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Energy and Physical Science

7 Articles

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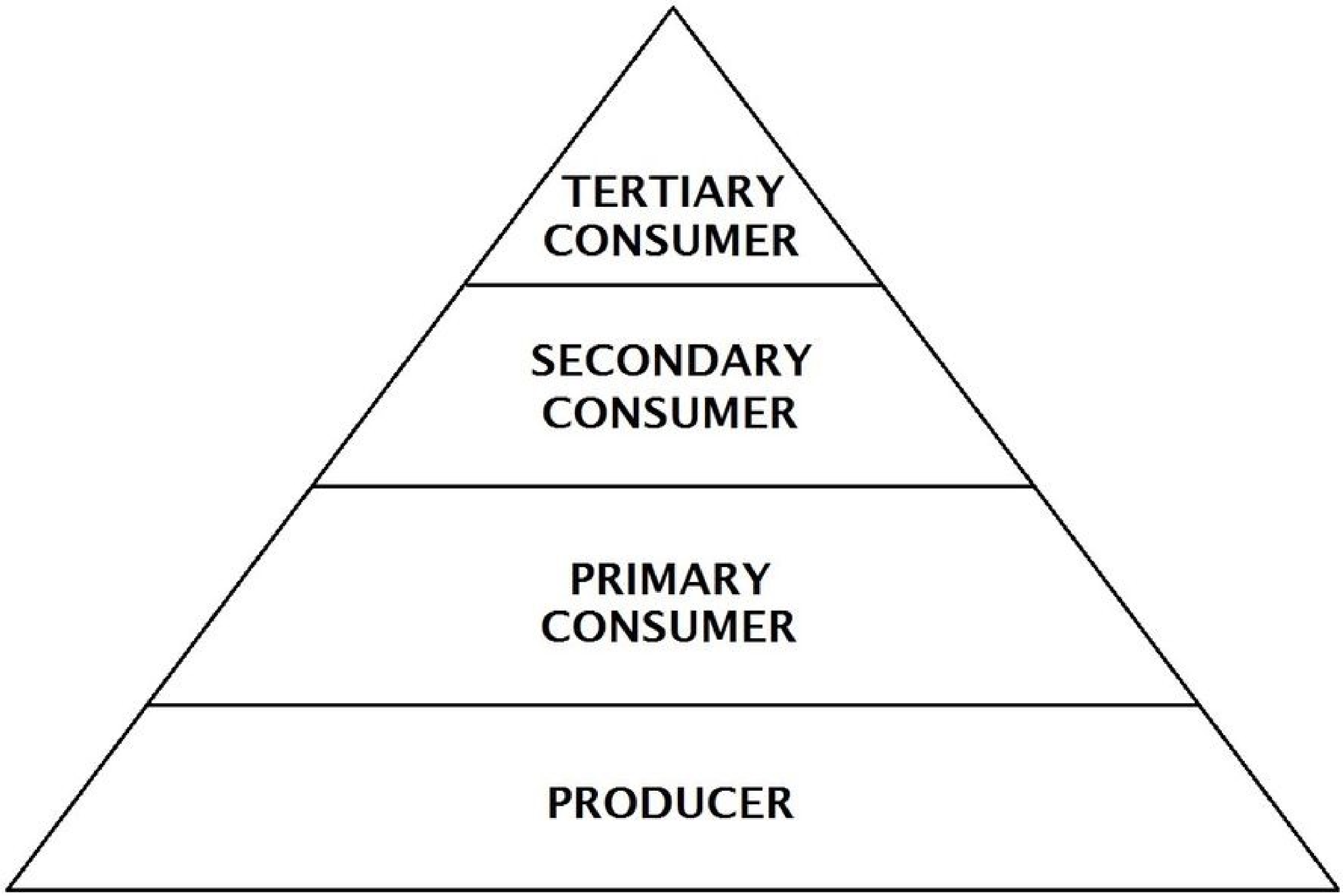
The Eco Pyramid

by Michael Stahl



An ecosystem is a community of living organisms interacting with one another as well as with nonliving things. One very important aspect of an ecosystem is the energy that flows through it. Energy is exchanged between members of an ecosystem, creating an energy flow and assisting in the continuation of life. However, not all of the organisms living in an ecosystem absorb equal amounts of energy. An eco pyramid effectively illustrates the amounts of energy that are absorbed by the different types of organisms in an ecosystem.

The power of the earth's sun gets the energy flow of most ecosystems going. Solar rays enter the earth's atmosphere and reach the surface where plants utilize the energy from them. Through a process called photosynthesis, plants like trees, grass, and bushes, create food for themselves. Plants are able to take in carbon dioxide from the atmosphere, and their roots absorb water from the surrounding soil. Plants then use the solar energy and the hydrogen from water to transform the carbon dioxide into a nourishing carbohydrate. With photosynthesis complete and food and energy absorbed, the plants release the oxygen part of the water that they had taken from the soil back out into the atmosphere. Other living things, like human beings, take in oxygen in the breathing process. The plants of an ecosystem are called "autotrophs," which means "self-feeders." They are also called "producers" in an ecosystem.

