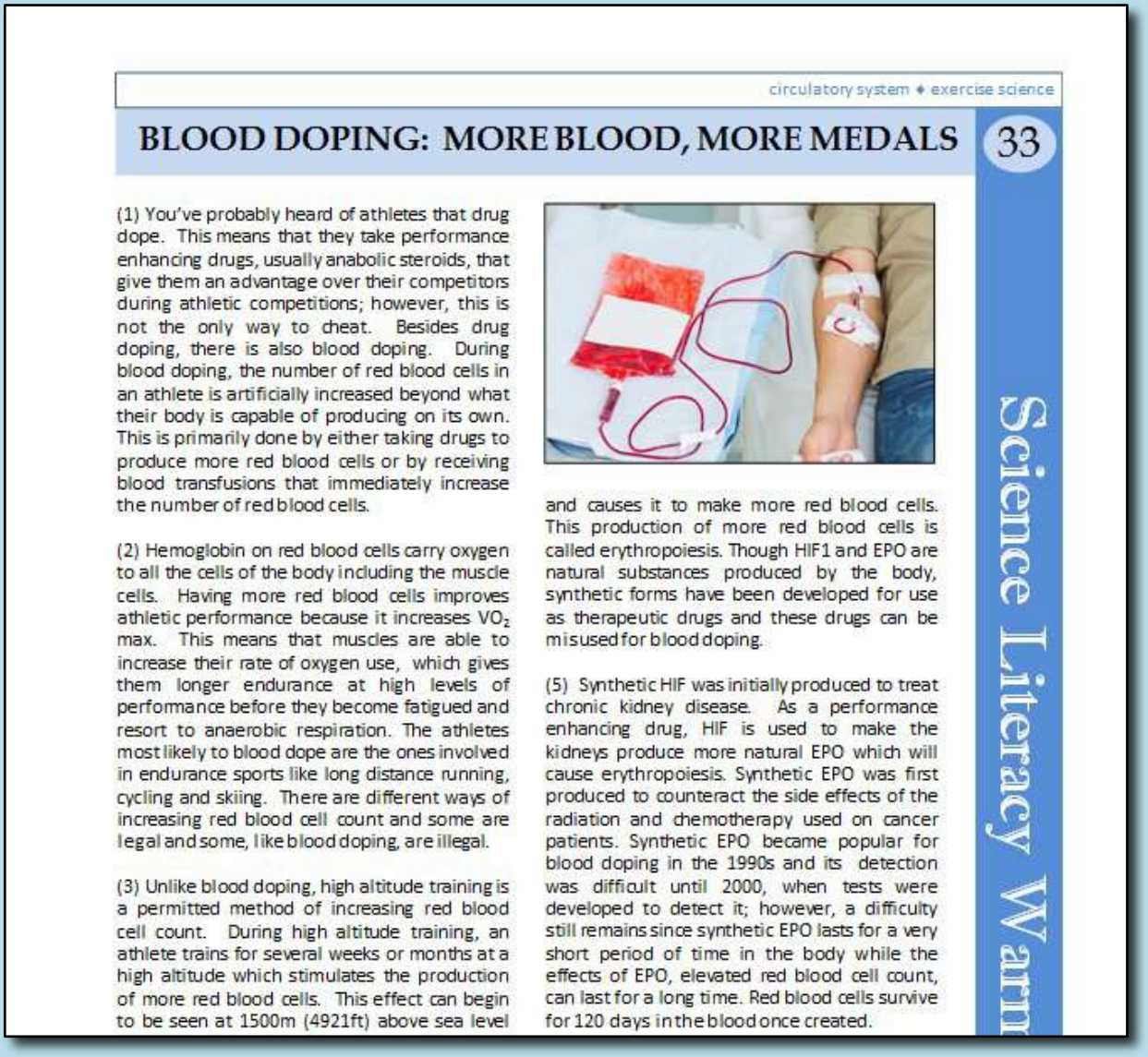
(3) Sensory neurons are responsible for carrying sensations from the body to the brain, including sensations of pain. A gene called NTRK1 is responsible for creating an enzyme that helps sensory neurons form properly

chemicals and some nociceptors are called sleeping or silent nociceptors because they only send pain signals when tissue damage has occurred. For example, if the temperature is too hot, thermal nociceptor can send signals of pain which are experienced as discomfort, but if the temperature increases to the point that it begins to cause tissue damage, the sleeping or silent nociceptors will activate and begin to add their pain signals to those of the thermal nociceptors. This informs the brain that the danger to the body has increased.

(5) The life expectancy of people with CIPA is lowered and death during childhood is increased. Since they can't feel pain, they often injure themselves repeatedly without knowing they are doing so and they can also let wounds become badly infected because of their lack of awareness. If an infection goes untreated, it can easily lead to the amputation of a limb or if an infection migrates into the blood, the person can suffer a life-threatening condition called sepsis where the entire body

SCIENCE READING ARTICLE #33: Blood Doping: More Blood, More Medals Gr. 8-12

Article highlights include:
Students will learn about why athletes blood dope, the performance enhancement effects of blood doping, blood doping techniques like drugs that stimulate red blood cell production and blood transfusions that increase red blood cell counts immediately. As well they will learn about the effects of high altitude training on red blood cell production (which is a legal method of increasing red blood cell count) and about the World Anti-Drug Doping Agency's use of athlete biological passports to detect cheating.



circulatory system ♦ exercise science

BLOOD DOPING: MORE BLOOD, MORE MEDALS 33

(1) You've probably heard of athletes that drug dope. This means that they take performance enhancing drugs, usually anabolic steroids, that give them an advantage over their competitors during athletic competitions; however, this is not the only way to cheat. Besides drug doping, there is also blood doping. During blood doping, the number of red blood cells in an athlete is artificially increased beyond what their body is capable of producing on its own. This is primarily done by either taking drugs to produce more red blood cells or by receiving blood transfusions that immediately increase the number of red blood cells.

(2) Hemoglobin on red blood cells carry oxygen to all the cells of the body including the muscle cells. Having more red blood cells improves athletic performance because it increases VO_2 max. This means that muscles are able to increase their rate of oxygen use, which gives them longer endurance at high levels of performance before they become fatigued and resort to anaerobic respiration. The athletes most likely to blood dope are the ones involved in endurance sports like long distance running, cycling and skiing. There are different ways of increasing red blood cell count and some are legal and some, like blood doping, are illegal.

(3) Unlike blood doping, high altitude training is a permitted method of increasing red blood cell count. During high altitude training, an athlete trains for several weeks or months at a high altitude which stimulates the production of more red blood cells. This effect can begin to be seen at 1500m (4921ft) above sea level

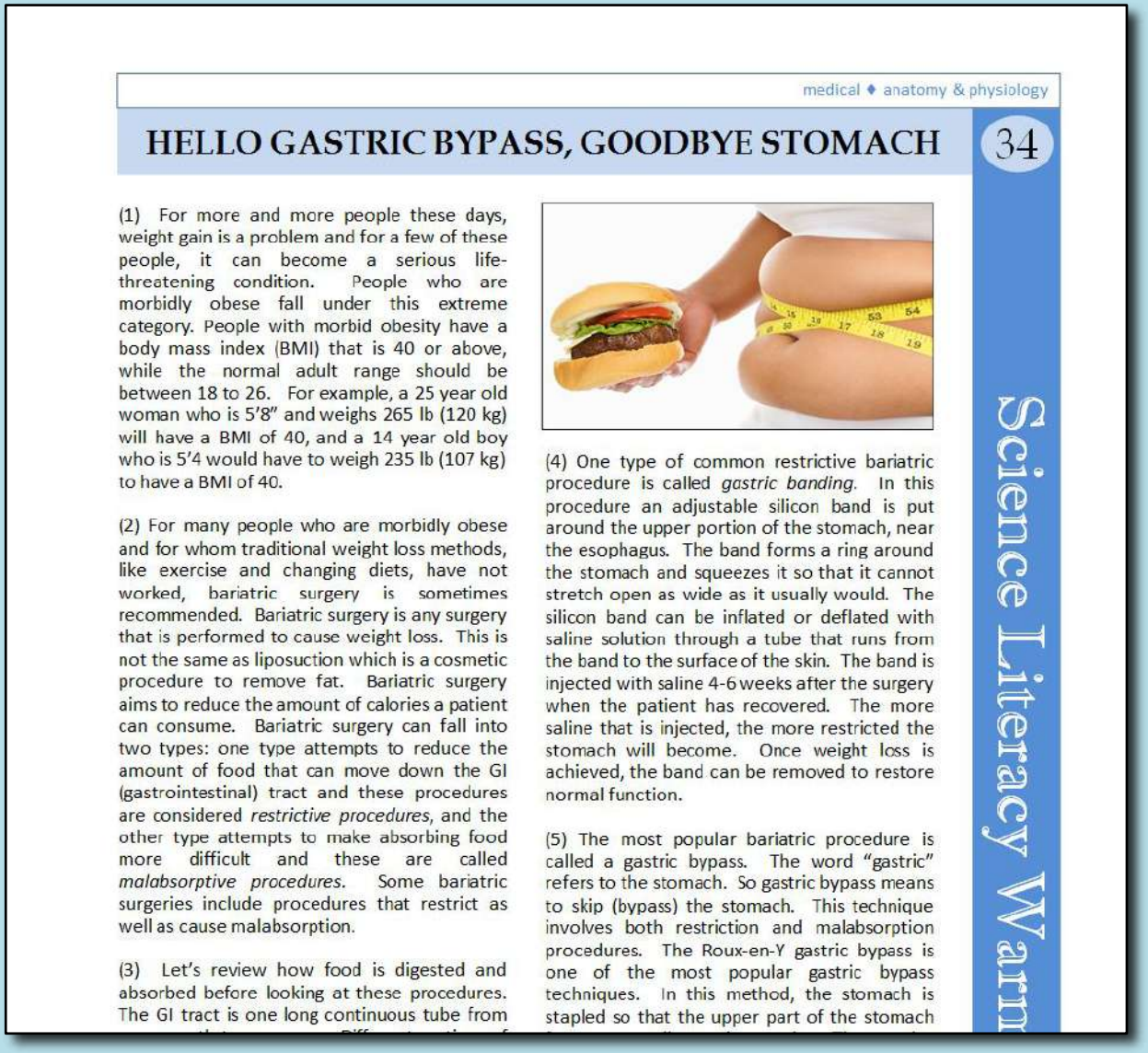
and causes it to make more red blood cells. This production of more red blood cells is called erythropoiesis. Though HIF1 and EPO are natural substances produced by the body, synthetic forms have been developed for use as therapeutic drugs and these drugs can be misused for blood doping.

(5) Synthetic HIF was initially produced to treat chronic kidney disease. As a performance enhancing drug, HIF is used to make the kidneys produce more natural EPO which will cause erythropoiesis. Synthetic EPO was first produced to counteract the side effects of the radiation and chemotherapy used on cancer patients. Synthetic EPO became popular for blood doping in the 1990s and its detection was difficult until 2000, when tests were developed to detect it; however, a difficulty still remains since synthetic EPO lasts for a very short period of time in the body while the effects of EPO, elevated red blood cell count, can last for a long time. Red blood cells survive for 120 days in the blood once created.

Science Literacy Warm

SCIENCE READING ARTICLE #34: Hello Gastric Bypass, Goodbye Stomach Gr. 7-12

Article highlights include:
Students will learn about morbid obesity and the two main types of bariatric procedures (restrictive methods and malabsorptive methods) that are used to treat this condition. Gastric banding and gastric bypass are specifically examined. This is a great extension activity for classes studying the digestive system or nutrition.



HELLO GASTRIC BYPASS, GOODBYE STOMACH

(1) For more and more people these days, weight gain is a problem and for a few of these people, it can become a serious life-threatening condition. People who are morbidly obese fall under this extreme category. People with morbid obesity have a body mass index (BMI) that is 40 or above, while the normal adult range should be between 18 to 26. For example, a 25 year old woman who is 5'8" and weighs 265 lb (120 kg) will have a BMI of 40, and a 14 year old boy who is 5'4 would have to weigh 235 lb (107 kg) to have a BMI of 40.

(2) For many people who are morbidly obese and for whom traditional weight loss methods, like exercise and changing diets, have not worked, bariatric surgery is sometimes recommended. Bariatric surgery is any surgery that is performed to cause weight loss. This is not the same as liposuction which is a cosmetic procedure to remove fat. Bariatric surgery aims to reduce the amount of calories a patient can consume. Bariatric surgery can fall into two types: one type attempts to reduce the amount of food that can move down the GI (gastrointestinal) tract and these procedures are considered *restrictive procedures*, and the other type attempts to make absorbing food more difficult and these are called *malabsorptive procedures*. Some bariatric surgeries include procedures that restrict as well as cause malabsorption.

(3) Let's review how food is digested and absorbed before looking at these procedures. The GI tract is one long continuous tube from

(4) One type of common restrictive bariatric procedure is called *gastric banding*. In this procedure an adjustable silicon band is put around the upper portion of the stomach, near the esophagus. The band forms a ring around the stomach and squeezes it so that it cannot stretch open as wide as it usually would. The silicon band can be inflated or deflated with saline solution through a tube that runs from the band to the surface of the skin. The band is injected with saline 4-6 weeks after the surgery when the patient has recovered. The more saline that is injected, the more restricted the stomach will become. Once weight loss is achieved, the band can be removed to restore normal function.

(5) The most popular bariatric procedure is called a gastric bypass. The word "gastric" refers to the stomach. So gastric bypass means to skip (bypass) the stomach. This technique involves both restriction and malabsorption procedures. The Roux-en-Y gastric bypass is one of the most popular gastric bypass techniques. In this method, the stomach is stapled so that the upper part of the stomach

SCIENCE READING ARTICLE #35: An Athlete's Perfect Twitch

Gr. 7-12

Article highlights include:
Students will learn about slow twitch and fast twitch muscle fibers, how they create and use energy differently, how they respond to training and which types of sport each muscle fiber is best suited to helping an athlete excel at. For example, a greater ratio of slow twitch to fast twitch muscles fibers will help an athlete excel at endurance sports like marathons and long distance cycling.

exercise science ♦ anatomy & physiology

AN ATHLETE'S PERFECT TWITCH

35

Science Literacy Warm

(1) Which sport is perfect for you? You might like sports or you might not. You might love playing sports but not be amazing at any of them. You might dislike sports, avoid them like the plague, and never know that you could be the star player of a team. No one doubts that effort, practice and proper training at any sport helps all athletes improve, but some people are lucky enough to have been born with a genetic advantage that makes it easier for them to become high performing athletes.

(2) Some of the major factors that influence athletic performance are body morphology (e.g. height and body composition), endurance (how long you can physically perform before tiring), strength, injury susceptibility (how likely you are to get injured) and how well a person responds to training. These factors are determined by varying amounts of genetic and environmental influences. For example, height, is almost 80% determined by genetic factors. Some athletic careers have been cut short when athletes have not grown tall enough (e.g. basketball players) or when some athletes have grown too tall (e.g. gymnasts). Aerobic endurance is 50% genetically determined and strength is 30% to 80% genetically determined depending on the muscle group and type of contraction.

