HUMAN HEALTH
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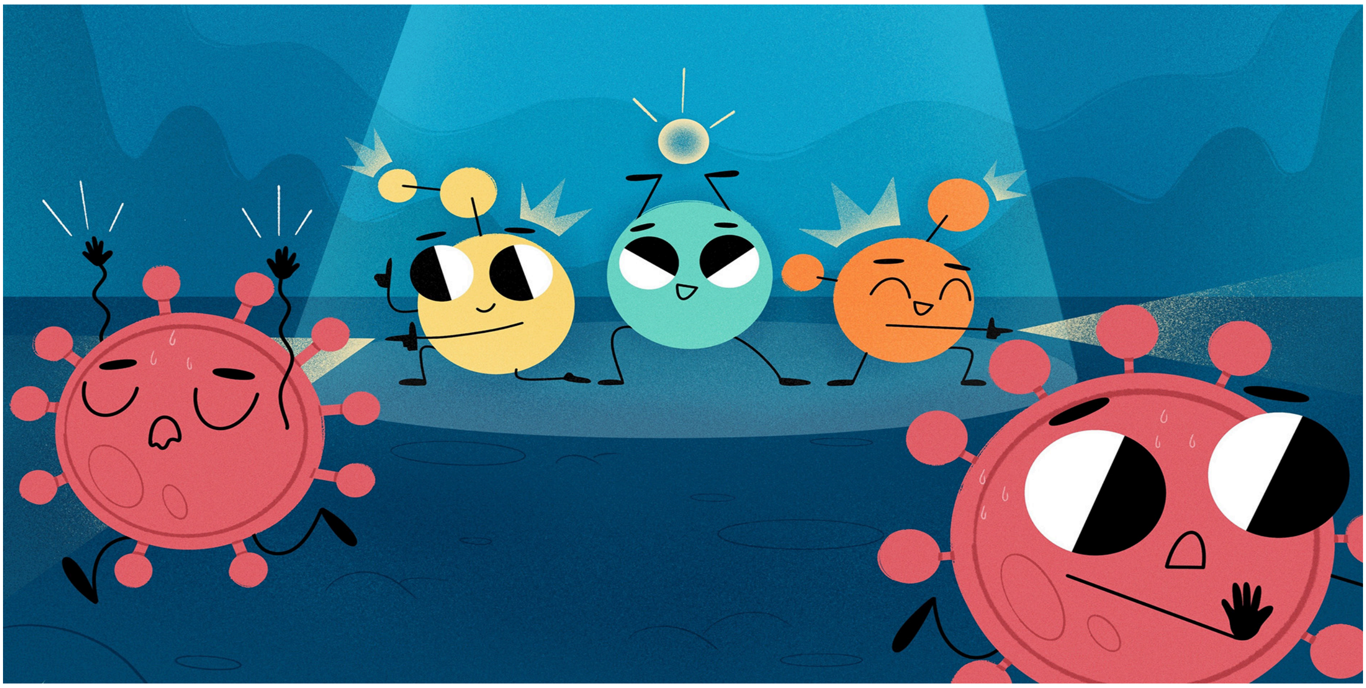

A NEW WAY TO TREAT DISEASES USING LIGHT-LOVING MOLECULES

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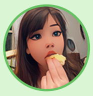

ARIANA
AGE: 8

KABIR
AGE: 12

Some tiny microorganisms creatures such as viruses, fungi, and bacteria can make us very sick. As these organisms evolve with us, they are becoming smarter and stronger, which is making it more difficult for medicines like antibiotics to fight them. Scientists are finding new ways to treat these infections, and one way is by using a cool treatment called photodynamic antimicrobial chemotherapy (PACT). PACT is based on tiny, colored molecules that take up light and use it to make tiny "bullets". These tiny bullets attack and kill microorganisms by punching holes in their cell membranes. Therefore, using PACT could help doctors and scientists to fight these attacks and keep people healthy.

HARMFUL MICROORGANISMS ARE FIGHTING BACK AGAINST TREATMENTS!

MICROORGANISMS
Tiny living things that exist around us which we cannot see without special tools like microscopes.