The carbohydrates that were produced by the photosynthesis process give the plant energy to continue on living. Herbivores are animals that eat mostly, if not strictly, plant life. Termites, koalas, field mice, and deer are a few examples of herbivores. Deer feed on leaves and grass, consuming the green plant life's energy. To consume means to eat something and absorb its nutrients for survival. After eating the plants of their choice, deer will then digest the plants and use whatever nutrients the plant had stored inside to create energy so that they can continue to live. The herbivores of an ecosystem are called "primary consumers." Some of the energy that the herbivores use is lost in the ecosystem when they create body heat. For example, when deer run and their bodies warm up, the excess heat within their bodies escapes into the atmosphere. If that did not happen, the deer's bodies would get too hot and their organs would fail to work any longer.

Energy is transferred again in an ecosystem's energy flow from primary consumers to "secondary consumers." Carnivores, or meat eaters, act as secondary consumers. Lions, tigers, and polar bears are carnivorous. They eat the meat of the herbivores after a hunt. When tigers eat their prey's meat, they go on to digest it and use the energy from it for their own survival. Like the herbivores in the previous section of the energy flow, carnivores also give off heat energy when their bodies warm up from exercise. Unfortunately for the carnivorous secondary consumers, they too will eventually find themselves targeted for their energy by other members of their ecosystem: the tertiary consumers.

Secondary consumers are carnivorous predators, meaning that they hunt down other animals and kill them for food. However, these animals are not at the very top of the food chain and they too can be hunted and utilized as a meal. Tertiary consumers are predators who lie at the top of the food chain. Human beings are the most obvious example of a tertiary consumer. Unlike the secondary consumers, tertiary consumers are not normally preyed upon by other members of the ecosystem.

Like the primary and secondary consumers, the tertiary consumers give off body heat. That energy is released into the atmosphere. Even if consumers or producers aren't hunted or eaten, all living things eventually die. When they do, they decompose. Bacteria and fungi attach themselves to a dead producer or consumer and begin to break down the matter of the body, releasing nutrients into the soil. These nutrients are then used to give life to new plants so that new energy from the sun can flow through the eco pyramid.

How Soccer Can Help Us Understand Physics

by ReadWorks

Sports provide a great way to understand some concepts in physics. Physics, after all, is the study of matter, motion, force, and energy. And since sports like soccer, swimming and cycling involve bodies moving through space, they can help us understand how the principles of physics work.

Imagine that you're looking at a soccer ball on a grassy field. If you do nothing to the ball, it will stay motionless on the grass. If you kick the ball, it will roll along the grass before coming to rest again. Pretty simple, right?

For thousands of years, though, people thought that objects like this soccer ball come to rest because they have a natural tendency to stop. It took a famous physicist by the name of Sir Isaac Newton, who lived in the 1600s, to prove that this was not exactly correct.

Newton suggested that objects like the soccer ball have a natural tendency to keep moving. The only reason they stop, he believed, is because an unbalanced force acts on them. By an unbalanced force, Newton meant the force applied to the soccer ball by its environment. When kicked, the surface of the ball travels over the grass, creating friction. The taller the grass, and the rougher the surface of the ball, the more friction is created. And the more friction that exists between the ball and the grass, the less it will travel after being kicked.

Now, imagine that there is no grass. Instead, the ball is resting on a frozen lake. When you kick the ball on the ice, the ball will go much farther than it would have on the grass. This is because ice provides a lot less friction than the grass.

Even so, ice does cause some friction. The ball's interaction with the frozen water crystals on the surface of the lake eventually causes it to come to rest again. But now imagine that instead of ice, the ball is in a place where there's no friction at all. The ball is floating in a vacuum. If you remove friction entirely, kicking the soccer ball would cause it to keep going and going at the same speed, until some force caused it to slow down and stop.

To paraphrase Sir Isaac Newton, a soccer ball on the grass will stay where it is unless acted on by a force. Similarly, once you kick the ball, it will remain in motion unless acted on by force. This, in so many words, is known as Newton's First Law of Motion.

The same principles apply for other sports. Take swimming. Olympic swimmers are in a constant battle with the force of water. Water slows them down. To increase their speed, swimmers often shave their entire bodies, reducing the amount of friction caused by hair. Since a swimming contest can be won or lost by a tenth of a second, anything they can do to remove friction will help-even if it means ridding their bodies of hair.

Recently, Olympic swimmers took to wearing full-body suits in the water, which made swimmers sleeker and reduced underwater friction. Swimmers wearing these suits began to break world records. They started winning all the races. Soon enough, Olympic officials, realizing that these suits posed an unfair advantage, banned the use of suits in Olympic competition. Swimmers had to fall back on their own, hairless skin.

The situation for professional cyclists is slightly different. Unlike the swimmer, who battles the water, the cyclist is confronted with forces from other sources that seek to slow him or her down: the force of the road and the force of the air. Like professional swimmers, pro cyclists are known to shave their body hair, to reduce the amount of friction caused by the wind. But the loss of body hair represents only a tiny reduction in surface friction compared to, say, wearing spandex shorts instead of baggy shorts with pockets that fill up with air as you ride.

To reduce friction and increase speed, cyclists adopt all kinds of techniques. They wear aerodynamic helmets. They crouch low over their bikes. They wear shirts and shorts that cling closely to their skin, preventing air from slipping inside and slowing them down. However, little can be done about the tires' interaction with the pavement. As in the case of the soccer ball, a bicycle wheel will eventually stop spinning if no force acts upon it to keep it moving. The rougher the road, the sooner that bike wheels will come to a stop.