(3) When it comes to skeletal muscles, everyone has three types of muscle fibers: slow twitch fibers, fast twitch A fibers and fast twitch B fibers. However, the proportion and distribution of these fibers in each individual differs and this has a large influence on the

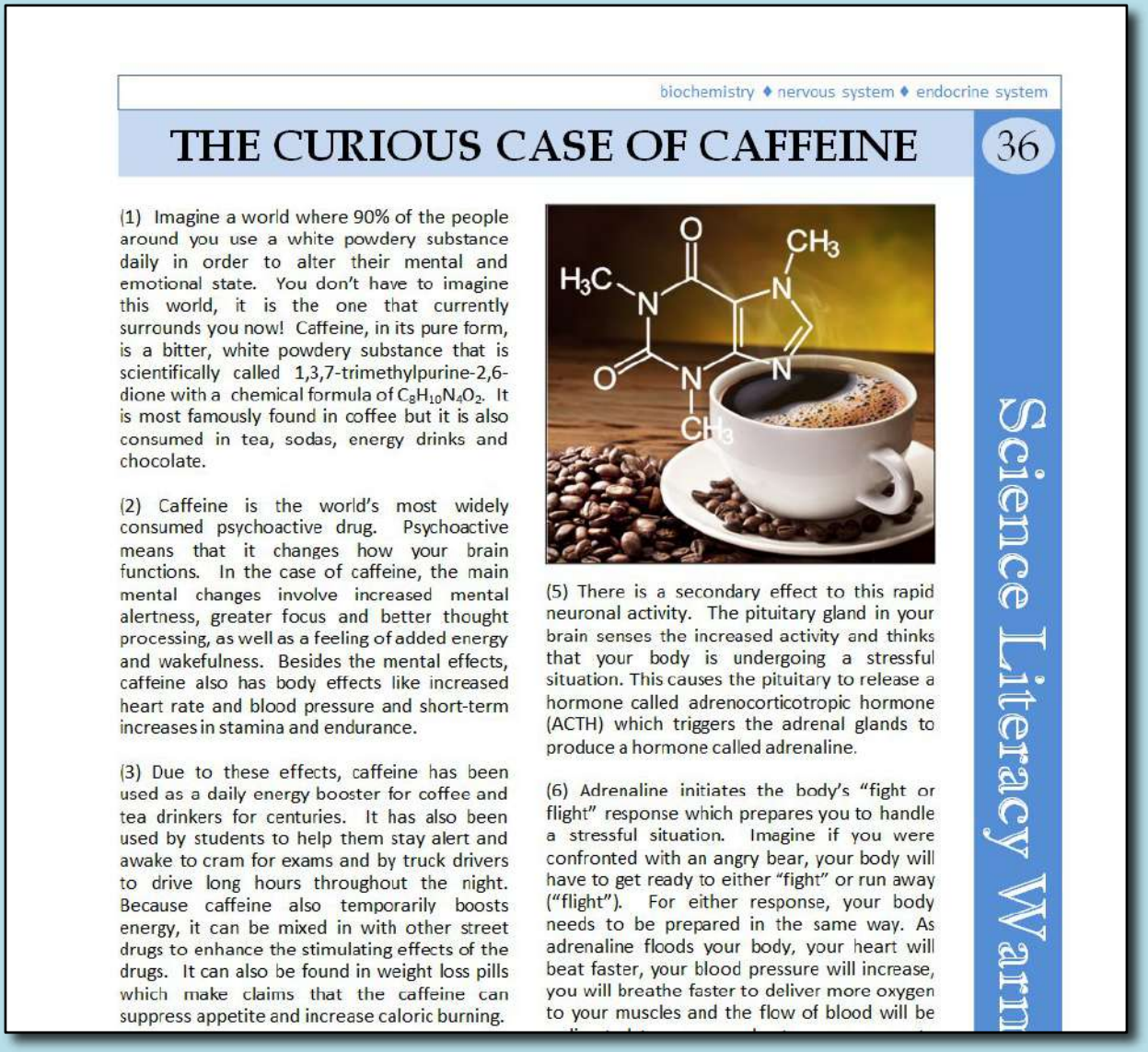
neck which holds your head erect for the entire day without fatiguing. For athletics, slow twitch fibers are the type that long distance runners or cyclists would use to perform their endurance sport. Imagine running a 42 km (26 mile) marathon or cycling 200 km (124 miles) of a stage of the Tour de France. Only slow twitch muscles can provide the sustained effort needed to complete such long distances.

(5) The other two types of muscle fibers are fast twitch fibers and can be broken down into fast twitch A and fast twitch B types. Fast twitch B are the muscle fibers which can be considered the opposite to slow twitch fibers. Unlike slow twitch fibers, fast twitch B fibers contract the fastest but they also get tired the quickest. They have very little mitochondria and can only be used for very short term anaerobic activities that require a big burst of explosive power like sprinting or jumping. Fast twitch B muscle fibers use glycogen and creatine phosphate for fuel instead of triglycerides. Fast twitch A muscle fibers are a

SCIENCE READING ARTICLE #36: The Curious Case of Caffeine

Gr. 7-12

Article highlights include:
Students will learn about the mental and physical effects of caffeine on the body, how caffeine acts on the brain to increase neuronal activity which causes alertness, how caffeine triggers the fight or flight reflex and how tolerance and addiction occur with regular caffeine intake.



biochemistry ♦ nervous system ♦ endocrine system

THE CURIOUS CASE OF CAFFEINE

36

(1) Imagine a world where 90% of the people around you use a white powdery substance daily in order to alter their mental and emotional state. You don't have to imagine this world, it is the one that currently surrounds you now! Caffeine, in its pure form, is a bitter, white powdery substance that is scientifically called 1,3,7-trimethylpurine-2,6-dione with a chemical formula of $C_8H_{10}N_4O_2$. It is most famously found in coffee but it is also consumed in tea, sodas, energy drinks and chocolate.

(2) Caffeine is the world's most widely consumed psychoactive drug. Psychoactive means that it changes how your brain functions. In the case of caffeine, the main mental changes involve increased mental alertness, greater focus and better thought processing, as well as a feeling of added energy and wakefulness. Besides the mental effects, caffeine also has body effects like increased heart rate and blood pressure and short-term increases in stamina and endurance.

(3) Due to these effects, caffeine has been used as a daily energy booster for coffee and tea drinkers for centuries. It has also been used by students to help them stay alert and awake to cram for exams and by truck drivers to drive long hours throughout the night. Because caffeine also temporarily boosts energy, it can be mixed in with other street drugs to enhance the stimulating effects of the drugs. It can also be found in weight loss pills which make claims that the caffeine can suppress appetite and increase caloric burning.

(5) There is a secondary effect to this rapid neuronal activity. The pituitary gland in your brain senses the increased activity and thinks that your body is undergoing a stressful situation. This causes the pituitary to release a hormone called adrenocorticotropic hormone (ACTH) which triggers the adrenal glands to produce a hormone called adrenaline.

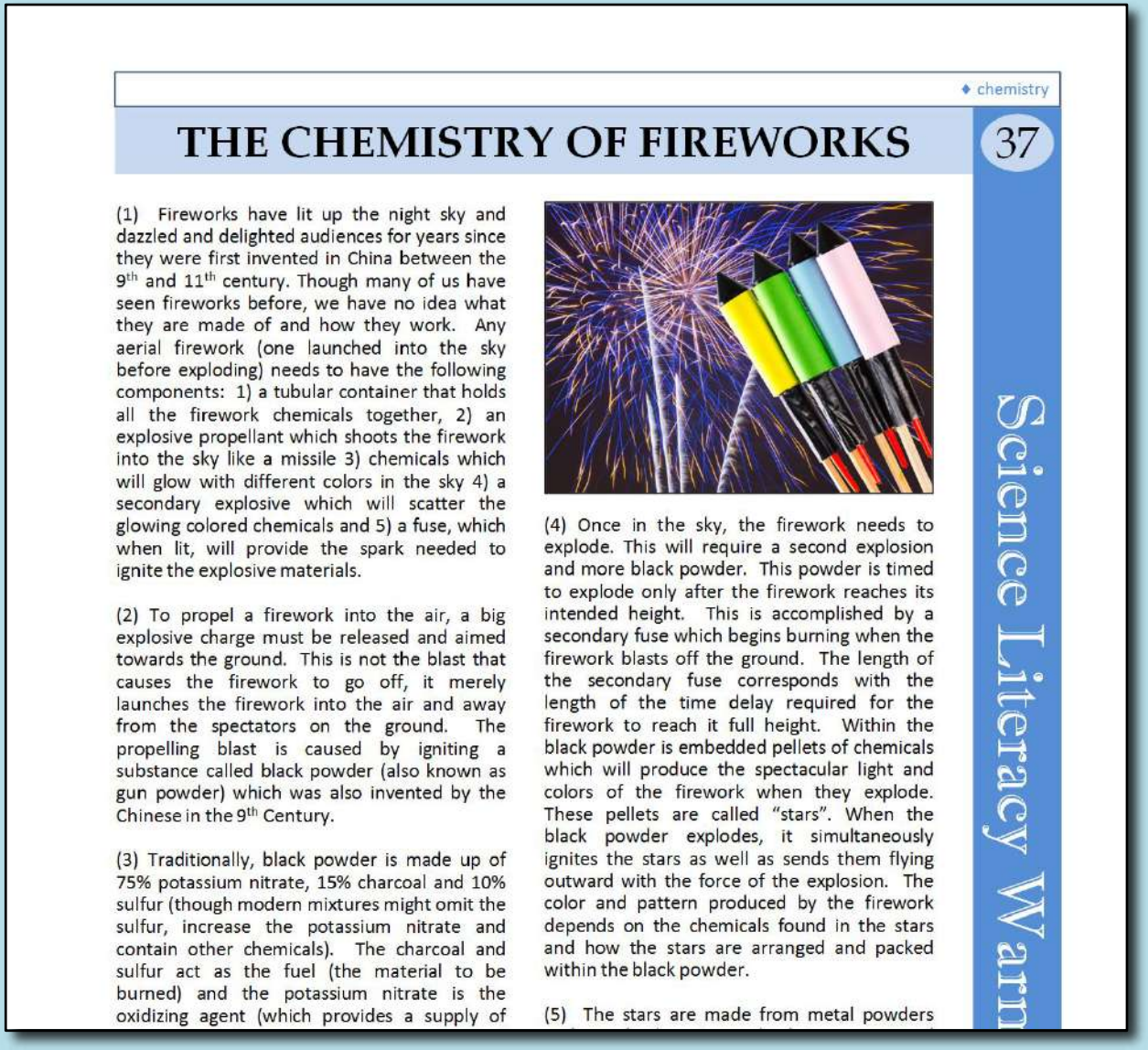
(6) Adrenaline initiates the body's "fight or flight" response which prepares you to handle a stressful situation. Imagine if you were confronted with an angry bear, your body will have to get ready to either "fight" or run away ("flight"). For either response, your body needs to be prepared in the same way. As adrenaline floods your body, your heart will beat faster, your blood pressure will increase, you will breathe faster to deliver more oxygen to your muscles and the flow of blood will be

Science Literacy Warm

SCIENCE READING ARTICLE #37: The Chemistry of Fireworks

Gr. 7-12

Article highlights include:
Students will learn about the various components of a firework and their role in the function of the firework. They will examine the composition of the gun powder which explodes to launch the firework into the air and examine the "stars" which are the metal salts that burn with various different colors when they are ignited within the firework.



♦ chemistry

THE CHEMISTRY OF FIREWORKS

37

(1) Fireworks have lit up the night sky and dazzled and delighted audiences for years since they were first invented in China between the 9th and 11th century. Though many of us have seen fireworks before, we have no idea what they are made of and how they work. Any aerial firework (one launched into the sky before exploding) needs to have the following components: 1) a tubular container that holds all the firework chemicals together, 2) an explosive propellant which shoots the firework into the sky like a missile 3) chemicals which will glow with different colors in the sky 4) a secondary explosive which will scatter the glowing colored chemicals and 5) a fuse, which when lit, will provide the spark needed to ignite the explosive materials.

(2) To propel a firework into the air, a big explosive charge must be released and aimed towards the ground. This is not the blast that causes the firework to go off, it merely launches the firework into the air and away from the spectators on the ground. The propelling blast is caused by igniting a substance called black powder (also known as gun powder) which was also invented by the Chinese in the 9th Century.

(3) Traditionally, black powder is made up of 75% potassium nitrate, 15% charcoal and 10% sulfur (though modern mixtures might omit the sulfur, increase the potassium nitrate and contain other chemicals). The charcoal and sulfur act as the fuel (the material to be burned) and the potassium nitrate is the oxidizing agent (which provides a supply of