Have you ever wondered what makes us sick and how we get diseases? Well, we live in a world where tiny living things called **microorganisms**, which we cannot see without special tools like microscopes, exist all around us. There are two main kinds of microorganisms: harmful microorganisms and beneficial microorganisms. Harmful ones can make us feel sick, while beneficial ones are like little helpers that take part in normal body processes like digesting food, getting rid of toxins, making vitamins, and strengthening our immune systems. Microorganisms include bacteria, viruses, fungi, and protozoa, and they exist all around us.

Microorganisms can cause diseases as they spread through the air, water, soil, food, or even when we touch each other like when we shake hands. When it comes to bacteria, there are medicines called **antibiotics** that can fight the bacteria and help us get better. But not all bacteria die when people take antibiotics. Some survive and become stronger against the medicine, which is called **antibiotic resistance** [1]. The next time we use the same medicine, it will not work as well. These strong microorganisms can share their resistance superpowers with other microorganisms, making them resistant, too. Even normal beneficial bacteria can change to become harmful with time in the presence of antibiotics.

Another downside of antibiotics is that sometimes they also harm the beneficial bacteria that we need in our bodies, like *Lactobacillus*, which helps with digestion [2]. When beneficial bacteria die, this can make it easier for dangerous bacteria to grow. As we mentioned, if harmful bacteria become resistant to antibiotics, they are much harder to fight. Luckily, scientists are working hard to find new ways to beat harmful bacteria and keep us healthy.

ANTIBIOTICS

Medicines that fight off bacterial infections in humans and animals by either killing the bacteria or making it hard for it to grow.

ANTIBIOTIC RESISTANCE

A process by which microorganisms become stronger over time and stop responding to antibiotics.

PHOTODYNAMIC ANTIMICROBIAL CHEMOTHERAPY

A new tool to fight off diseases using light, dyes, and oxygen.

WHAT SOLUTION DO WE HAVE?

Scientists have discovered a cool new way to fight bacteria, called **photodynamic antimicrobial chemotherapy** (PACT). PACT can help us when regular antibiotics can no longer do the job [2]. Research on PACT is currently happening all around the world, and in some countries, like the USA, it is now being tested in humans [3].

PACT uses light to fight against harmful microorganisms. You probably know that plants use sunlight to make their food by photosynthesis, right? Well, PACT works similarly. Plants have a natural **light-loving molecule** (LLM) called chlorophyll (Figure 1). The intense green color of chlorophyll helps the plant take up light energy and convert it into food. For PACT, instead of using chlorophyll like plants do, scientists make their own LLMs in the lab, in the form of colorful (green, blue, purple, etc.) dyes. The crucial thing about these dyes is that they can absorb light energy just like chlorophyll does, but in PACT, instead of making food, the colorful dyes transform light energy into tiny "bullets" known as **reactive oxygen species** (ROS) that can damage harmful microorganisms.

LIGHT-LOVING MOLECULE

Any molecule that can take up light energy and convert it into any other form of energy.

REACTIVE OXYGEN SPECIES

Small substances produces by light-loving molecules in the presence of light that target and kill microorganisms.

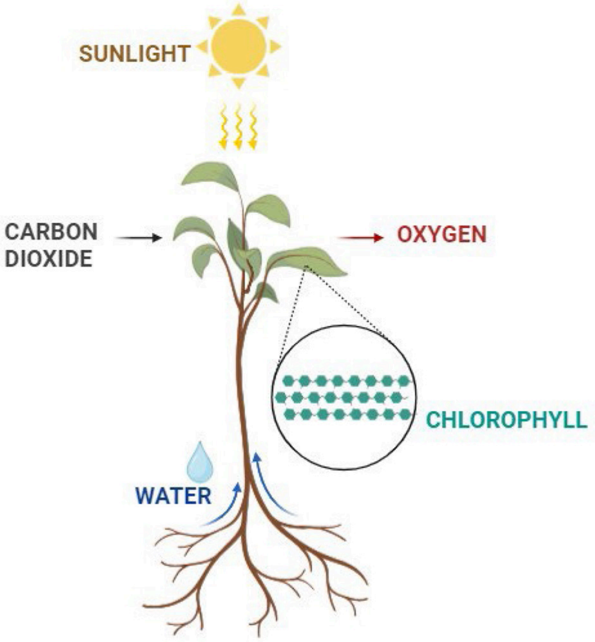

Figure 1

Figure 1

In the process of photosynthesis, plants use a light-loving molecule called chlorophyll to take up energy from sunlight and, in the presence of carbon dioxide and water, convert it into oxygen and food. For PACT, scientists make their own colorful molecules that can transform light into tiny "bullets" to fight harmful microorganisms (figure created by BioRender.com).