For this reason, cyclists tend to have large, bulging thigh muscles. These muscles allow the cyclist to continue exerting force on the bicycle pedals, which cause the wheels to keep spinning despite their constant interaction with the road. Of course, other factors come into play, too. The heavier you are, the more work you have to do to keep the bike moving-that is, unless you're moving down a hill, in which case the gravitational force of your weight acts to your advantage.

Also, your ability to keep your legs pushing the pedals depends on how fit you are, not just how strong your legs are. Many people who are out of shape would run out of breath before they complete a mile-long bike ride, whereas a person who is fit and has a lot of stamina could travel two miles without much difficulty.

Whether you are in shape or not, what really matters when trying to kick a ball, swim a lap, or bicycle a 5 mile race are the forces of physics. Without them, every time you kicked a soccer ball, the ball would keep going, forever.

Mix the Old with the New

by ReadWorks

Chefs in busy restaurants do a lot of different things. They check the inventory of ingredients used for each popular dish. They may supervise a kitchen staff, making sure their assistants are working well as a team. They may ensure that diners are not waiting too long for their food. They may taste the food before it leaves the kitchen. They do a lot and think about everything that goes into the food and experience their restaurant serves.

But they may not think about how they and their staff change the properties, structure and state of matter of food... but they are doing that with many dishes they serve.

Do you know how to change the properties, structure and state of matter of a substance? If you have made ice before, the answer is yes.

When you put an ice tray filled with water in a freezer, the temperature of the water in that ice tray lowers. The freezer makes a physical change of state to the water by turning it from a liquid to a solid.

When we cook, we change many things about the food we are preparing. These could be any number of properties: size, shape, mass, color or temperature. We can change the physical or chemical nature of the food. We can even change the state of matter the food is currently in to another state of matter.

STATES OF MATTER

There are four common states of matter we see almost every day: solid, liquid, gas and plasma. We can observe all four of them in a kitchen. A solid is as simple as an ice cube, or frozen water. Melt that ice cube, and you produce water, a liquid. Boil that water, and you produce steam, or water vapor. Believe it or not, plasma can be found in kitchens too. It's found in fluorescent lights, neon signs and plasma televisions. Other examples of plasma include the sun and lightning.

CHEMICAL CHANGES

A chemical change produces something from other materials and occurs on the molecular level. Some examples of chemical changes that take place in a kitchen are frying an egg, grilling fish or burning that egg or fish. When you smell onions sautéing in a pan or catch a whiff of the chicken roasting in the oven, the scent coming from the food is also a chemical reaction. Hopefully the scents you smell are only appetizing ones.

There are undesirable chemical changes that occur in the kitchen, too. If you smell the odor of rotting food, you've got a chemical change that needs some addressing! After you wash your metal pots and pans, make sure they dry properly. If they don't dry, the metal could react to the oxygen in the air and rust. Rust is evidence of another chemical change you don't want in your kitchen.

PHYSICAL CHANGES

Physical changes in the kitchen do not produce a new substance. Changes in state or phase are physical changes. For example, cutting vegetables, or even dissolving salt in a hot soup are examples of physical changes. In general, physical changes can be reversed using physical means. In the example of dissolving salt in a hot soup, evaporating the water naturally or applying heat to boil off the water can return the salt to its original state of matter.

When water is boiled, steam is created. That steam is water vapor, or the gas phase of water. That change from a liquid to a gas is an example of a physical change.

Let's say you're making a smoothie with strawberries, bananas, kale and orange juice. When you're cutting the fruits and vegetable into smaller pieces, it's a simple physical change. When you add them to the blender with the orange juice, the physical change that takes place during blending is more complex, and you now have a liquid. You can even go fullcircle and turn your liquid smoothie into a solid by turning it into popsicles in the freezer.

A DIFFERENT KIND OF COOKING

There are some chefs in this world who reject or reinterpret traditional cooking techniques and cuisines. They push the boundary of food with new techniques to create entirely new combinations of flavor and texture. They take states of matter, physical changes, and chemical changes of food to a whole different level.

MOLECULAR GASTRONOMY

While some chefs may not actively think about the science behind the food they serve, others are using a modern style and science of cooking called molecular gastronomy. Molecular gastronomy is a scientific discipline that studies the physical and chemical processes that occur while cooking. Chefs who practice molecular gastronomy study and apply scientific principles when cooking and preparing their dishes. Their goal is to use their knowledge to make a tasty and unique dining experience.

They are concerned about *how* to make food delicious as well as *what* makes food delicious. To understand this, they have to consider many factors. Some of these factors include how their ingredients are grown, processed and transported. Where did the seeds used to grow the fruit come from? What kind of dirt and how much water did this vegetable receive? After harvest, was it ever put in a plastic bag? Was it sent by air, truck, and/or boat? What negative effects did transportation have on the produce?

Only after all that is determined do many molecular gastronomy chefs finally get to the cooking part of their craft. They want to understand how ingredients change with different cooking techniques. They want to know how all of a person's senses, not just taste, play in to the enjoyment or dislike of food. They go deeper and learn how the brain interprets the signals our senses send to ultimately determine the flavor tasted. They even experiment with how food is presented, who prepares it, and what mood the diner is in.