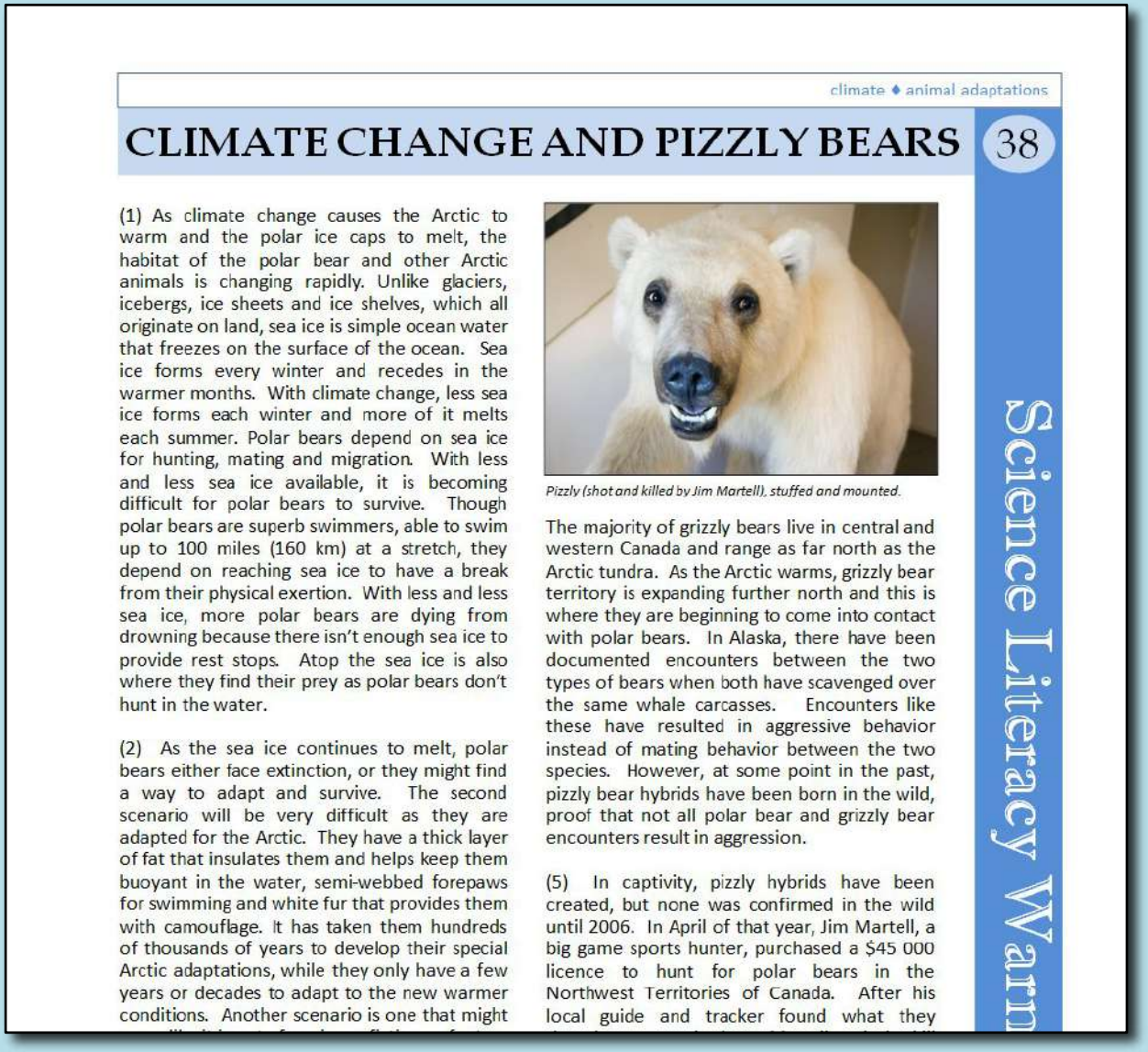
(4) Once in the sky, the firework needs to explode. This will require a second explosion and more black powder. This powder is timed to explode only after the firework reaches its intended height. This is accomplished by a secondary fuse which begins burning when the firework blasts off the ground. The length of the secondary fuse corresponds with the length of the time delay required for the firework to reach it full height. Within the black powder is embedded pellets of chemicals which will produce the spectacular light and colors of the firework when they explode. These pellets are called "stars". When the black powder explodes, it simultaneously ignites the stars as well as sends them flying outward with the force of the explosion. The color and pattern produced by the firework depends on the chemicals found in the stars and how the stars are arranged and packed within the black powder.

(5) The stars are made from metal powders

Science Literacy Warm

SCIENCE READING ARTICLE #38: Climate Change and Pizzly Bears — Gr. 7-12

Article highlights include:
Students will learn about how climate change is warming the Arctic and threatening the habitat of the polar bear. As this happens, it makes way for grizzly bear territory to expand further north which increases the interaction between the two species, with possible mating opportunities. Beyond speculation, two real cases of pizzly bear offspring in the wild (as confirmed by genetic testing) is discussed along with the possibility of other Arctic hybrids.



climate ♦ animal adaptations

CLIMATE CHANGE AND PIZZLY BEARS 38

(1) As climate change causes the Arctic to warm and the polar ice caps to melt, the habitat of the polar bear and other Arctic animals is changing rapidly. Unlike glaciers, icebergs, ice sheets and ice shelves, which all originate on land, sea ice is simple ocean water that freezes on the surface of the ocean. Sea ice forms every winter and recedes in the warmer months. With climate change, less sea ice forms each winter and more of it melts each summer. Polar bears depend on sea ice for hunting, mating and migration. With less and less sea ice available, it is becoming difficult for polar bears to survive. Though polar bears are superb swimmers, able to swim up to 100 miles (160 km) at a stretch, they depend on reaching sea ice to have a break from their physical exertion. With less and less sea ice, more polar bears are dying from drowning because there isn't enough sea ice to provide rest stops. Atop the sea ice is also where they find their prey as polar bears don't hunt in the water.

(2) As the sea ice continues to melt, polar bears either face extinction, or they might find a way to adapt and survive. The second scenario will be very difficult as they are adapted for the Arctic. They have a thick layer of fat that insulates them and helps keep them buoyant in the water, semi-webbed forepaws for swimming and white fur that provides them with camouflage. It has taken them hundreds of thousands of years to develop their special Arctic adaptations, while they only have a few years or decades to adapt to the new warmer conditions. Another scenario is one that might

Pizzly (shot and killed by Jim Martell), stuffed and mounted.

The majority of grizzly bears live in central and western Canada and range as far north as the Arctic tundra. As the Arctic warms, grizzly bear territory is expanding further north and this is where they are beginning to come into contact with polar bears. In Alaska, there have been documented encounters between the two types of bears when both have scavenged over the same whale carcasses. Encounters like these have resulted in aggressive behavior instead of mating behavior between the two species. However, at some point in the past, pizzly bear hybrids have been born in the wild, proof that not all polar bear and grizzly bear encounters result in aggression.

(5) In captivity, pizzly hybrids have been created, but none was confirmed in the wild until 2006. In April of that year, Jim Martell, a big game sports hunter, purchased a $45 000 licence to hunt for polar bears in the Northwest Territories of Canada. After his local guide and tracker found what they

Science Literacy Warm

SCIENCE READING ARTICLE #39: The Science of Self-Control

Gr. 7-12

Article highlights include:
Students will learn about the famous Marshmallow Experiments done in the 1970s. These experiments demonstrate a strong correlation between the ability to exert self-control in children and their later success as adults. Students will also learn about how habit retraining can help overcome the negative behaviors that seem to stem from the lack of self-control.

♦ behavioral science

THE SCIENCE OF SELF-CONTROL

39

Science Literacy Warm

(1) What is the most important characteristic a person can possess that will guarantee them success in life? Can there be only one trait that ensures success? Not likely, but if you could have one trait to help you be successful would you pick self-control? Self-control seems quite a boring characteristic to have, but you will be amazed at how powerful this little trait can be.

(2) In the 1960s and 1970s, Walter Mischel and Ebbe B. Ebbesen of Stanford University conducted what is now famously known as the "Marshmallow Experiment". The original purpose of this test was to see when self-control and the ability to delay gratification developed in children. Delaying gratification means that though there is something very rewarding in front of you, you choose to delay having it because delaying will gain you a greater reward in the end. Giving in to instant gratification means that you choose the immediate, but less valuable reward, over the delayed but better reward.

(3) A common example would be choosing to play a video game when you get home from school instead of completing an assignment due for school the next day. The video game is immediately fun and therefore instantly rewarding. It's harder to tell yourself that you should do the assignment first to ensure that it gets done and that there will be time to play the video game after you've completed the assignment. For this, you have to be able to delay gratification (postpone playing the game) for a more important reward (completing the assignment on time and getting a good mark

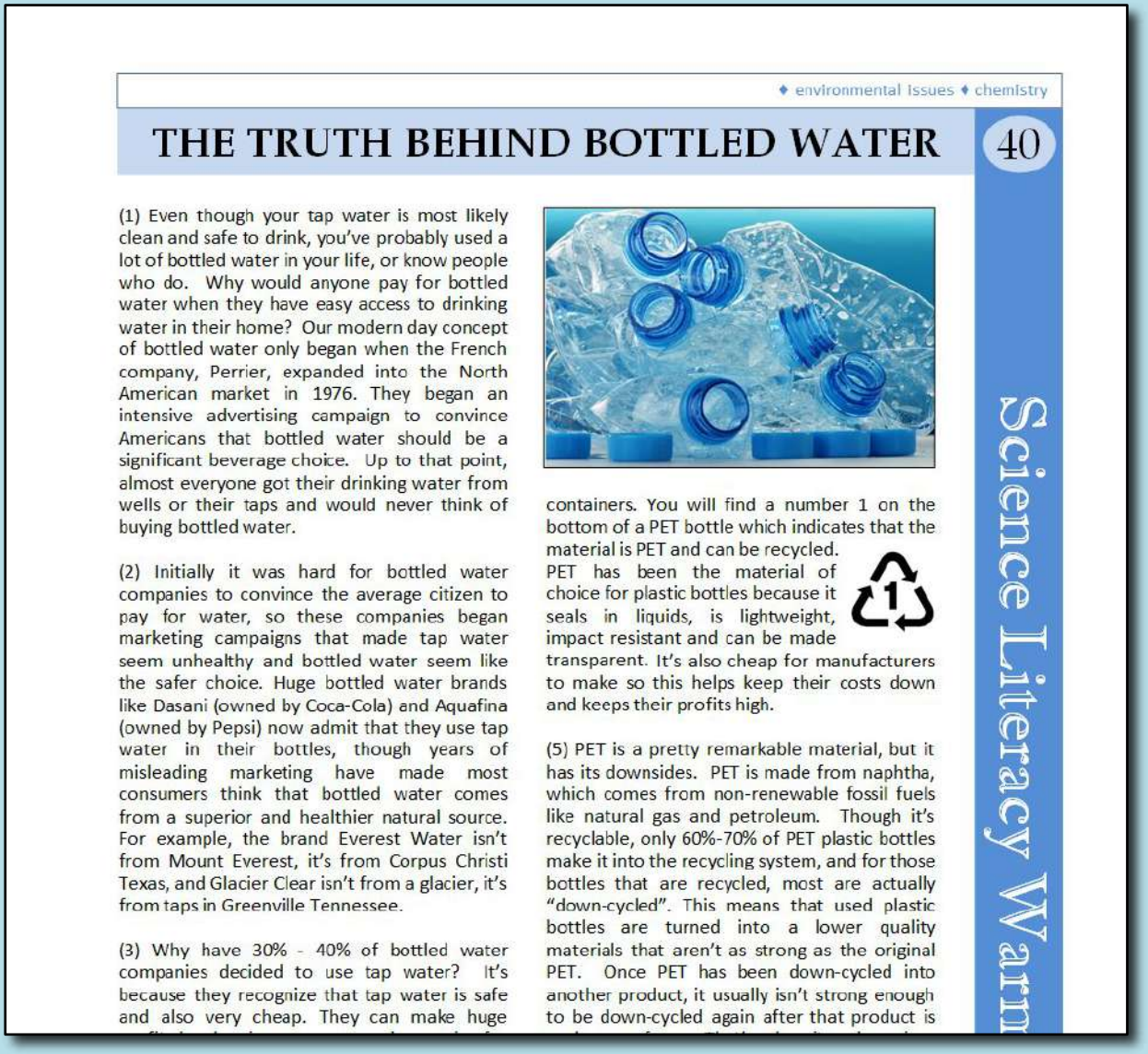
(5) The marshmallow experiment revealed three types of responses. Some kids ate the marshmallow on the plate as soon as the adult left the room. Some kids tried to distract themselves from eating the marshmallow but could not wait the entire 15 minutes before they gave up. The third group of kids successfully distracted themselves for 15 minutes and gained another marshmallow.

(6) By themselves, these results are not too significant, but when combined with follow up studies done on these children years later, the findings are remarkable. The studies revealed that the subjects who showed the most self-control as children became adults who achieved higher SAT scores and higher educational attainment, had lower levels of obesity, better responses to stress, better decision making skills, better marriages, were happier in their careers and had better social skills as reported by their parents.

(7) Interestingly, MRI (magnetic resonance

SCIENCE READING ARTICLE #40: The Truth Behind Bottled Water — Gr. 7-12

Article highlights include:
Students will learn about how bottled water companies have convinced us to buy bottled water and the environmental impact of creating so much plastic water bottle waste. They will discover that PET (polyethylene terephthalate) is the most common type of plastic beverage container and will read about PET's properties, how it is it is recycled (and down-cycled) and how it eventually makes its way into our landfills and oceans.



♦ environmental issues ♦ chemistry

THE TRUTH BEHIND BOTTLED WATER

40

Science Literacy Warm

(1) Even though your tap water is most likely clean and safe to drink, you've probably used a lot of bottled water in your life, or know people who do. Why would anyone pay for bottled water when they have easy access to drinking water in their home? Our modern day concept of bottled water only began when the French company, Perrier, expanded into the North American market in 1976. They began an intensive advertising campaign to convince Americans that bottled water should be a significant beverage choice. Up to that point, almost everyone got their drinking water from wells or their taps and would never think of buying bottled water.

(2) Initially it was hard for bottled water companies to convince the average citizen to pay for water, so these companies began marketing campaigns that made tap water seem unhealthy and bottled water seem like the safer choice. Huge bottled water brands like Dasani (owned by Coca-Cola) and Aquafina (owned by Pepsi) now admit that they use tap water in their bottles, though years of misleading marketing have made most consumers think that bottled water comes from a superior and healthier natural source. For example, the brand Everest Water isn't from Mount Everest, it's from Corpus Christi Texas, and Glacier Clear isn't from a glacier, it's from taps in Greenville Tennessee.

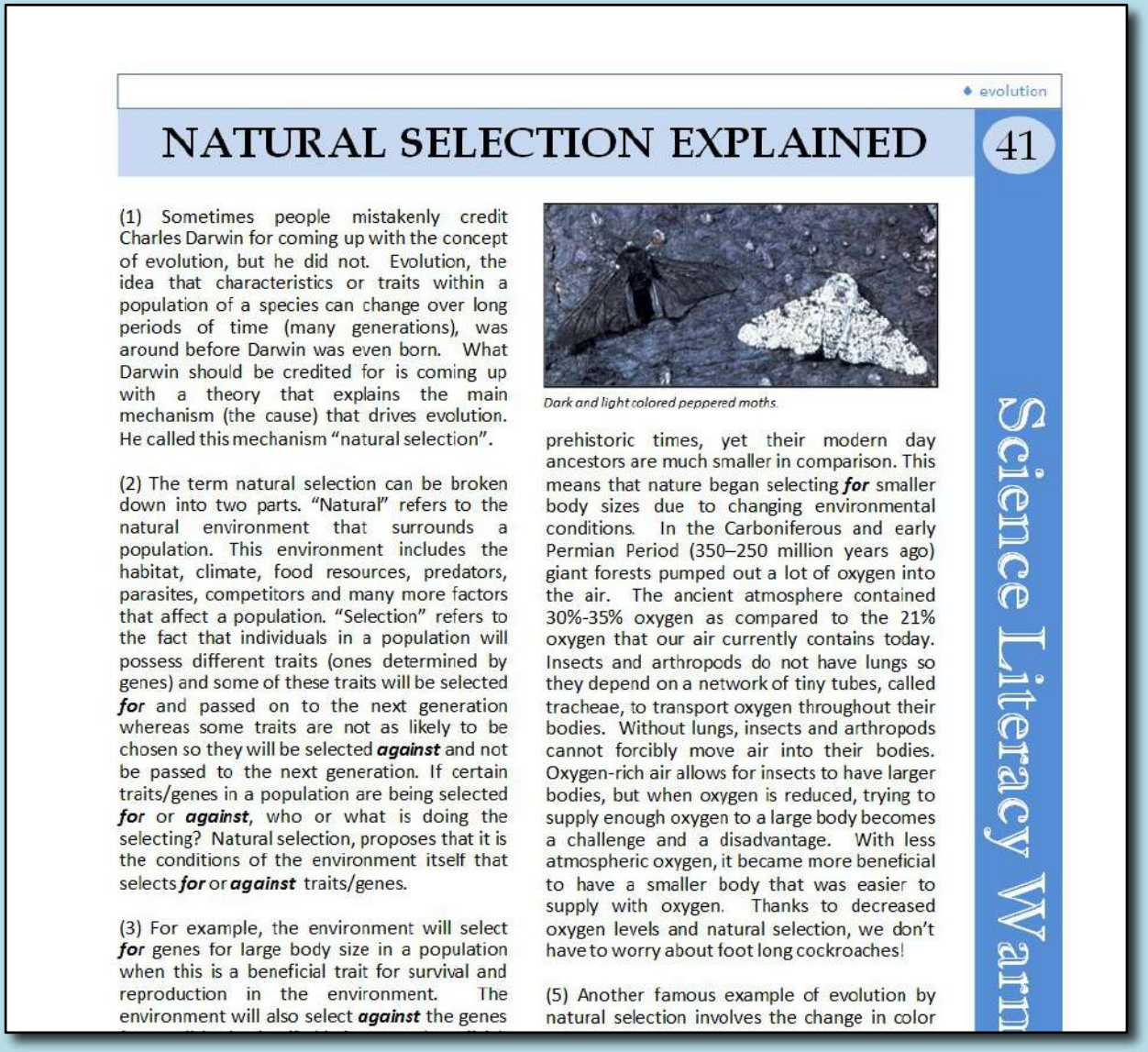
(3) Why have 30% - 40% of bottled water companies decided to use tap water? It's because they recognize that tap water is safe and also very cheap. They can make huge

containers. You will find a number 1 on the bottom of a PET bottle which indicates that the material is PET and can be recycled. PET has been the material of choice for plastic bottles because it seals in liquids, is lightweight, impact resistant and can be made transparent. It's also cheap for manufacturers to make so this helps keep their costs down and keeps their profits high.