HOW DOES PACT WORK AGAINST INFECTIONS?

PACT begins when LLMs are deposited to the site in the body where the microorganisms are growing. Getting PACT into the right location can involve injecting the dyes or directly applying them to the infected area by using a cream or gel. At this stage, the LLMs do not harm the microorganisms. Next, scientists shine the right color of light on the area where the LLMs were placed, filling the LLM molecules with light energy and causing them to produce ROS (Figure 2). These ROS bullets can penetrate microorganisms and damage or destroy important structures, like the cell membrane and the DNA. Damage to the cell membrane causes the fluids inside the microorganisms to leak out, which leads to the death of the microorganisms. When microorganisms die, they can no longer cause disease, so the person feels better [2].

As long as the LLMs are receiving light energy, this process continues until all the microorganisms near the LLMs are dead. As an example, toothaches can be caused by bacteria growing around a tooth and causing an infection. LLMs can be injected into the gums in the infected area, followed by shining light on that area. The LLMs then produce tiny ROS bullets that are harmful to the microorganisms causing the dental infection. The microorganisms die, and soon the patient's toothache goes away (Figure 3).

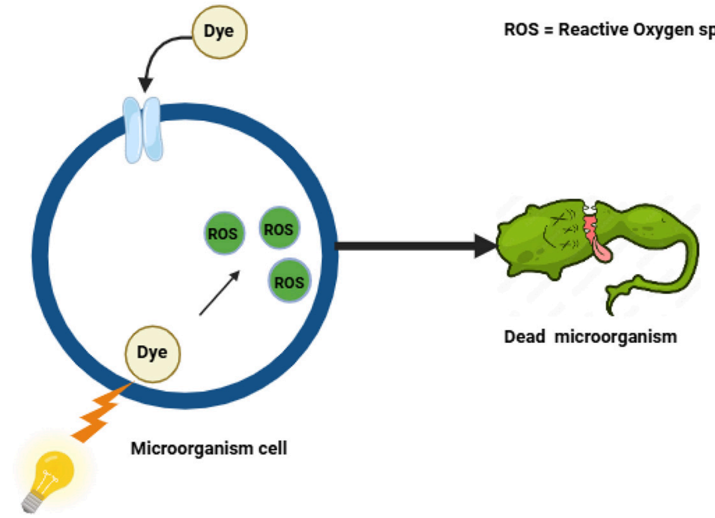

Figure 2

Figure 2

In PACT, LLMs are injected or applied to the body at the site of infection, so that these dyes will end up close to the infecting microorganisms or even inside them. Then, doctors shine the right color of light on the area, which energizes the LLMs and causes them to produce "bullets" called ROS. ROS can harm the microorganisms by making holes in the cell membrane, leading to the death of the microorganisms (figure created by BioRender.com).

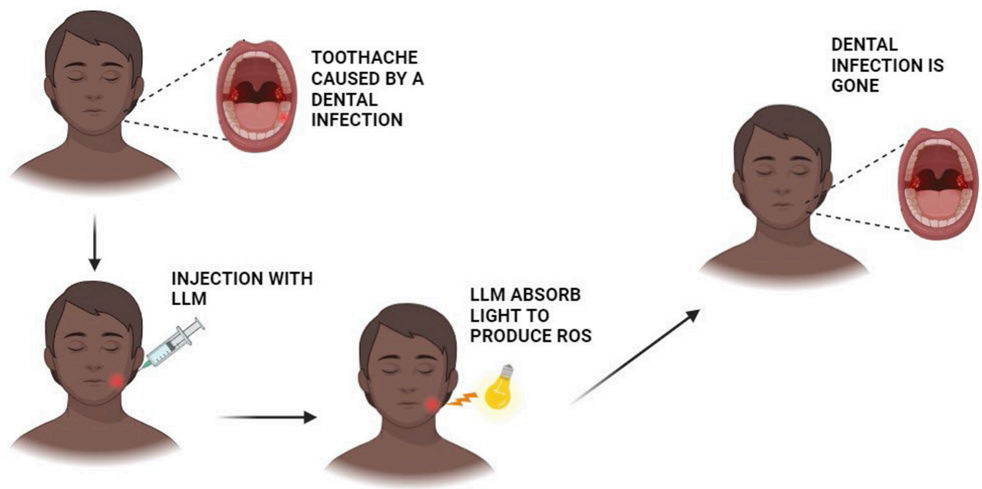

Figure 3

Figure 3

PACT can be used to treat a toothache caused by a dental infection (figure created by BioRender.com).