Many of these factors are what most chefs consider anyway, but what really differentiates molecular gastronomy chefs is in the preparation and presentation steps. And when it comes down to it, a molecular gastronomy chef is many things at once: a little physicist, a sprinkle of chemist, a dash of agriculturist, a spoonful of biologist, and a heap of psychologist to top it off. That's a solid list of ingredients that hopefully turns into fun and tasty food.

PREPARATION

Molecular gastronomy chefs look at how ingredients are changed by different cooking methods. These cooking methods affect the eventual flavor and texture of food ingredients.

One method is called direct spherification. This is the process of turning a liquid into little caviarlike balls. Employing gelling solutions like sodium alginate, liquids like fruit and vegetable juices, and even milk, are dropped into calcium chloride and water to form a thin shell around the liquid. This jelly membrane creates the ball that pops with the liquid's intense flavor when eaten. The spheres are fragile and are usually served immediately.

Another method is a variation on the existing technique of using foams. Wellknown foams include whipped cream and mousse, and also involve the use of air or another gas to create lighter texture and feel when eaten. A variation on the foaming technique is to make foam that is made of mainly air. You can make foams out of almost anything. It can have so much air that it resembles big soap bubbles. This changes the texture into something lighter while allowing the flavor to remain. Steak bubbles, anyone?

A recipe that combines the foam and spherification techniques is Apple Caviar with Banana Foam served on a spoon. Combining apple juice in the form of spheres and banana foam whisked with heavy cream, milk, sugar and gelatin, this spoonful is not your typical dessert!

Some molecular gastronomy cooking methods involve temperature regulation. One method is called sousvide and entails cooking food, like meats, in airtight plastic bags in a water bath. This ensures the entire piece of meat is cooked evenly and also retains its juices. Cooking times when using the sousvide method don't have to, but can increase dramatically. Some chefs choose to tenderize tough meats like beef brisket with a sousvide water bath that lasts for two to three days.

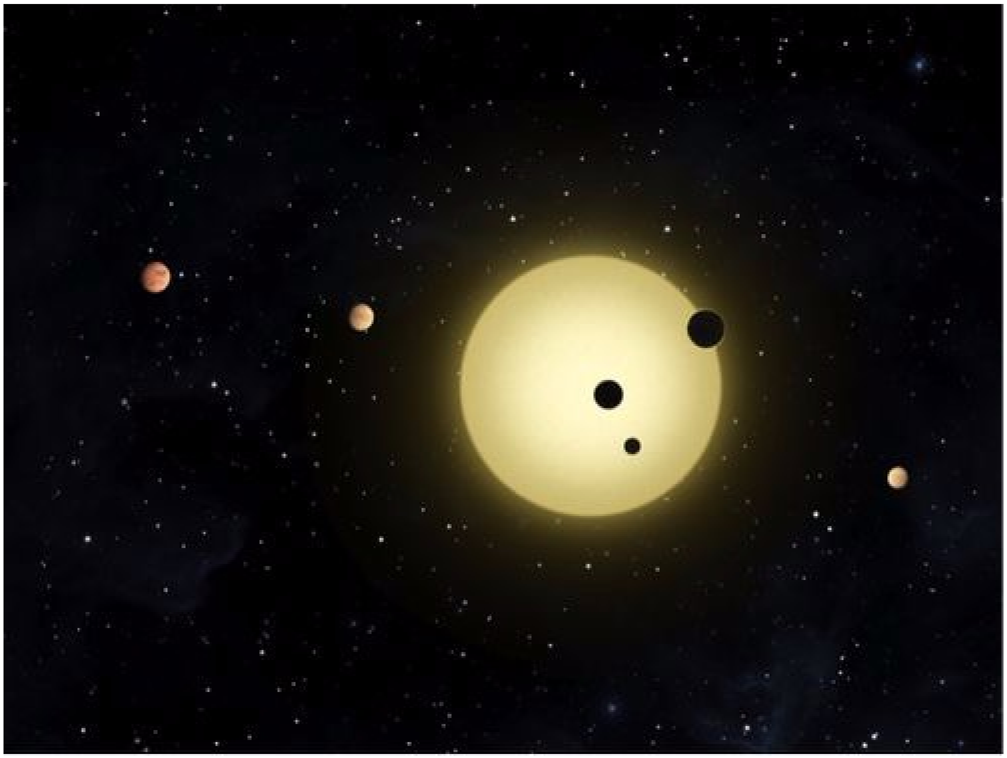
Although it may seem like weird science or just plain ridiculous, molecular gastronomy chefs want to explore new possibilities in the kitchen. Combining new and old cooking techniques, new equipment and technologies, and various sciences, these chefs may be inventing the food of the future. Whether they are successful or not, they are definitely making things fun.

GOOD FOOD IS GOOD FOOD

Whether a chef uses traditional or new cooking methods, the fundamentals of cooking are the same. Both traditional and molecular gastronomy chefs change the properties of the food they serve. They change the states of matter, properties and structure of food to, hopefully, serve a great meal.

As Time Flies By

by ReadWorks



Numerous films and science-fiction novels have used time travel to send their characters to the past and the future. The technology to make time travel possible, of course, does not exist. But even if the technology needed to travel through the ages did exist, how would it actually work?