(5) PET is a pretty remarkable material, but it has its downsides. PET is made from naphtha, which comes from non-renewable fossil fuels like natural gas and petroleum. Though it's recyclable, only 60%-70% of PET plastic bottles make it into the recycling system, and for those bottles that are recycled, most are actually "down-cycled". This means that used plastic bottles are turned into a lower quality materials that aren't as strong as the original PET. Once PET has been down-cycled into another product, it usually isn't strong enough to be down-cycled again after that product is

SCIENCE READING ARTICLE #41: Natural Selection Explained — Gr. 8-12

Article highlights include:
Students will learn about natural selection using specific examples. One example is the change in color of the peppered moth from its light colored form to its dark colored form. The other example is the dramatic change in the size of the giant insects of the prehistoric era to the much smaller ones we have today. Artificial selection is also discussed in contrast to natural selection.



♦ evolution

NATURAL SELECTION EXPLAINED

41

(1) Sometimes people mistakenly credit Charles Darwin for coming up with the concept of evolution, but he did not. Evolution, the idea that characteristics or traits within a population of a species can change over long periods of time (many generations), was around before Darwin was even born. What Darwin should be credited for is coming up with a theory that explains the main mechanism (the cause) that drives evolution. He called this mechanism "natural selection".

(2) The term natural selection can be broken down into two parts. "Natural" refers to the natural environment that surrounds a population. This environment includes the habitat, climate, food resources, predators, parasites, competitors and many more factors that affect a population. "Selection" refers to the fact that individuals in a population will possess different traits (ones determined by genes) and some of these traits will be selected ***for*** and passed on to the next generation whereas some traits are not as likely to be chosen so they will be selected ***against*** and not be passed to the next generation. If certain traits/genes in a population are being selected ***for*** or ***against***, who or what is doing the selecting? Natural selection, proposes that it is the conditions of the environment itself that selects ***for*** or ***against*** traits/genes.

(3) For example, the environment will select ***for*** genes for large body size in a population when this is a beneficial trait for survival and reproduction in the environment. The environment will also select ***against*** the genes

Dark and light colored peppered moths.

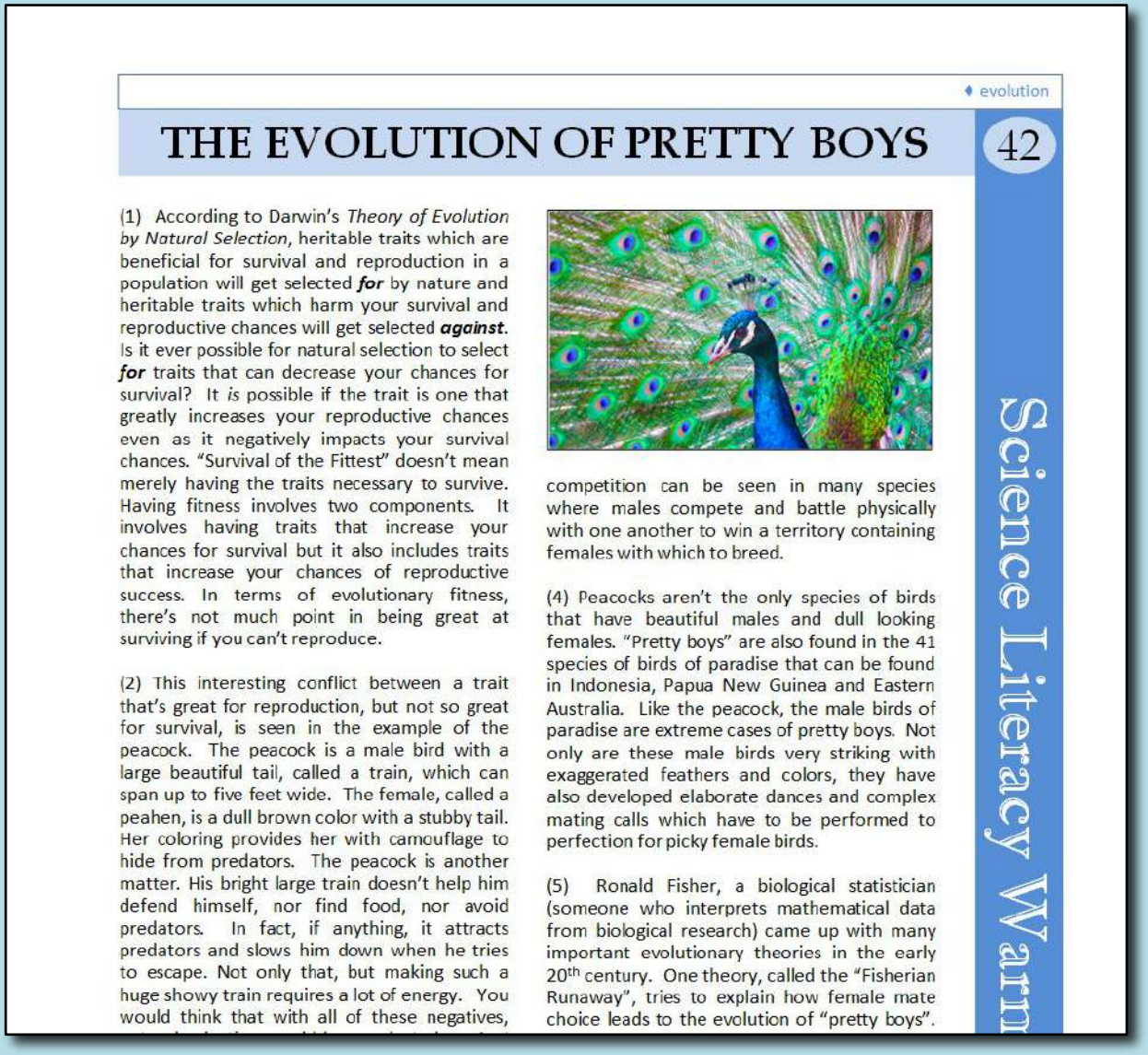
prehistoric times, yet their modern day ancestors are much smaller in comparison. This means that nature began selecting ***for*** smaller body sizes due to changing environmental conditions. In the Carboniferous and early Permian Period (350–250 million years ago) giant forests pumped out a lot of oxygen into the air. The ancient atmosphere contained 30%-35% oxygen as compared to the 21% oxygen that our air currently contains today. Insects and arthropods do not have lungs so they depend on a network of tiny tubes, called tracheae, to transport oxygen throughout their bodies. Without lungs, insects and arthropods cannot forcibly move air into their bodies. Oxygen-rich air allows for insects to have larger bodies, but when oxygen is reduced, trying to supply enough oxygen to a large body becomes a challenge and a disadvantage. With less atmospheric oxygen, it became more beneficial to have a smaller body that was easier to supply with oxygen. Thanks to decreased oxygen levels and natural selection, we don't have to worry about foot long cockroaches!

(5) Another famous example of evolution by natural selection involves the change in color

Science Literacy Warm

SCIENCE READING ARTICLE #42: The Evolution of Pretty Boys — Gr. 8-12

Article highlights include:
Students will learn about sexual selection and how female mate choice has strongly influenced the physical and behavioral traits that have evolved in males. This is especially seen in bird populations like peafowls and birds of paradise where the males exhibit extraordinarily beautiful plumage and intricate and interesting courtship behaviors. Ronald Fishers "Fisherian runaway" hypothesis as well as other interesting evolutionary theories behind sexual selection are examined. Male competition using the example of elephant seal bulls is also discussed.



♦ evolution

THE EVOLUTION OF PRETTY BOYS

42

Science Literacy Warm

(1) According to Darwin's *Theory of Evolution by Natural Selection*, heritable traits which are beneficial for survival and reproduction in a population will get selected ***for*** by nature and heritable traits which harm your survival and reproductive chances will get selected ***against***. Is it ever possible for natural selection to select ***for*** traits that can decrease your chances for survival? It *is* possible if the trait is one that greatly increases your reproductive chances even as it negatively impacts your survival chances. "Survival of the Fittest" doesn't mean merely having the traits necessary to survive. Having fitness involves two components. It involves having traits that increase your chances for survival but it also includes traits that increase your chances of reproductive success. In terms of evolutionary fitness, there's not much point in being great at surviving if you can't reproduce.

(2) This interesting conflict between a trait that's great for reproduction, but not so great for survival, is seen in the example of the peacock. The peacock is a male bird with a large beautiful tail, called a train, which can span up to five feet wide. The female, called a peahen, is a dull brown color with a stubby tail. Her coloring provides her with camouflage to hide from predators. The peacock is another matter. His bright large train doesn't help him defend himself, nor find food, nor avoid predators. In fact, if anything, it attracts predators and slows him down when he tries to escape. Not only that, but making such a huge showy train requires a lot of energy. You would think that with all of these negatives,

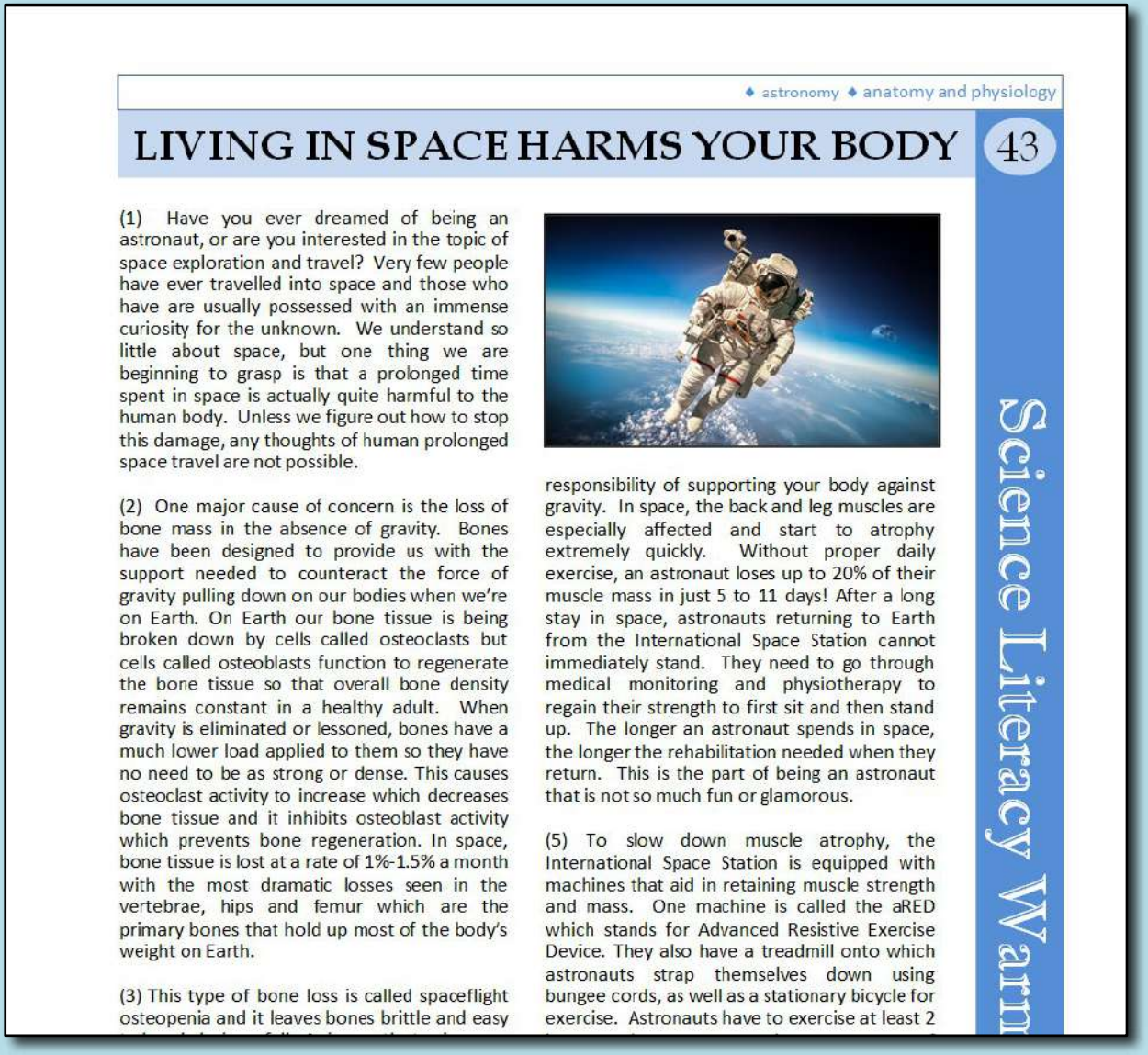
competition can be seen in many species where males compete and battle physically with one another to win a territory containing females with which to breed.

(4) Peacocks aren't the only species of birds that have beautiful males and dull looking females. "Pretty boys" are also found in the 41 species of birds of paradise that can be found in Indonesia, Papua New Guinea and Eastern Australia. Like the peacock, the male birds of paradise are extreme cases of pretty boys. Not only are these male birds very striking with exaggerated feathers and colors, they have also developed elaborate dances and complex mating calls which have to be performed to perfection for picky female birds.

