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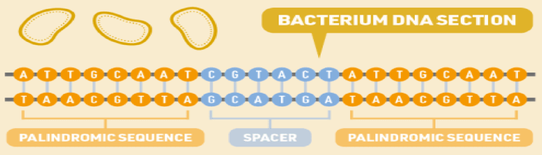
CHEMISTRY E-BULLETIN

Science Day Special Edition – "By Students - For Students"

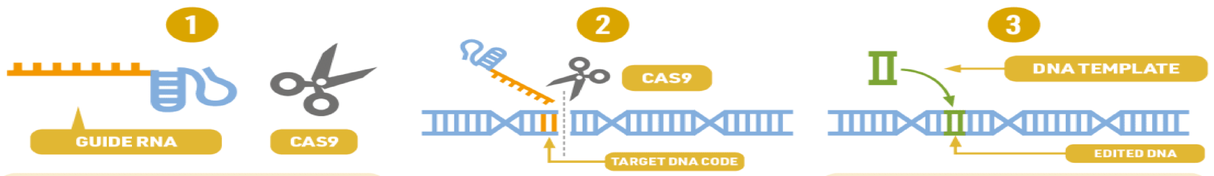
CB - Volume 1(1)
February 2021

2020 NOBEL PRIZE IN CHEMISTRY

The Nobel Prize in Chemistry 2020 was awarded to Emmanuelle Charpentier and Jennifer A. Doudna for the development of CRISPR-Cas9 genetic scissors, a method for genome editing.



CRISPR stands for clustered regularly interspaced short palindromic repeats. It refers to repeated sequences in bacteria and archaea DNA. These sequences are part of an immune system; if a bacterium survives a viral infection, it adds a section of the virus genetic code to the CRISPR region of its own to serve as a memory in case it's infected again. **Charpentier** and **Doudna** saw that this could be used as a gene editing tool.



The first step in the CRISPR gene editing process is the creation of a strand of guide RNA. This matches the DNA sequence where we want to make a cut. A scissor protein, Cas9, binds to the guide RNA.

The guide RNA searches for the target section of DNA and transports the scissor protein to it. The scissor protein cuts the DNA at this point.

The cell will try and repair the cut DNA. This process is error-prone, disrupting the gene function. If we add a template, the cell will use this to carry out the repair, allowing us to edit the genetic code.

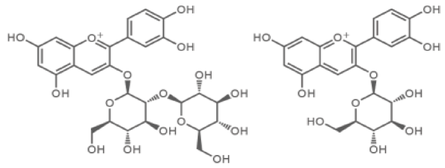
WHY DOES THIS RESEARCH MATTER?

The ability to edit genomes has already found uses in plant breeding. Therapies which use it to treat some types of cancer are already in clinical trials, and it's hoped it may lead to cures for inherited diseases.

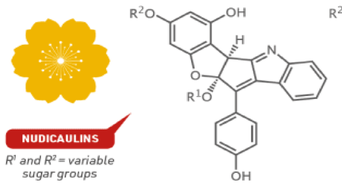
THE CHEMISTRY OF POPPIES: COLOURS AND OPIUM

WHAT CAUSES THE COLOUR OF POPPIES?

The red colour of the common poppy, *Papaver rhoeas*, is due to anthocyanin pigments in the petals. There are a number of different pigments present, including cyanidin 3-sophoroside, commonly known as mecocyanin, and cyanidin 3-glucoside.

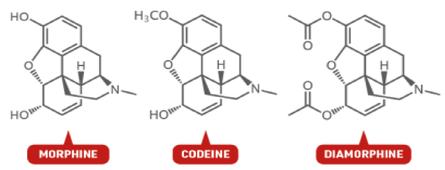


Other red poppies also contain anthocyanins, but some other species of poppy contain additional pigments. The yellow colours of the Iceland poppy (*Papaver nudicaule*), and alpine poppy (*Papaver alpinum*) are due to pigments called nudicaulins.

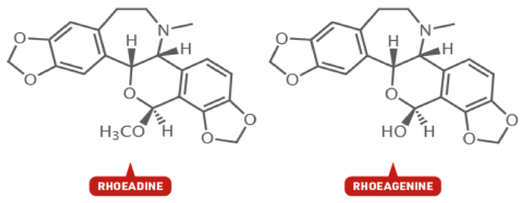


POPPIES, OPIUM AND ALKALOIDS

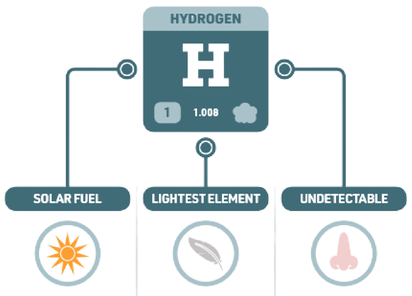
The opium poppy, *Papaver somniferum*, has been used in medicine for thousands of years. A milky fluid, opium, can be extracted from the unripe seed capsule. It contains the alkaloids morphine, codeine and papaverine. Heroin (diamorphine) can be derived from morphine. Both morphine and heroin are powerful and addictive painkillers. In some countries cultivation of opium poppies is illegal.

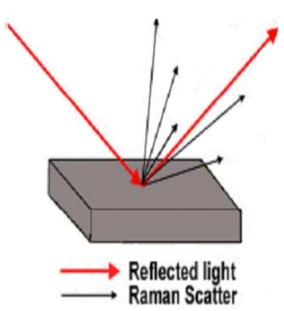


The common poppy contains different alkaloids, including rhoeadine and rhoeagenine. These alkaloids only have very mild pain-killing properties, and are non-addictive.