That question may not have a simple answer at the moment, but it does raise a lot of interesting points regarding what it means to "travel through time." For a regular student, one piece of this challenge that is easier to think about is not time at all-it's space.

In 2009, a blogger and scientist who goes by the username "Shechner" wrote a detailed examination of time travel in the film *Back to the Future*. The hero of that story, Marty McFly, travels from the year 1985 to 1955 by driving a car that has a time travel device built into it.

During an experiment at the Twin Pines Mall in Hill Valley, California, Marty videotapes the car as it accelerates to 88 miles per hour. Then it disappears in a burst of smoke and flames. One minute later, the car reappears precisely where it disappeared. It has traveled exactly one minute into the future.

The interesting thing that Shechner questioned when dissecting this moment is not whether it's possible for an automobile to travel one minute into the future or 30 years into the past. His question is about where the vehicle will end up: if you do travel through time, how can you be sure you'll end up in the exact same place that you left?

Minutes in Motion

Astronomers have spent centuries charting the stars and tracking the movements of planets across space and time. Hundreds of years of research and observations have given our civilization the very idea of time, in the form of days and years.

A single day on Earth can be broken into daytime and nighttime. The passing of day and night is caused by the rotation of the planet. Every 24 hours, the earth makes one complete rotation on its axis. During this rotation, the parts of the earth that face toward the sun are in daytime. The parts of the earth facing away from the sun are in nighttime.

Just as the earth is rotating on its axis, it's also traveling through space. Our planet, along with all the other planets in our solar system, makes an orbit around the sun. The amount of time it takes for the earth to make one complete orbit is about 365 days. The way we measure years is based on how long it takes our planet to make it all the way around the sun.

While it's common to think that time is continuously moving forward, it's also possible to think time is the result of Earth's planetary motions. In this way, time is about tracking the position of the earth in space.

Back to the Future or Flung Into Space?

Drawing on this knowledge about space and time, consider the case of Marty McFly.

In the film *Back to the Future*, Marty watches the time machine travel one minute into the future and appear in the exact same spot. Taking into account the movements of the earth, this seems impossible. If the planet is always rotating on its axis and at the same time always circling the sun, then the Twin Pines Mall parking lot wouldn't be in the same place it was just one minute earlier.

Just how far does the earth move in a single minute? According to Shechner's calculations, it moves precisely 1,123.17 miles. This number measures the speed of Earth's orbit around the sun as well as the speed of Earth's rotation on its axis. It may not seem like it, but every human being on Earth travels over 1,000 miles per minute through space, just by being on the planet. The only thing that stops us from flying off into the atmosphere is gravity.

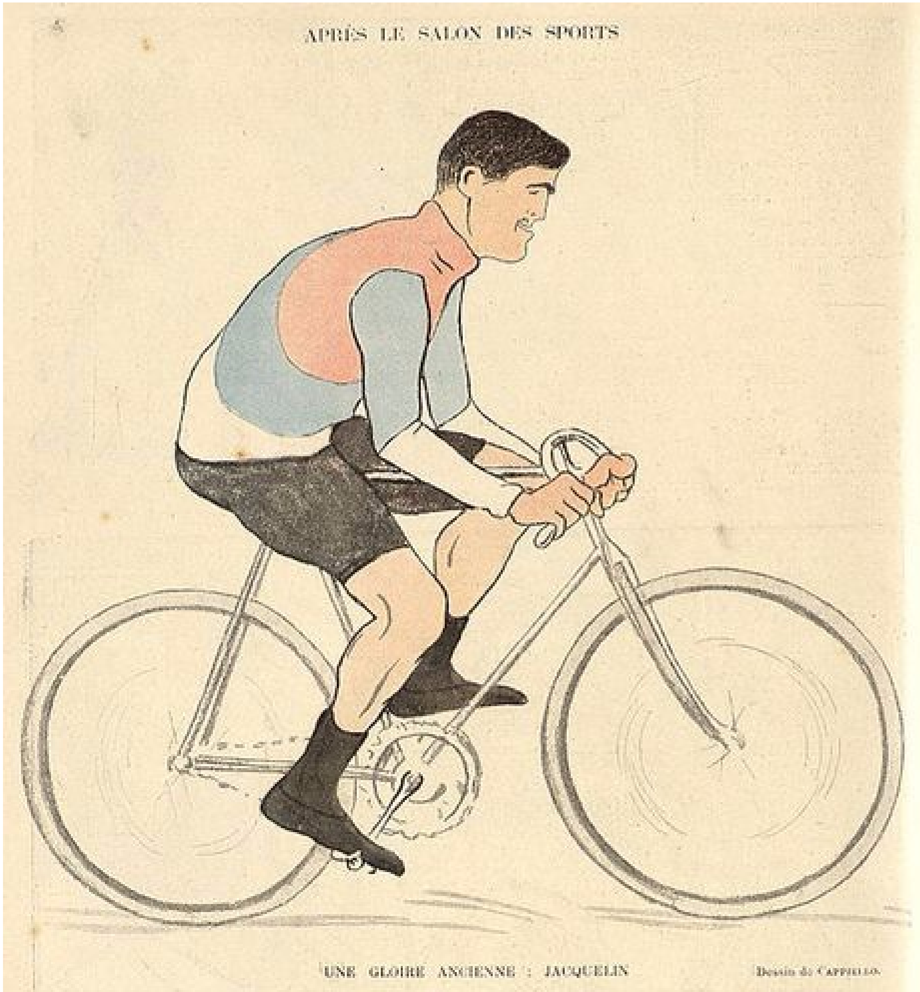
If a time-traveling car cruises one minute into the future, then it could reappear a thousand miles away on another place on the earth's surface, a thousand miles away from the earth in space, or a thousand miles deep into the earth's crust. It's very unlikely, however, that the car would be fast enough to catch up with the movements of the planet to end up in the exact place where it disappeared.