(5) Ronald Fisher, a biological statistician (someone who interprets mathematical data from biological research) came up with many important evolutionary theories in the early 20th century. One theory, called the "Fisherian Runaway", tries to explain how female mate choice leads to the evolution of "pretty boys".

SCIENCE READING ARTICLE #43: Living in Space Harms Your Body — Gr. 7-12

Article highlights include:
Students will learn about the downsides of living in space. Time spent in weightless conditions lead to serious bone loss and almost immediate and severe muscle atrophy. It also leads to cardiac muscle weakening as well as damages the optic nerves. These and the other fascinating negative effects of space living are discussed.



♦ astronomy ♦ anatomy and physiology

LIVING IN SPACE HARMS YOUR BODY

43

Science Literacy Warm

(1) Have you ever dreamed of being an astronaut, or are you interested in the topic of space exploration and travel? Very few people have ever travelled into space and those who have are usually possessed with an immense curiosity for the unknown. We understand so little about space, but one thing we are beginning to grasp is that a prolonged time spent in space is actually quite harmful to the human body. Unless we figure out how to stop this damage, any thoughts of human prolonged space travel are not possible.

(2) One major cause of concern is the loss of bone mass in the absence of gravity. Bones have been designed to provide us with the support needed to counteract the force of gravity pulling down on our bodies when we're on Earth. On Earth our bone tissue is being broken down by cells called osteoclasts but cells called osteoblasts function to regenerate the bone tissue so that overall bone density remains constant in a healthy adult. When gravity is eliminated or lessoned, bones have a much lower load applied to them so they have no need to be as strong or dense. This causes osteoclast activity to increase which decreases bone tissue and it inhibits osteoblast activity which prevents bone regeneration. In space, bone tissue is lost at a rate of 1%-1.5% a month with the most dramatic losses seen in the vertebrae, hips and femur which are the primary bones that hold up most of the body's weight on Earth.

(3) This type of bone loss is called spaceflight osteopenia and it leaves bones brittle and easy

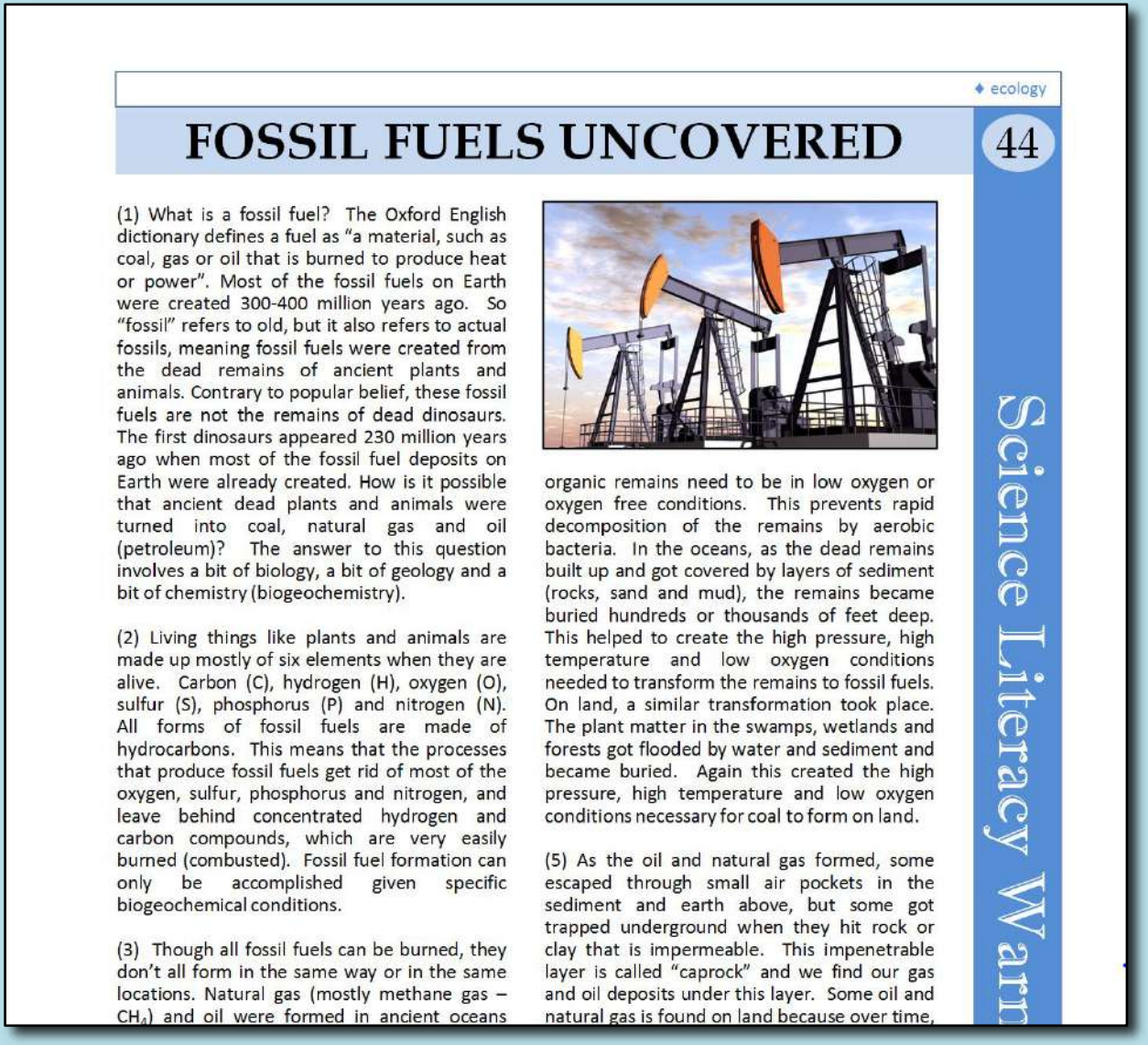
responsibility of supporting your body against gravity. In space, the back and leg muscles are especially affected and start to atrophy extremely quickly. Without proper daily exercise, an astronaut loses up to 20% of their muscle mass in just 5 to 11 days! After a long stay in space, astronauts returning to Earth from the International Space Station cannot immediately stand. They need to go through medical monitoring and physiotherapy to regain their strength to first sit and then stand up. The longer an astronaut spends in space, the longer the rehabilitation needed when they return. This is the part of being an astronaut that is not so much fun or glamorous.

(5) To slow down muscle atrophy, the International Space Station is equipped with machines that aid in retaining muscle strength and mass. One machine is called the aRED which stands for Advanced Resistive Exercise Device. They also have a treadmill onto which astronauts strap themselves down using bungee cords, as well as a stationary bicycle for exercise. Astronauts have to exercise at least 2

SCIENCE READING ARTICLE #44: Fossil Fuels Uncovered

Gr. 7-12

Article highlights include:
Students will learn about fossil fuels, in particular: oil, natural gas and coal. They will learn about the conditions under which fossil fuels are created and what turns some organic remains into oil and natural gas, while other remains form coal. They will also learn about the negative environmental consequences of fossil fuel use (e.g. climate change) and a movement to "Keep it in the ground".



♦ ecology

FOSSIL FUELS UNCOVERED

44

Science Literacy Warm

(1) What is a fossil fuel? The Oxford English dictionary defines a fuel as "a material, such as coal, gas or oil that is burned to produce heat or power". Most of the fossil fuels on Earth were created 300-400 million years ago. So "fossil" refers to old, but it also refers to actual fossils, meaning fossil fuels were created from the dead remains of ancient plants and animals. Contrary to popular belief, these fossil fuels are not the remains of dead dinosaurs. The first dinosaurs appeared 230 million years ago when most of the fossil fuel deposits on Earth were already created. How is it possible that ancient dead plants and animals were turned into coal, natural gas and oil (petroleum)? The answer to this question involves a bit of biology, a bit of geology and a bit of chemistry (biogeochemistry).

(2) Living things like plants and animals are made up mostly of six elements when they are alive. Carbon (C), hydrogen (H), oxygen (O), sulfur (S), phosphorus (P) and nitrogen (N). All forms of fossil fuels are made of hydrocarbons. This means that the processes that produce fossil fuels get rid of most of the oxygen, sulfur, phosphorus and nitrogen, and leave behind concentrated hydrogen and carbon compounds, which are very easily burned (combusted). Fossil fuel formation can only be accomplished given specific biogeochemical conditions.

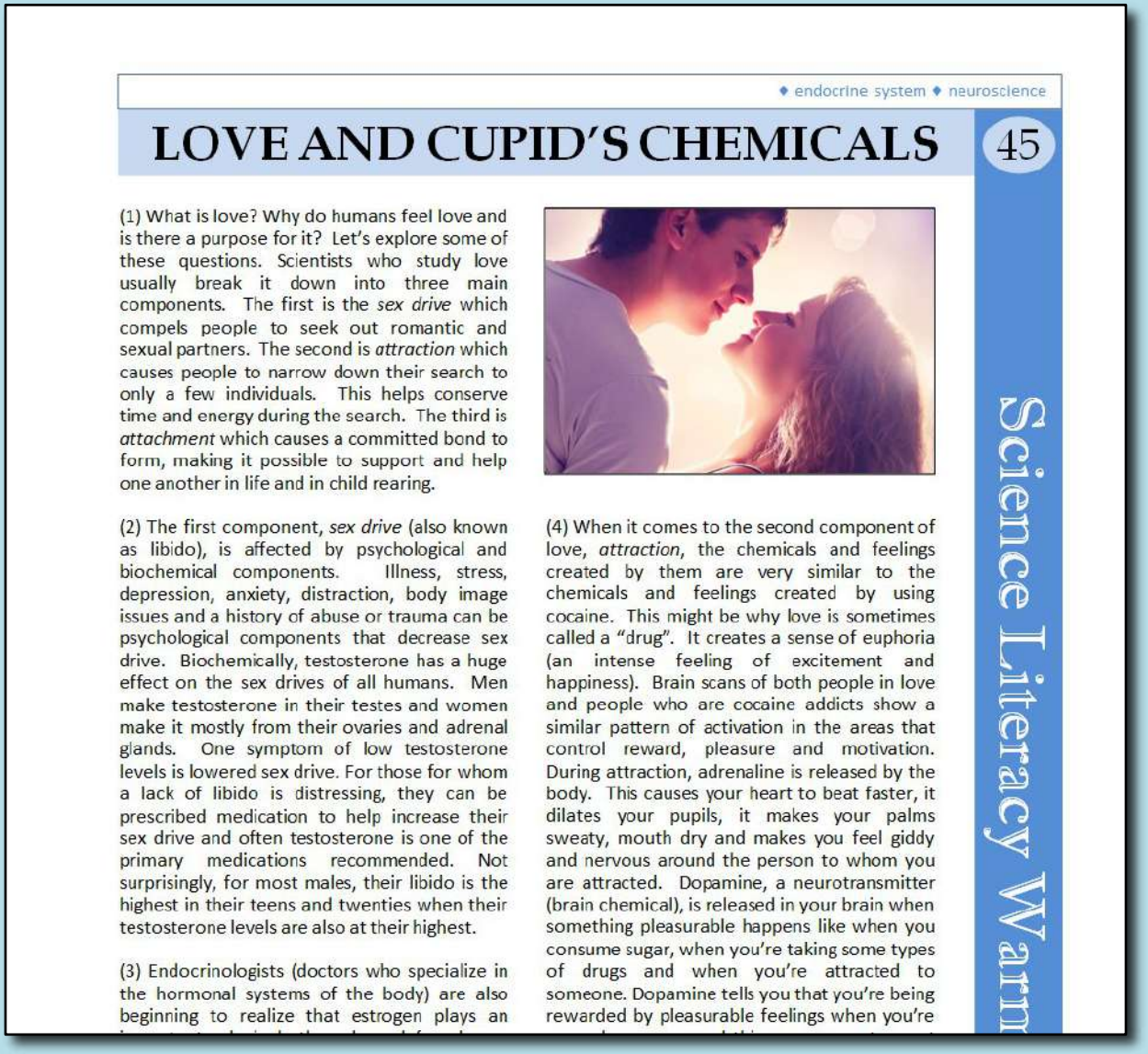
(3) Though all fossil fuels can be burned, they don't all form in the same way or in the same locations. Natural gas (mostly methane gas – CH_4) and oil were formed in ancient oceans

organic remains need to be in low oxygen or oxygen free conditions. This prevents rapid decomposition of the remains by aerobic bacteria. In the oceans, as the dead remains built up and got covered by layers of sediment (rocks, sand and mud), the remains became buried hundreds or thousands of feet deep. This helped to create the high pressure, high temperature and low oxygen conditions needed to transform the remains to fossil fuels. On land, a similar transformation took place. The plant matter in the swamps, wetlands and forests got flooded by water and sediment and became buried. Again this created the high pressure, high temperature and low oxygen conditions necessary for coal to form on land.

(5) As the oil and natural gas formed, some escaped through small air pockets in the sediment and earth above, but some got trapped underground when they hit rock or clay that is impermeable. This impenetrable layer is called "caprock" and we find our gas and oil deposits under this layer. Some oil and natural gas is found on land because over time,

SCIENCE READING ARTICLE #45: Love and Cupid's Chemicals — Gr. 7-12

Article highlights include:
Students will learn about the three scientifically recognized components of love: sex drive (libido), attraction and attachment. They will learn about what characterizes each stage and the major hormones involved in each stage. Some interesting studies are also discussed which examine how lowering certain hormones affect libido and attachment. This is a great article to use around Valentine's Day if you don't need to use it for a sub plan.



♦ endocrine system ♦ neuroscience

LOVE AND CUPID'S CHEMICALS

45

Science Literacy Warm

(1) What is love? Why do humans feel love and is there a purpose for it? Let's explore some of these questions. Scientists who study love usually break it down into three main components. The first is the *sex drive* which compels people to seek out romantic and sexual partners. The second is *attraction* which causes people to narrow down their search to only a few individuals. This helps conserve time and energy during the search. The third is *attachment* which causes a committed bond to form, making it possible to support and help one another in life and in child rearing.

(2) The first component, *sex drive* (also known as libido), is affected by psychological and biochemical components. Illness, stress, depression, anxiety, distraction, body image issues and a history of abuse or trauma can be psychological components that decrease sex drive. Biochemically, testosterone has a huge effect on the sex drives of all humans. Men make testosterone in their testes and women make it mostly from their ovaries and adrenal glands. One symptom of low testosterone levels is lowered sex drive. For those for whom a lack of libido is distressing, they can be prescribed medication to help increase their sex drive and often testosterone is one of the primary medications recommended. Not surprisingly, for most males, their libido is the highest in their teens and twenties when their testosterone levels are also at their highest.