WHERE CAN WE USE PACT IN REAL LIFE?

PACT is not just an ordinary tool; it is a versatile warrior that can be used by doctors and scientists to fight sicknesses caused by harmful microorganisms that are difficult to treat with antibiotics. You can also imagine it as a healer, fighting off acne, skin infections, yeast infections like oral thrush, and even athlete's foot. But its capabilities do not stop there. Think about **parasites**—organisms that feed, grow, and reproduce inside other living things while causing them harm. Parasites cause diseases that lead to many thousands of deaths every year. PACT shows promising results in fighting against parasitic diseases including Chagas disease, malaria, leishmaniasis, and trypanosomiasis [4].

PARASITES

Organisms that feed, grow, and reproduce inside other living things while causing them harm.

But what about viruses? To date, viral infections have no cure. However, PACT might be able to control viral infections such as herpes, influenza, and HIV. It cannot make viral infections disappear completely, but it can weaken the viruses, helping the immune system to fight them. Interestingly, PACT might also be effective against COVID-19, as well as dental, eye, respiratory, and stomach infections [5]. And do not forget those stubborn antibiotic-resistant bacteria [6]. PACT is ready to face the challenge of combating antibiotic resistance and protecting us against dangerous evolving microorganisms [7]. The wonders of PACT do not just end with humans it can also be used to fight diseases that affect animals, such as dogs and horses.

ADVANTAGES AND LIMITATIONS OF PACT

PACT has many advantages compared to the commonly available antibiotics used to treat bacterial infections. For example, unlike some antibiotics that kill beneficial bacteria along with harmful ones, PACT can target only harmful microorganisms because it can be delivered strictly to the infected area. Unlike antibiotics, which can lead to resistance, PACT does not make microorganisms stronger over time, and no resistance has been reported against PACT. The dyes used in PACT are relatively safe for the human body, in both the presence and absence of light, which limits the possibility of the treatment itself causing harm. Additionally, the dyes can be reused, making the technology less expensive and environmentally friendly. For example, if you have an infection outside the body the dye can be attached to surfaces of harmless objects or put in tiny carriers that carry them to the infected area. If the infection is inside the body the dyes are often designed such that they can be naturally eliminated by the body so that they don't cause further harm to patients. To achieve this, doctors utilize certain delivery systems or materials that can decompose safely.

But every hero has its challenges, and PACT is no exception. PACT is more effective in dealing with microorganisms that are found on the surface of the human body, but it might not work well against those that are deep inside. Moreover, patients may remain sensitive to light for a while after treatment, until the body has time to get rid of the dyes. The tools and dyes needed for PACT can be quite expensive, too. Finally, unlike antibiotics, which can be easily administered with an injection or an oral medicine, treatment with PACT requires doctors to follow several steps, including the administration of the dye at the infected area, introduction of light, and monitoring the progress of the treatment.

In conclusion, PACT combines light with dyes to wage war against diseases caused by harmful microorganisms. Dyes absorb light energy and convert it into small ROS "bullets" that attack and destroy microorganisms. However, doctors and scientists must be careful and think about how PACT might affect us (and other living things) in the long term. Scientists are still working to learn more about how PACT works, and they are conducting tests to ensure that it is safe and effective for everyone.

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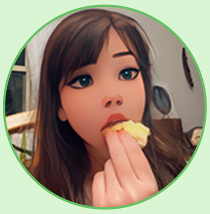

ARIANA, AGE: 8

Ariana loves to know how the body works. She is always curious. She is fascinated about learning all she can about how to improve humans and animals' lives. She is passionate and enthusiastic. One of her favorite things to do is sitting down on the sofa looking at books or videos about the body or about animals. She wants to be a vet when she grows up.

KABIR, AGE: 12

Hi, I am Kabir. I am 12 years old. My favorite food is butter chicken. I enjoy playing Fifa and playing outside. My Favorite hobbies include: soccer, basketball, and football. My favorite subjects are Science and P.E because it allows me to do what I am good at and take a break from all of my stressful activities including my core classes. Each year I do a science project to showcase what I know and bring my ideas to life.

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