This puzzle isn't enough to ruin *Back to the Future*, which is considered by some to be a classic of blockbuster films. And if time travel technology is invented someday, the scientists may rely on a theory of time that doesn't depend on our current understanding of space.

In the meantime, though, all of us on planet Earth will keep moving with Earth, experiencing the passing minutes and changing seasons.

Heat, Energy, and Bicycling in New York City

by ReadWorks



New York City is one of the densest cities in the world, with millions of people squeezed into a mere 303 square miles. Although it has the world's largest subway system, traffic can still be quite bad, particularly at rush hour. The city decided that it would be a good idea to encourage more people to use bicycles. If more people rode bicycles, the roads would be less clogged with cars. Also, when you ride a bicycle, you are exercising, which makes you healthy. But how can you encourage people to ride more bikes?

The city came up with an innovative solution. In 2013, city workers began installing long racks of bicycles in different neighborhoods. These bicycles were, for a small fee, available for anyone to use. A person could ride the bicycle from one bike rack to another bike rack and park it there. This system was ideal for people who did not own bikes or who wanted to take a bicycle on a short ride without having to return it to the place they took it from. This also made it possible to move quickly between areas that did not connect easily by the subway. The city hoped that people would start using these bicycles instead of taxis or other kinds of cars.

While the city installed the bikes in part because of concerns about traffic, it was also interested in another question: how we use and spend energy. Any time an object is in motion, it is both producing energy and, in many cases, expending energy. For example, a car does not just move because we want it to move. It is powered by a special kind of engine, called an internal combustion engine that burns fuel. When this fuel is burned, it causes a cylinder to spin in circles. This cylinder is connected to the wheels of the car. As the cylinder spins, so do the wheels. So, one type of energy - fuel - is transformed into another type of energy - forward motion. Energy contained in the motion of an object is called "motion energy."

Just as cars can be considered a kind of energy conversion device, converting fuel to forward motion, so can bicycles. When you step on the pedals of a bicycle, it causes the wheels of the bicycle to spin, pushing the bicycle forward. The energy of your foot pressing down is converted into energy that propels the bicycle. Nearly all transportation - airplanes, trains, pogo sticks - can be thought of as devices that take one form of energy and make it into another form of energy.

When there is a change in one of the forms of energy used to power modes of transportation, then the energy generated by these devices changes as well. Let's say you're pedaling very fast on a bicycle. You are exerting a lot of energy as you do this. You can tell because your heart rate may increase, you may breathe harder, and you may begin to sweat - a sign that your body is trying to cool itself. This is producing a lot of motion energy in the bicycle because you are causing it to move very fast. But if you stop pedaling, then the bicycle will begin to slow down, and the motion energy in the bicycle will decrease. You will also be expending less energy. Your heart rate and your breathing will slow down, too. The decline in your own motion energy - the movement of your feet - is causing the motion energy of another object - the bicycle - to fall at about the same rate.

In the early days of the program, the bike racks were only moderately popular. People were still getting used to the idea of borrowing a bike for a short time at one location, riding it, and then leaving it in another location. Perhaps another reason that people were initially reluctant to use the bike racks is that they were introduced during a very hot week, at the beginning of summer. As discussed above, when you ride a bicycle, you often sweat. This is particularly true when the temperature is high, because your body produces sweat as a way of trying to keep your body cool. If your body gets too hot, you can get sick, so it's in your body's interest to maintain a constant temperature.

How much the temperature of a body increases when it gets warm depends on a number of different factors. While it makes sense that one person in 100-degree heat will get hotter than a person in 75-degree heat, even if two people are exposed to the same temperature, their bodies may react differently. In fact, one person may get much hotter than the other. This is because the amount of heat - which is a form of energy - needed to change the temperature of another object depends on the properties of that object. For example, a person who is wearing a sweatshirt in summer is likely to get much hotter than a person who is wearing a t-shirt. This is because the sweatshirt insulates the person, trapping heat inside. The t-shirt, which is more open, lets the heat escape. So, even if the amount of heat energy directed at the person is the same, the temperatures of different people will react differently.

That raises another question: why does sweat makes people colder? This has to do with a special property of heat. Heat is a kind of energy, and energy moves spontaneously from hotter regions or objects to colder ones. So, consider what happens when your body releases sweat. When it is released, sweat is colder than your body's temperature. When it is on the surface of your skin, it draws the heat from your skin into the water, because heat migrates from warm areas to cold ones.

This causes the sweat to warm up. Then the sweat rises into the air and takes some of your body heat with it, cooling the body down.