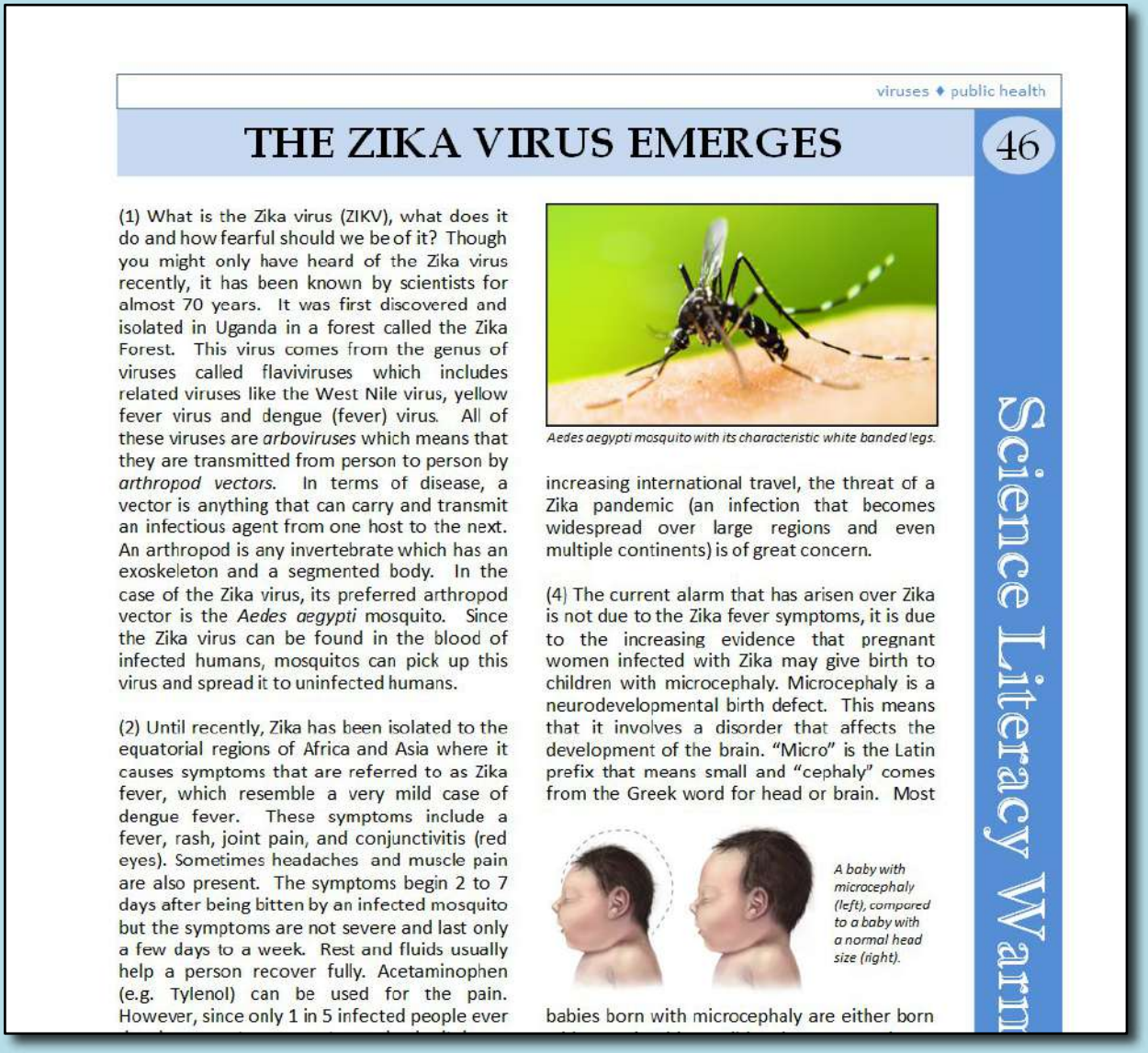
(3) Endocrinologists (doctors who specialize in the hormonal systems of the body) are also beginning to realize that estrogen plays an

(4) When it comes to the second component of love, *attraction*, the chemicals and feelings created by them are very similar to the chemicals and feelings created by using cocaine. This might be why love is sometimes called a "drug". It creates a sense of euphoria (an intense feeling of excitement and happiness). Brain scans of both people in love and people who are cocaine addicts show a similar pattern of activation in the areas that control reward, pleasure and motivation. During attraction, adrenaline is released by the body. This causes your heart to beat faster, it dilates your pupils, it makes your palms sweaty, mouth dry and makes you feel giddy and nervous around the person to whom you are attracted. Dopamine, a neurotransmitter (brain chemical), is released in your brain when something pleasurable happens like when you consume sugar, when you're taking some types of drugs and when you're attracted to someone. Dopamine tells you that you're being rewarded by pleasurable feelings when you're

SCIENCE READING ARTICLE #46: The Zika Virus Emerges

Gr. 7-12

Article highlights include:
Students will learn about the Zika virus, where it first came from, where it's spreading to, how it is transmitted, and the symptoms it produces. Also discussed is the link between Zika and microcephaly (babies born with small heads) which is the major concern with the Zika outbreak, and the potential for Zika to turn into a pandemic.



THE ZIKA VIRUS EMERGES

(1) What is the Zika virus (ZIKV), what does it do and how fearful should we be of it? Though you might only have heard of the Zika virus recently, it has been known by scientists for almost 70 years. It was first discovered and isolated in Uganda in a forest called the Zika Forest. This virus comes from the genus of viruses called flaviviruses which includes related viruses like the West Nile virus, yellow fever virus and dengue (fever) virus. All of these viruses are *arboviruses* which means that they are transmitted from person to person by *arthropod vectors*. In terms of disease, a vector is anything that can carry and transmit an infectious agent from one host to the next. An arthropod is any invertebrate which has an exoskeleton and a segmented body. In the case of the Zika virus, its preferred arthropod vector is the *Aedes aegypti* mosquito. Since the Zika virus can be found in the blood of infected humans, mosquitos can pick up this virus and spread it to uninfected humans.

(2) Until recently, Zika has been isolated to the equatorial regions of Africa and Asia where it causes symptoms that are referred to as Zika fever, which resemble a very mild case of dengue fever. These symptoms include a fever, rash, joint pain, and conjunctivitis (red eyes). Sometimes headaches and muscle pain are also present. The symptoms begin 2 to 7 days after being bitten by an infected mosquito but the symptoms are not severe and last only a few days to a week. Rest and fluids usually help a person recover fully. Acetaminophen (e.g. Tylenol) can be used for the pain. However, since only 1 in 5 infected people ever

Aedes aegypti mosquito with its characteristic white banded legs.

increasing international travel, the threat of a Zika pandemic (an infection that becomes widespread over large regions and even multiple continents) is of great concern.

(4) The current alarm that has arisen over Zika is not due to the Zika fever symptoms, it is due to the increasing evidence that pregnant women infected with Zika may give birth to children with microcephaly. Microcephaly is a neurodevelopmental birth defect. This means that it involves a disorder that affects the development of the brain. "Micro" is the Latin prefix that means small and "cephaly" comes from the Greek word for head or brain. Most

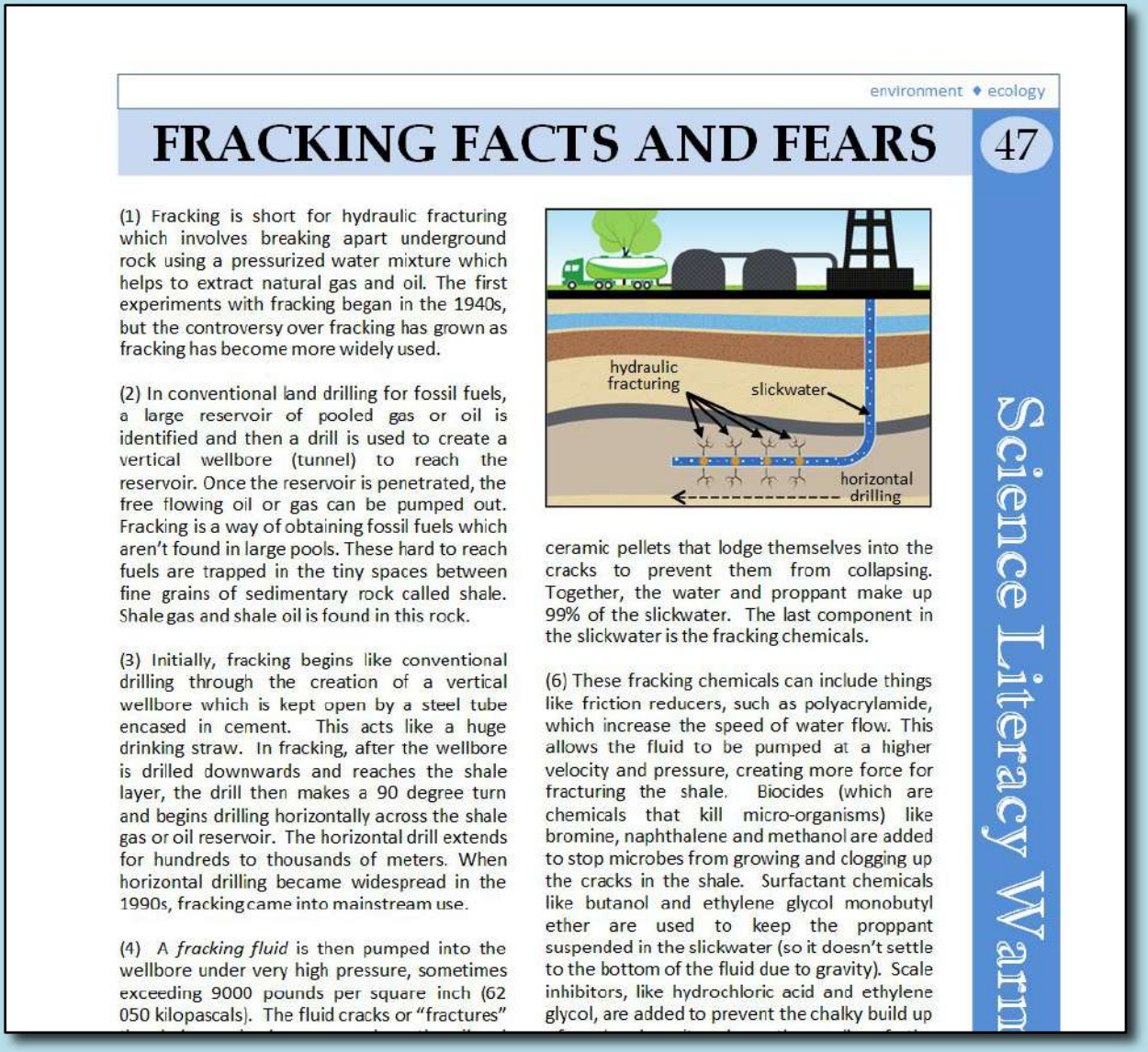
A baby with microcephaly (left), compared to a baby with a normal head size (right).

babies born with microcephaly are either born

SCIENCE READING ARTICLE #47: Fracking Facts and Fears

Gr. 7-12

Article highlights include:
Students will learn about extracting shale oil and gas through the process of fracking. Conventional drilling versus fracking is compared. Horizontal drilling and the chemicals used in the fracking process are explained. The various concerns and risks surrounding fracking are discussed as well as the stance different countries have taken on the fracking issue.



environment ♦ ecology

FRACKING FACTS AND FEARS

47

Science Literacy Warm

(1) Fracking is short for hydraulic fracturing which involves breaking apart underground rock using a pressurized water mixture which helps to extract natural gas and oil. The first experiments with fracking began in the 1940s, but the controversy over fracking has grown as fracking has become more widely used.

(2) In conventional land drilling for fossil fuels, a large reservoir of pooled gas or oil is identified and then a drill is used to create a vertical wellbore (tunnel) to reach the reservoir. Once the reservoir is penetrated, the free flowing oil or gas can be pumped out. Fracking is a way of obtaining fossil fuels which aren't found in large pools. These hard to reach fuels are trapped in the tiny spaces between fine grains of sedimentary rock called shale. Shale gas and shale oil is found in this rock.

(3) Initially, fracking begins like conventional drilling through the creation of a vertical wellbore which is kept open by a steel tube encased in cement. This acts like a huge drinking straw. In fracking, after the wellbore is drilled downwards and reaches the shale layer, the drill then makes a 90 degree turn and begins drilling horizontally across the shale gas or oil reservoir. The horizontal drill extends for hundreds to thousands of meters. When horizontal drilling became widespread in the 1990s, fracking came into mainstream use.

(4) A *fracking fluid* is then pumped into the wellbore under very high pressure, sometimes exceeding 9000 pounds per square inch (62 050 kilopascals). The fluid cracks or "fractures"

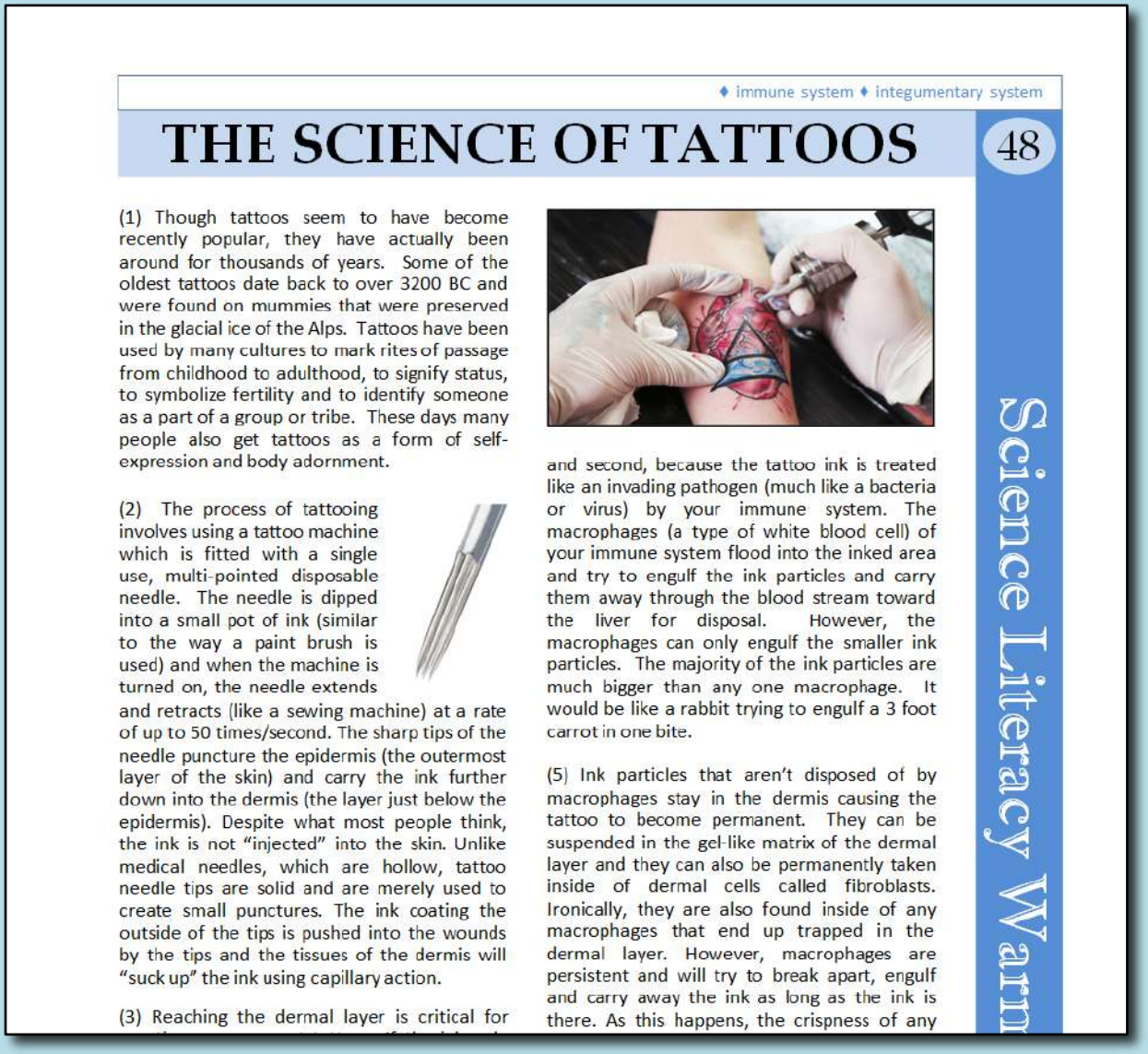
ceramic pellets that lodge themselves into the cracks to prevent them from collapsing. Together, the water and proppant make up 99% of the slickwater. The last component in the slickwater is the fracking chemicals.