Atom of the Month

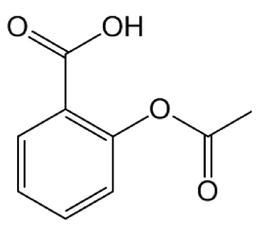




Sir C.V. Raman

Biography
(Click here)
Early Life, Career, Awards and Achievements

Molecule of the Month



Acetyl-salicylic acid

Aspirin
The first Modern Pharmaceutical

Scientist of the Month

Nāgārjuna (नागार्जुन)
Indian metallurgist & alchemist

CHEM QUIZ

Website of the Month

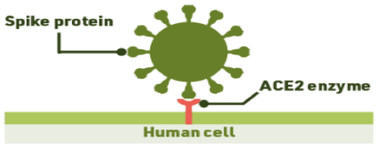
Compound Interest

CHEM VS. COVID TIMELINE

FEB 2020

Structures of SARS-CoV-2 spike protein published

What is the spike protein?



The spike protein binds to an enzyme (ACE2) found in cell membranes in parts of our body including the lungs. This helps the virus enter cells, initiating infection.

Subunit 1
The part of the protein that binds to the ACE2 enzyme.

Subunit 2
The part of the protein that fuses with the human cell membrane, helping the virus enter the cell.

Sugar molecules called glycans coat the spike proteins, camouflaging them from our immune system as they enter the body.

From February 2020, studies identified structures of the SARS-CoV-2 spike protein using electron microscopy. Scientists at the University of Texas were amongst the first to determine the structure.

How did it help?

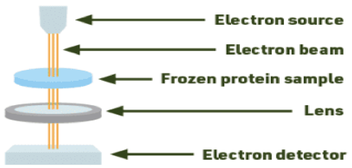
Vaccines
Many vaccines for COVID-19 depend on the spike protein. For example, the Novavax vaccine uses nanoparticles made up of spike proteins.

Treatment
Knowing the structure of the spike protein lets researchers identify drugs which could target it. This could lead to new treatments for COVID-19.

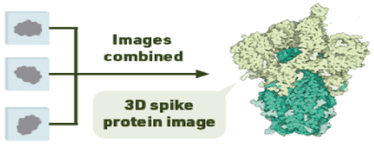
Understanding mutations
Some mutations can introduce changes to the spike protein structure. Knowing its original structure lets us identify how these changes affect it.

Determining the structure

Cryo-electron microscopy (cryo-EM) uses the deflection of electrons to determine the structure of the protein.



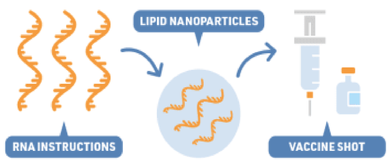
Thousands of 2D images are combined to make a 3D, atomic-scale image of the protein. This lets us understand how the protein helps the virus infect our cells, and how medicines might interact with it.



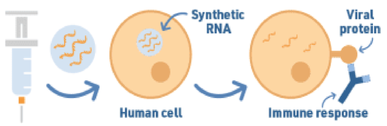
WHAT ARE RNA VACCINES AND HOW DO THEY WORK?

WHAT ARE RNA VACCINES?

The genetic code of the SARS-CoV-2 virus is made up of RNA. Scientists isolated the part of this genetic code that contains the instructions for making the virus's spike protein.



Synthetic RNA which codes for the virus spike protein is packed in lipid nanoparticles (very small fat droplets). This stops our bodies' enzymes breaking it down and helps our cells take it in.



Once the synthetic RNA is inside one of our cells, the cell follows the RNA instructions to produce the virus spike protein. Its production then triggers an immune response in our bodies.

RNA VACCINES: BENEFITS AND CHALLENGES

VACCINE PRODUCTION
RNA is easy to make in a lab, so RNA vaccines can be developed quicker than other vaccines.

SAFETY OF THE VACCINES
RNA can't cause infection and is broken down by normal processes in our cells. An RNA vaccine hasn't been licensed for use in humans before but they've been under development for several years for other viruses, including influenza, HIV, and Zika.

STORAGE AND TRANSPORT
Some RNA vaccines must be stored at low temperatures to remain stable, which makes storage and transport more challenging.

RNA VACCINES FOR COVID-19

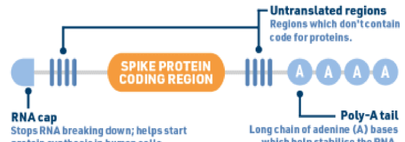
Several proposed vaccines for COVID-19 are RNA vaccines. They can be based on two different types of RNA.

mRNA vaccines	saRNA vaccine
Moderna Pfizer & BioNTech CureVac	Imperial College Arcturus

mRNA AND saRNA: WHAT'S THE DIFFERENCE?

The structures of mRNA and saRNA are similar but have a key difference, as the diagrams below show.

mRNA mRNA stands for messenger ribonucleic acid



saRNA saRNA stands for self-amplifying ribonucleic acid

As saRNA produces more copies of itself once it's in a cell, it can be given in smaller doses than mRNA vaccines. This makes the cost per dose lower and means higher numbers of doses can be produced from the same volume of vaccine.

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