Your body is constantly monitoring its own temperature. Many of the buildings in New York have air conditioning in the summer. When you walk from the hot street outside to the cool lobby of a tall office building, you can feel the change immediately. After a while, your body temperature will go down. This is because, just as the heat from your body moves to the sweat on your skin, it will also move to the cool air produced by the air conditioning. When your body gets cool enough, it will no longer need to produce sweat to cool you down.

As people continue to ride bicycles, you can expect their collective body temperatures to rise, as their bodies produce energy to power the bicycles and they spend more time outdoors in the hot sun. If the city chooses to install more bikes, then it may also want to install more air conditioning - or pass out more sticks of deodorant.

Why Humans Can't Live Off Sunlight

by ReadWorks

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow{\text{Light}} \underset{\text{Sugar}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2}$$

photosynthesis equation

In 2013, a resident of Seattle, Washington, named Naveena Shine decided that she would embark on an experiment. Shine had become fascinated with photosynthesis, the process by which plants are able to make their own food using sunlight. Sunlight contains a significant amount of energy, which plants are able to use to convert water, carbon dioxide, and minerals into oxygen and organic compounds, including nutrients like glucose. Shine reasoned that the human body, if forced to, could do the same thing. So Shine set out to test her hypothesis. In May, she declared that, for the next six months, she would not eat food. Instead, she would limit her diet to only sunlight, water, and tea.

Shine saw her experiment as an important moment in human history, perhaps even a next step in the evolutionary process. On her website, she outlined the many potential advantages of humans being able to produce their own food from sunlight: people would not have to work as hard to earn money to buy food; instead of cooking and shopping, they would have more time to do other things, and many of the earth's natural resources used in the production and preparation of food would be saved for future generations. And why wouldn't it work?

"Plants live on light, and then we eat plants," she concluded. "Are we simply not accessing our inherent ability to live on light?"

Shine also claimed that several people had successfully lived on light before her. She cited a German chemist named Michael Werner, who claims to have eaten no food since 2001, and Ellen Greve, an Australian spiritual leader-known to her followers as Jasmuheen-who said she had not touched a meal since 1993. (These claims were never proven true.) To prove that she was not sneaking food to eat, Shine said she would set up eight video cameras in her trailer to record her every movement. On May 3, 2013, with her predecessors in mind, Shine began her experiment.

The results were dramatic, although perhaps not in the way Shine had planned. Over the next five weeks, Shine lost 30 pounds, dropping from 160 pounds to 130. She felt weak and occasionally had difficulty standing. She reported that when she went outside to get her daily regimen of sun, her hands were cold. Shine predicted that this would be the moment when her body would produce its own food.

"I have the feeling my body has reached a point where it has used up all its stored fats, and is now looking around for what to consume next," she wrote on Facebook. "I suspect this might be the point where it decides either find and hook into the source where it is able to live on light, or consume the body for sustenance."

Shine's experiment received a lot of criticism. Many of her detractors pointed out that, even if her hypothesis was valid, famously cloudy Seattle might not have been the best place to test it out.

On June 19, after 47 days of the experiment, Shine called it quits. She had lost 33 pounds and was having difficulties holding down water in her stomach. However, Shine did not rule the experiment a failure. Instead, she blamed the early termination on several other, more practical factors, including a lack of funds. Shine had charged the cameras in her trailer to her credit cards. She had expected that visitors to her website would donate funds to pay for the cameras and sustain her experiment. However, after 45 days, she had received only $435, forcing her to leave her trailer and return to work. She also cited the overwhelmingly negative reaction to her experiment as another reason for its termination.

"From the feedback I am getting," she wrote, "it is becoming patently clear that most of the world is by no means ready to receive the information I am attempting to produce."

Shine appears to have escaped from the experiment without permanent damage-although she did sustain a steep drop in her weight and some credit card debt. However, starving yourself can do serious harm to the body and is very dangerous. Others who have attempted the same experiment have not been so lucky. At least four people, inspired by similar teachings about the nutritional value of sunlight, have died from self-inflicted starvation. Starving is dangerous because when the body is deprived of vital nutrients, it begins to shut down some of its vital organs, greatly increasing the chances of illness. If deprivation lasts long enough, then the person can sustain long-lasting injuries or even die.

What was Shine's mistake? Well, she made several. Most importantly, she misunderstood how energy is produced in plants versus how it's produced in humans. While sunlight does indeed contain energy, only plants are able to render this energy into a usable form. Dr. Ronald Hoffman, a clinician and spokesman about health and nutrition, told the UK's*Guardian* newspaper that Shine's ideas were "delusional" and explained her error.

"Plants have what are called chloroplasts that contain chlorophyll, and they have the ability to capture energy from sunlight," Hoffman said. "Humans don't have chlorophyll or chloroplasts. No humans do. It is impossible for a human to have that."

A chloroplast is a structure that is able to produce a very specific chemical reaction in which plants use light energy and carbon dioxide to produce sugars. A chemical reaction is when atoms of one substance are rearranged to make a different substance. During photosynthesis, carbon dioxide atoms the plant draws from the air are split into carbon atoms and oxygen atoms. The carbon atoms are used by the plant to make sugar, a form of carbohydrate. (Carbohydrates are compounds made of carbon, hydrogen, and oxygen.) The plant then discards any oxygen it does not use as a waste product. This is much like how human beings breathe out carbon dioxide as a waste product of our own bodily system.