(6) These fracking chemicals can include things like friction reducers, such as polyacrylamide, which increase the speed of water flow. This allows the fluid to be pumped at a higher velocity and pressure, creating more force for fracturing the shale. Biocides (which are chemicals that kill micro-organisms) like bromine, naphthalene and methanol are added to stop microbes from growing and clogging up the cracks in the shale. Surfactant chemicals like butanol and ethylene glycol monobutyl ether are used to keep the proppant suspended in the slickwater (so it doesn't settle to the bottom of the fluid due to gravity). Scale inhibitors, like hydrochloric acid and ethylene glycol, are added to prevent the chalky build up

SCIENCE READING ARTICLE #48: The Science of Tattoos

Gr. 7-12

Article highlights include:
Students will learn about the science of tattoos. They will learn how tattoos are applied, what makes them permanent, and how the immune system causes tattoos to fade. They will also read about how the immune system aids the laser tattoo removal procedure to help get rid of tattoo ink. The safety of tattoo inks is also discussed along with how they can be affected by MRIs.



♦ immune system ♦ integumentary system

THE SCIENCE OF TATTOOS

48

Science Literacy Warm

(1) Though tattoos seem to have become recently popular, they have actually been around for thousands of years. Some of the oldest tattoos date back to over 3200 BC and were found on mummies that were preserved in the glacial ice of the Alps. Tattoos have been used by many cultures to mark rites of passage from childhood to adulthood, to signify status, to symbolize fertility and to identify someone as a part of a group or tribe. These days many people also get tattoos as a form of self-expression and body adornment.

(2) The process of tattooing involves using a tattoo machine which is fitted with a single use, multi-pointed disposable needle. The needle is dipped into a small pot of ink (similar to the way a paint brush is used) and when the machine is turned on, the needle extends and retracts (like a sewing machine) at a rate of up to 50 times/second. The sharp tips of the needle puncture the epidermis (the outermost layer of the skin) and carry the ink further down into the dermis (the layer just below the epidermis). Despite what most people think, the ink is not "injected" into the skin. Unlike medical needles, which are hollow, tattoo needle tips are solid and are merely used to create small punctures. The ink coating the outside of the tips is pushed into the wounds by the tips and the tissues of the dermis will "suck up" the ink using capillary action.

(3) Reaching the dermal layer is critical for

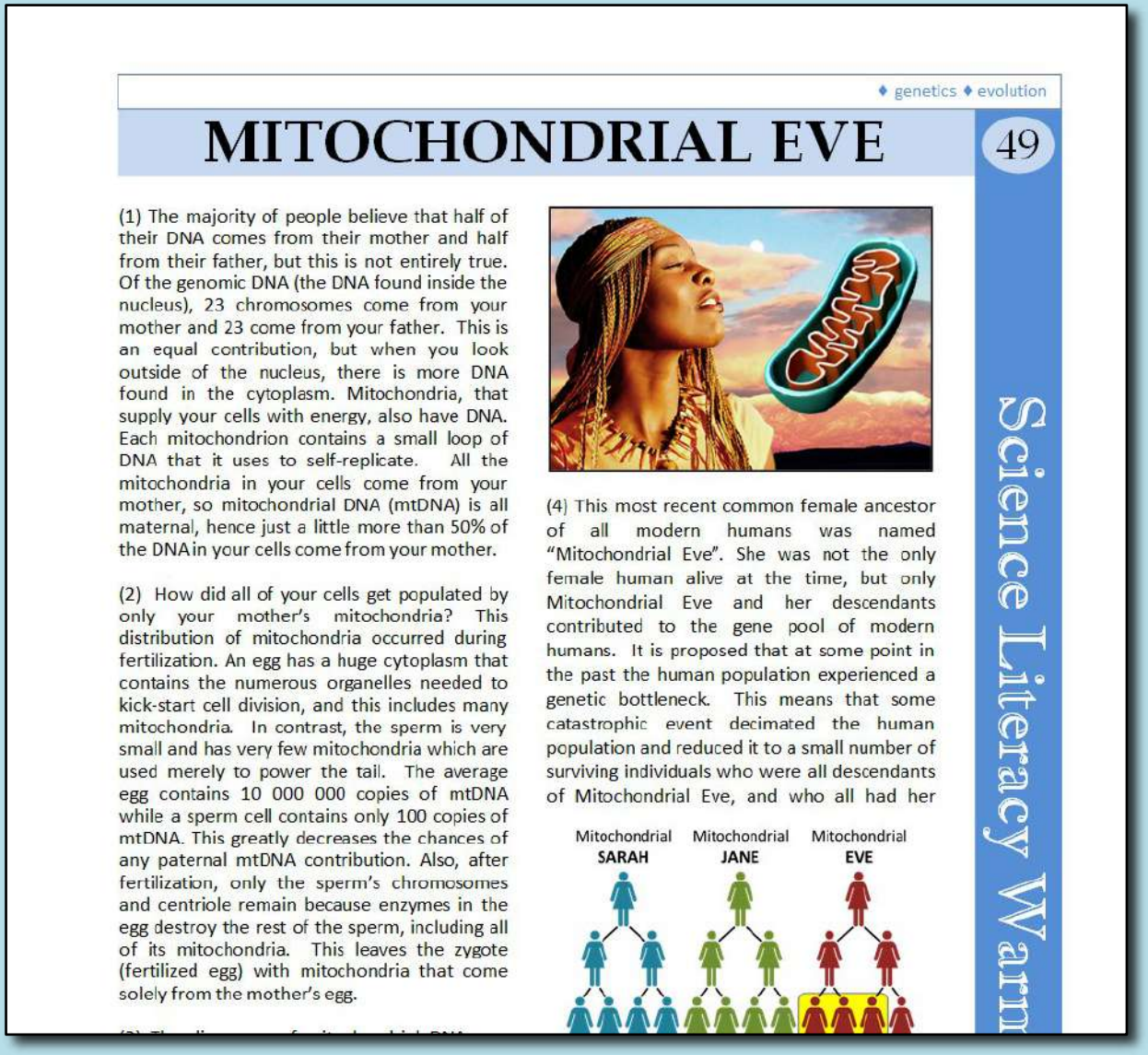
and second, because the tattoo ink is treated like an invading pathogen (much like a bacteria or virus) by your immune system. The macrophages (a type of white blood cell) of your immune system flood into the inked area and try to engulf the ink particles and carry them away through the blood stream toward the liver for disposal. However, the macrophages can only engulf the smaller ink particles. The majority of the ink particles are much bigger than any one macrophage. It would be like a rabbit trying to engulf a 3 foot carrot in one bite.

(5) Ink particles that aren't disposed of by macrophages stay in the dermis causing the tattoo to become permanent. They can be suspended in the gel-like matrix of the dermal layer and they can also be permanently taken inside of dermal cells called fibroblasts. Ironically, they are also found inside of any macrophages that end up trapped in the dermal layer. However, macrophages are persistent and will try to break apart, engulf and carry away the ink as long as the ink is there. As this happens, the crispness of any

SCIENCE READING ARTICLE #49: Mitochondrial Eve

Gr. 9-12

Article highlights include:
Students will learn about mitochondrial DNA and Mitochondrial Eve. Mitochondrial Eve is the most recent common ancestor of all modern anatomical humans. Students will read about how mitochondrial DNA has helped geneticists discover Mitochondrial Eve, about the research behind her discovery and about the implications of this research on the evolutionary origins of humans. Also discussed is how this data supports the Out of Africa theory of human migration and expansion.



♦ genetics ♦ evolution

MITOCHONDRIAL EVE

49

(1) The majority of people believe that half of their DNA comes from their mother and half from their father, but this is not entirely true. Of the genomic DNA (the DNA found inside the nucleus), 23 chromosomes come from your mother and 23 come from your father. This is an equal contribution, but when you look outside of the nucleus, there is more DNA found in the cytoplasm. Mitochondria, that supply your cells with energy, also have DNA. Each mitochondrion contains a small loop of DNA that it uses to self-replicate. All the mitochondria in your cells come from your mother, so mitochondrial DNA (mtDNA) is all maternal, hence just a little more than 50% of the DNA in your cells come from your mother.

(2) How did all of your cells get populated by only your mother's mitochondria? This distribution of mitochondria occurred during fertilization. An egg has a huge cytoplasm that contains the numerous organelles needed to kick-start cell division, and this includes many mitochondria. In contrast, the sperm is very small and has very few mitochondria which are used merely to power the tail. The average egg contains 10 000 000 copies of mtDNA while a sperm cell contains only 100 copies of mtDNA. This greatly decreases the chances of any paternal mtDNA contribution. Also, after fertilization, only the sperm's chromosomes and centriole remain because enzymes in the egg destroy the rest of the sperm, including all of its mitochondria. This leaves the zygote (fertilized egg) with mitochondria that come solely from the mother's egg.

(4) This most recent common female ancestor of all modern humans was named "Mitochondrial Eve". She was not the only female human alive at the time, but only Mitochondrial Eve and her descendants contributed to the gene pool of modern humans. It is proposed that at some point in the past the human population experienced a genetic bottleneck. This means that some catastrophic event decimated the human population and reduced it to a small number of surviving individuals who were all descendants of Mitochondrial Eve, and who all had her

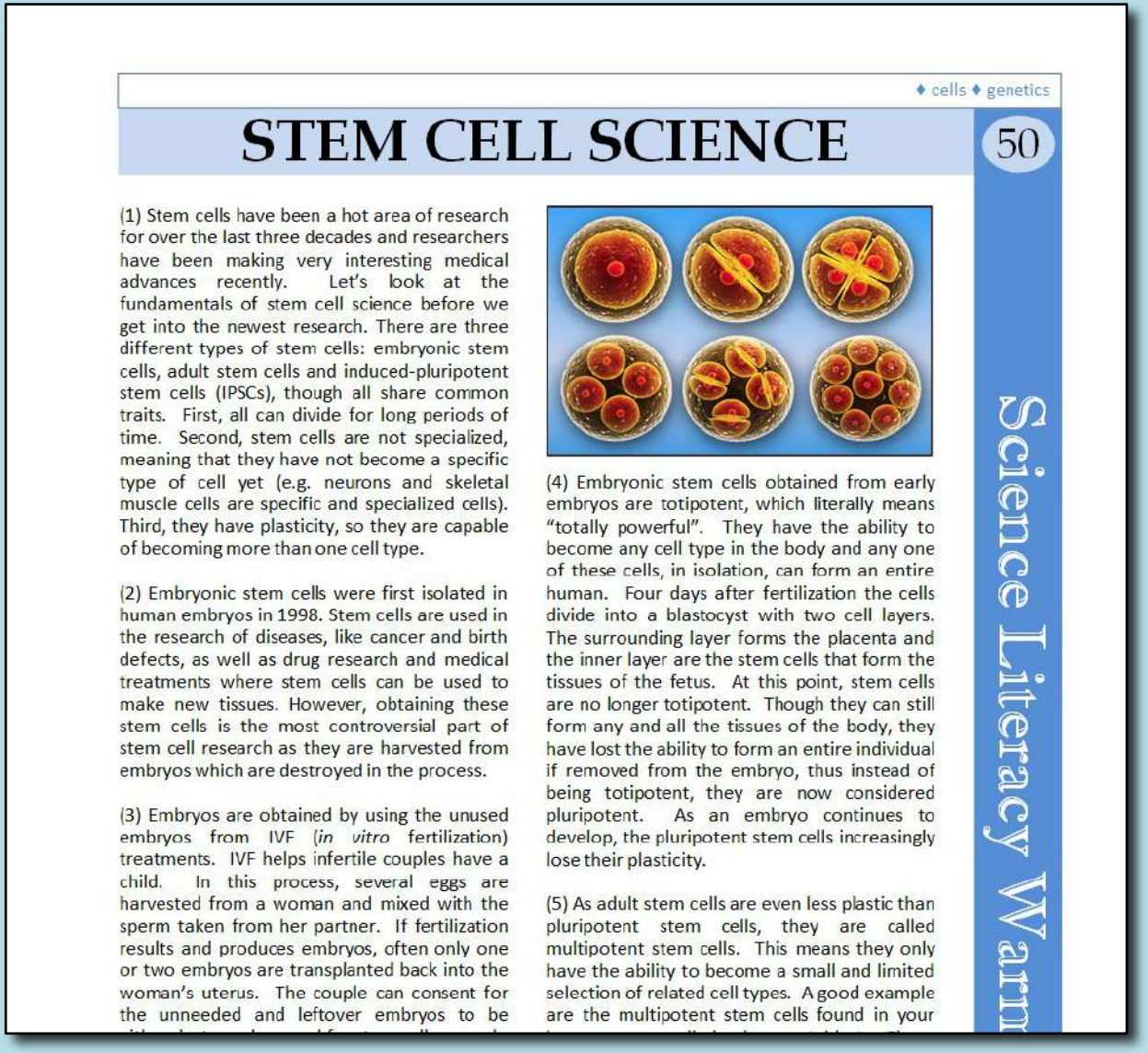
Mitochondrial SARAH | Mitochondrial JANE | Mitochondrial EVE

Science Literacy Warm

SCIENCE READING ARTICLE #50: Stem Cell Science

Gr. 7-12

Article highlights include:
Students will learn about stem cells and stem cell research. They will read about the difference between embryonic stem cells and adult stem cells as well as understand the controversy over stem cell research. They will examine the difference between totipotent, pluripotent and multipotent stem cells. Lastly, they will read about the exciting advances in stem cell research opened up by the advent of IPSCs (induced pluripotent stem cells) which helps bypass many of the ethical issues in stem cell research.