The sugars plants produce during photosynthesis are of a form that plants can use to survive and grow. In this way, the energy that is contained in sunlight is transformed into a different kind of energy. However, the structures capable of making this transformation-chloroplasts-are present only in plants, not humans. When Shine concluded that her experiment would work because plants live on energy from the sun and people eat plants, she was not recognizing that humans do not eat sunlight; people eat the sugars that plants produce. For example, if people eat sweet strawberries, they are not eating the energy from the sun. They are eating a kind of fruit sugar, called fructose, that the strawberry plant produces. If Shine had had a better understanding of photosynthesis and how the human body works, she probably would not have believed her experiment would work.

Sir Isaac Newton and LeBron James

by ReadWorks

The English physicist and mathematician Sir Isaac Newton discovered three basic laws of motion. The First Law says that objects at rest and objects in motion will remain at rest or in motion, unless they are acted upon by an "unbalanced force." The Second Law says that when a force acts on a mass, acceleration is produced. The greater an object's mass is, the more force is needed to accelerate it.

Newton's laws of motion have become known throughout the world, including his Third Law of Motion. It reads: "For every action, there is an equal and opposite reaction." A simpler way of saying this might be: "When you push an object, it pushes back." For every force, in other words, there is a reaction force equal in size.

There are many ways to describe how the Third Law of Motion works in the world of sports. One of the more interesting examples is the way that LeBron James dunks a basketball.

In order for LeBron James to score a slam-dunk, he must exert a certain amount of force against the surface of the basketball court. LeBron James is a big man. He is 6 feet, 8 inches tall. He weighs 245 pounds. When he is standing upright, with his arms raised above his head, his reach extends to 8 feet and 10 ¼ inches.

The rim of the basketball hoop is exactly 10 feet high. For LeBron James to slam the ball, he must propel himself high enough that he can force the basketball, which is approximately 9.39 inches in diameter, into the hoop. This requires that he reach well above the height of the rim, which he does fairly often. In photographs and slow-motion replays of LeBron James dunking the basketball, his elbow is often equal to the height of the rim!

LeBron James may be tall, strong, and fast. He may be extremely mobile and flexible. But it is no easy feat to dunk a basketball, especially when you weigh 245 pounds. His vertical leap-that is, the maximum height he can reach when he jumps-is around 44 inches. The average vertical leap in the National Basketball Association, or NBA, is about 27 inches. That means that LeBron James, despite his large size, can jump more than 10 inches higher than most players in the NBA! This is a serious benefit in basketball, a game of inches in which how high someone can jump often means the difference between scoring and missing the shot.

Why can LeBron James jump higher than other basketball players? The answer has to do with Newton's Third Law of Motion. When LeBron James jumps, he is driving force into the court. That force is created by the energy stored inside his muscles. And how high he jumps depends not just on how much energy he forces into the surface of the court, but also on how well he does it.

When LeBron James jumps, he pushes down on the surface of the court. This is the "action" that Newton mentions in his Third Law. The "reaction" comes when the floor pushes back using an equal amount of force.

It may seem strange to think of the floor exerting force on an object, especially a basketball player. But this concept is what Sir Isaac Newton understood way back in 1687, when he published his most famous book, *Mathematical Principles of Natural Philosophy*.

Newton would have been fascinated by LeBron James's jumping ability. But he would also have understood that it is not simply the strength of James's legs that enables him to jump so high. The stability of his body, located in his core and his torso, also contributes to the energy that he forces into the surface of the court. The energy and strength of LeBron James's *entire body* is what enables him to reach such fantastic heights.

Watching LeBron James dunk on television often causes people to think he is defying the force of gravity, which pulls us and other objects to the ground. In reality, no one can defy such force. LeBron James just happens to be so strong and agile that, when he jumps into the air, he *appears* to be defying the force of gravity. He seems almost capable of flying.

Naturally, smaller basketball players require less force to dunk a basketball. Since they are lighter, they don't have to combat the same gravitational pull. On the other hand, the fact that they are lighter means they do not have as much mass to store energy. The more muscles you have, the more energy you can force into the ground, and the higher you can go.

This is why professional basketball players appear to have no fat on their bodies at all. Fat does not store energy as effectively as muscle, but it still contributes to one's body weight. Fat on a basketball player is equal to wearing lead weights around their hips during a game. Obviously, this would hinder a player's performance, especially his ability to dunk.

Physicists have spent time thinking about the physics of dunking. To remain in the air for one second, they say, one would have to have a vertical leap of 4 feet, which is higher than pretty much any basketball player of all time. One exception is Michael Jordan, who is believed to have the highest vertical leap-48 inches, or 4 feet-of any professional basketball player. Michael Jordan was just 6 feet, 6 inches tall-average for an NBA player-but his vertical leap placed his head about 6 inches above the rim.

That one of the best basketball players in history also has the highest vertical leap is no coincidence. Michael Jordan's body was strong, stable, and proportioned in such a way that the force he pushed onto the ground placed him above the rest. He was one of the best overall athletes in the game, and his slam-dunking ability was an indication of his prowess.

From basketball players like LeBron James to Michael Jordan, it may seem like they are bending the rules of physics and gravity when they dunk a basketball. On the contrary, they are able to perform crowd-rousing dunks because of these rules.