♦ cells ♦ genetics

STEM CELL SCIENCE

50

Science Literacy Warm

(1) Stem cells have been a hot area of research for over the last three decades and researchers have been making very interesting medical advances recently. Let's look at the fundamentals of stem cell science before we get into the newest research. There are three different types of stem cells: embryonic stem cells, adult stem cells and induced-pluripotent stem cells (IPSCs), though all share common traits. First, all can divide for long periods of time. Second, stem cells are not specialized, meaning that they have not become a specific type of cell yet (e.g. neurons and skeletal muscle cells are specific and specialized cells). Third, they have plasticity, so they are capable of becoming more than one cell type.

(2) Embryonic stem cells were first isolated in human embryos in 1998. Stem cells are used in the research of diseases, like cancer and birth defects, as well as drug research and medical treatments where stem cells can be used to make new tissues. However, obtaining these stem cells is the most controversial part of stem cell research as they are harvested from embryos which are destroyed in the process.

(3) Embryos are obtained by using the unused embryos from IVF (*in vitro* fertilization) treatments. IVF helps infertile couples have a child. In this process, several eggs are harvested from a woman and mixed with the sperm taken from her partner. If fertilization results and produces embryos, often only one or two embryos are transplanted back into the woman's uterus. The couple can consent for the unneeded and leftover embryos to be

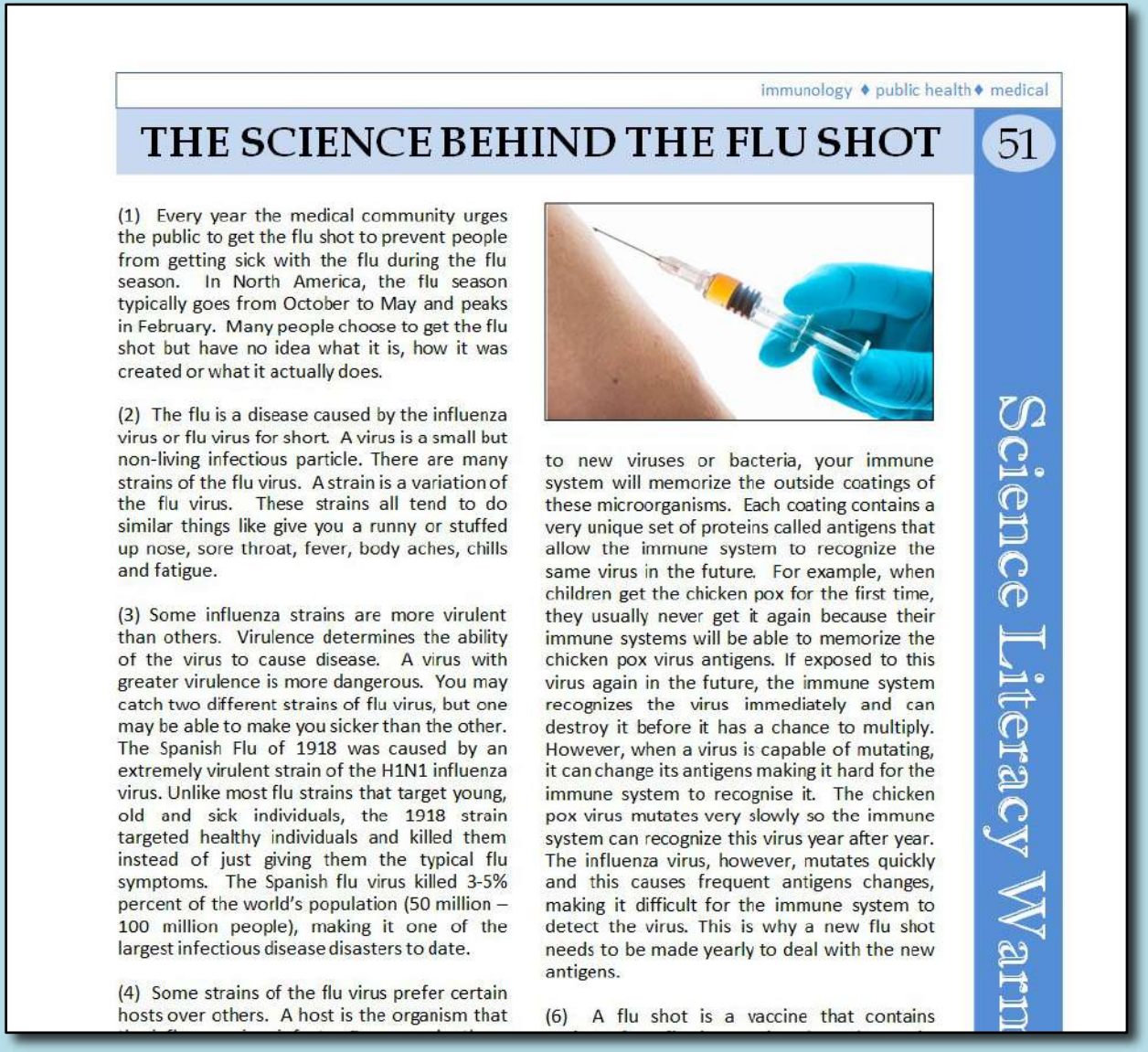
(4) Embryonic stem cells obtained from early embryos are totipotent, which literally means "totally powerful". They have the ability to become any cell type in the body and any one of these cells, in isolation, can form an entire human. Four days after fertilization the cells divide into a blastocyst with two cell layers. The surrounding layer forms the placenta and the inner layer are the stem cells that form the tissues of the fetus. At this point, stem cells are no longer totipotent. Though they can still form any and all the tissues of the body, they have lost the ability to form an entire individual if removed from the embryo, thus instead of being totipotent, they are now considered pluripotent. As an embryo continues to develop, the pluripotent stem cells increasingly lose their plasticity.

(5) As adult stem cells are even less plastic than pluripotent stem cells, they are called multipotent stem cells. This means they only have the ability to become a small and limited selection of related cell types. A good example are the multipotent stem cells found in your

SCIENCE READING ARTICLE #51: The Science of the Flu Shot

Gr. 7-12

Article highlights include:
Students will learn about viruses, the types of viruses that cause the flu, how the immune system detects and remembers viruses, how vaccines like the flu shot work and how the flu shot vaccine is manufactured.



immunology ♦ public health ♦ medical

THE SCIENCE BEHIND THE FLU SHOT

51

Science Literacy Warm

(1) Every year the medical community urges the public to get the flu shot to prevent people from getting sick with the flu during the flu season. In North America, the flu season typically goes from October to May and peaks in February. Many people choose to get the flu shot but have no idea what it is, how it was created or what it actually does.

(2) The flu is a disease caused by the influenza virus or flu virus for short. A virus is a small but non-living infectious particle. There are many strains of the flu virus. A strain is a variation of the flu virus. These strains all tend to do similar things like give you a runny or stuffed up nose, sore throat, fever, body aches, chills and fatigue.

(3) Some influenza strains are more virulent than others. Virulence determines the ability of the virus to cause disease. A virus with greater virulence is more dangerous. You may catch two different strains of flu virus, but one may be able to make you sicker than the other. The Spanish Flu of 1918 was caused by an extremely virulent strain of the H1N1 influenza virus. Unlike most flu strains that target young, old and sick individuals, the 1918 strain targeted healthy individuals and killed them instead of just giving them the typical flu symptoms. The Spanish flu virus killed 3-5% percent of the world's population (50 million – 100 million people), making it one of the largest infectious disease disasters to date.

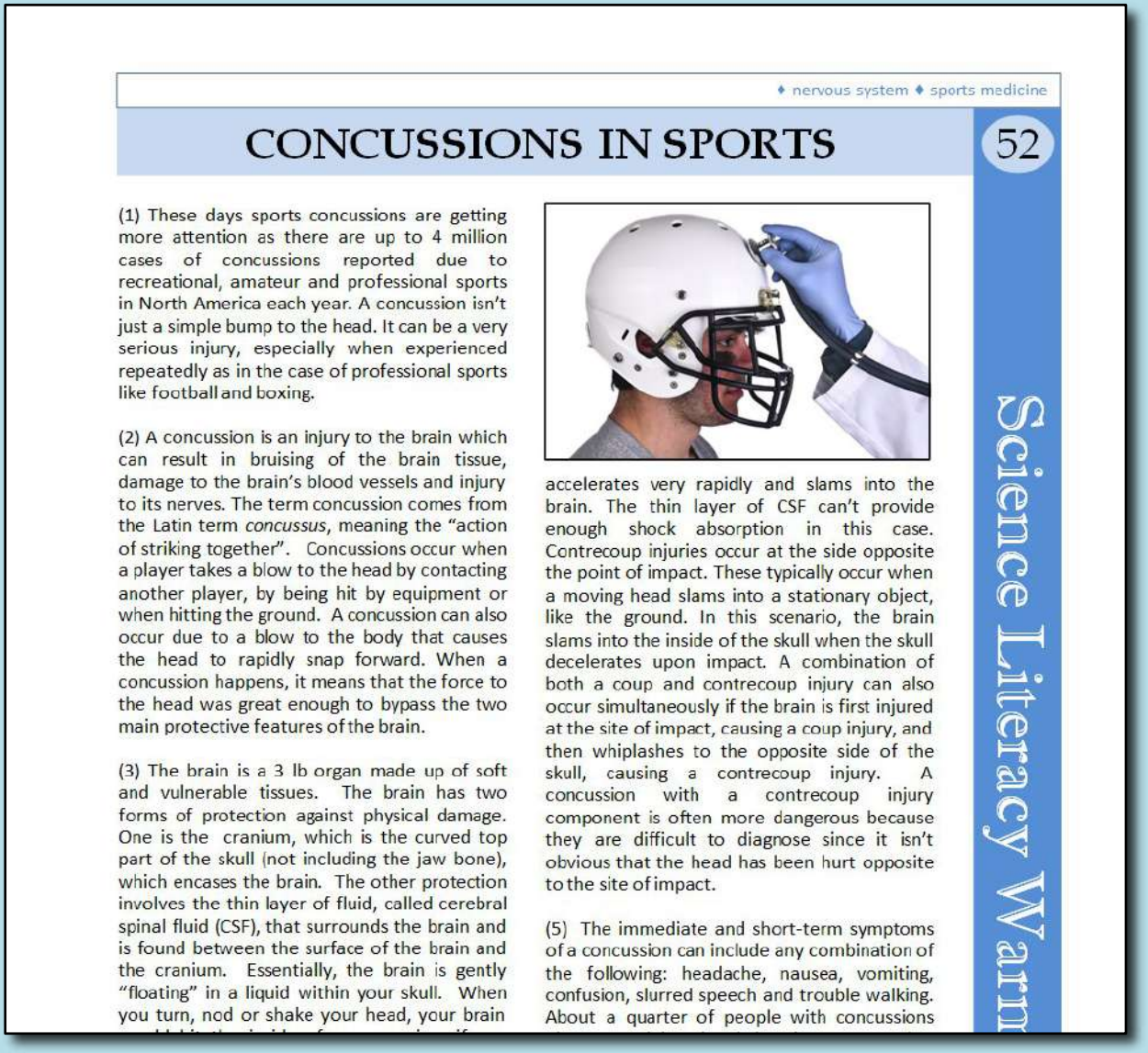
(4) Some strains of the flu virus prefer certain hosts over others. A host is the organism that

to new viruses or bacteria, your immune system will memorize the outside coatings of these microorganisms. Each coating contains a very unique set of proteins called antigens that allow the immune system to recognize the same virus in the future. For example, when children get the chicken pox for the first time, they usually never get it again because their immune systems will be able to memorize the chicken pox virus antigens. If exposed to this virus again in the future, the immune system recognizes the virus immediately and can destroy it before it has a chance to multiply. However, when a virus is capable of mutating, it can change its antigens making it hard for the immune system to recognise it. The chicken pox virus mutates very slowly so the immune system can recognize this virus year after year. The influenza virus, however, mutates quickly and this causes frequent antigens changes, making it difficult for the immune system to detect the virus. This is why a new flu shot needs to be made yearly to deal with the new antigens.

(6) A flu shot is a vaccine that contains

SCIENCE READING ARTICLE #52: Concussions in Sports — Gr. 7-12

Article highlights include:
Students will learn how sports plays a role in concussions, the short-term and long-term symptoms of concussions, the difference between coup and contrecoup injuries in concussions and how repeated concussions can lead to various more serious disorders like CTE (chronic traumatic encephalopathy) as has been experienced by many professional football players and boxers.



♦ nervous system ♦ sports medicine

CONCUSSIONS IN SPORTS

52

Science Literacy Warm

(1) These days sports concussions are getting more attention as there are up to 4 million cases of concussions reported due to recreational, amateur and professional sports in North America each year. A concussion isn't just a simple bump to the head. It can be a very serious injury, especially when experienced repeatedly as in the case of professional sports like football and boxing.

(2) A concussion is an injury to the brain which can result in bruising of the brain tissue, damage to the brain's blood vessels and injury to its nerves. The term concussion comes from the Latin term *concussus*, meaning the "action of striking together". Concussions occur when a player takes a blow to the head by contacting another player, by being hit by equipment or when hitting the ground. A concussion can also occur due to a blow to the body that causes the head to rapidly snap forward. When a concussion happens, it means that the force to the head was great enough to bypass the two main protective features of the brain.

(3) The brain is a 3 lb organ made up of soft and vulnerable tissues. The brain has two forms of protection against physical damage. One is the cranium, which is the curved top part of the skull (not including the jaw bone), which encases the brain. The other protection involves the thin layer of fluid, called cerebral spinal fluid (CSF), that surrounds the brain and is found between the surface of the brain and the cranium. Essentially, the brain is gently "floating" in a liquid within your skull. When you turn, nod or shake your head, your brain

accelerates very rapidly and slams into the brain. The thin layer of CSF can't provide enough shock absorption in this case. Contrecoup injuries occur at the side opposite the point of impact. These typically occur when a moving head slams into a stationary object, like the ground. In this scenario, the brain slams into the inside of the skull when the skull decelerates upon impact. A combination of both a coup and contrecoup injury can also occur simultaneously if the brain is first injured at the site of impact, causing a coup injury, and then whiplashes to the opposite side of the skull, causing a contrecoup injury. A concussion with a contrecoup injury component is often more dangerous because they are difficult to diagnose since it isn't obvious that the head has been hurt opposite to the site of impact.

(5) The immediate and short-term symptoms of a concussion can include any combination of the following: headache, nausea, vomiting, confusion, slurred speech and trouble walking. About a quarter of people with concussions