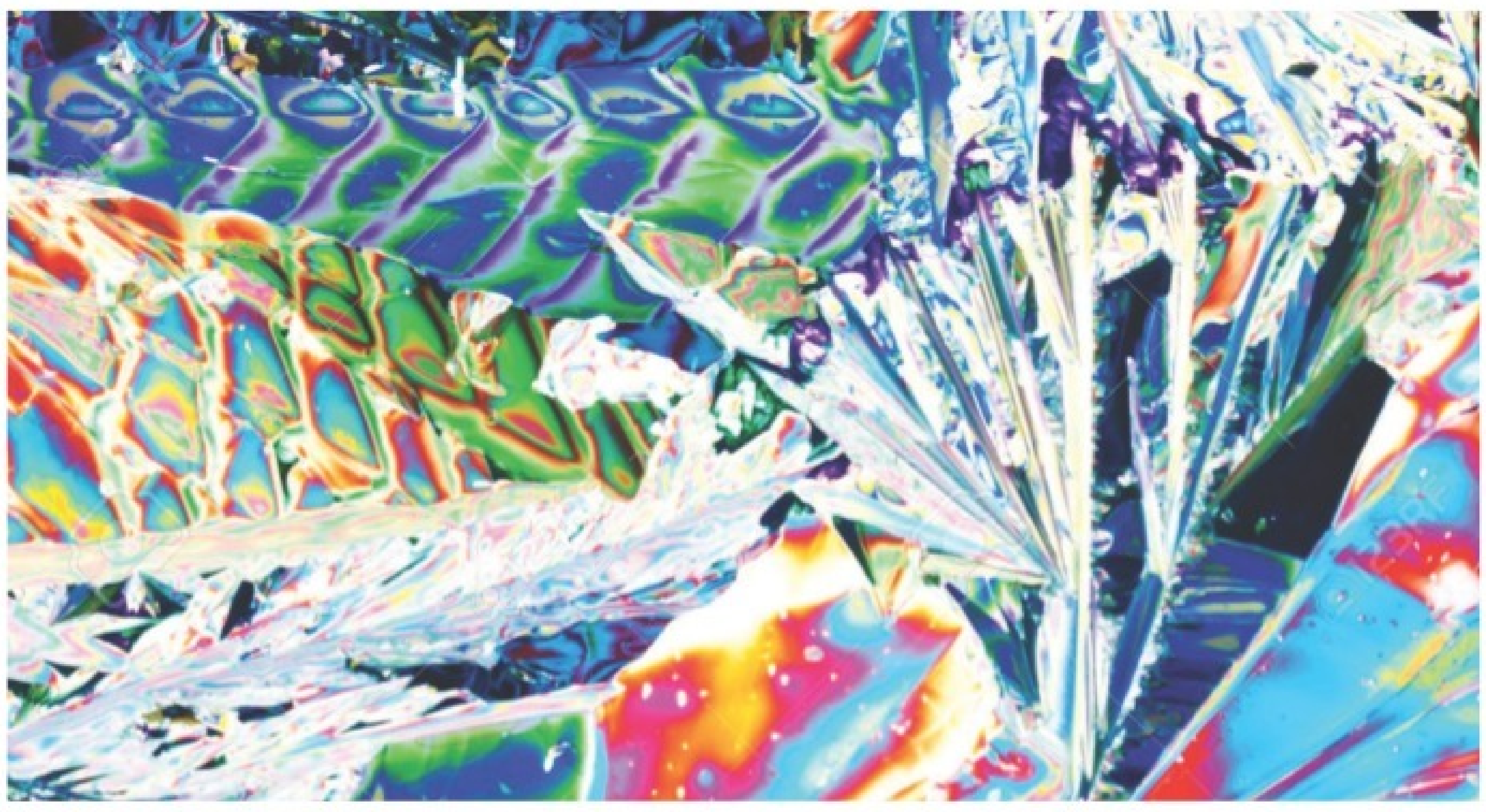
Recognising unrecognised patterns

Training in the arts may be another tool in scientists' bag of tricks


The crystals of tartaric acid in polarised light

S ANANTHANARAYANAN

The progress of science has been marked by extraordinary people who recognised patterns, which others could not. That capacity was not entirely a "gift" but came from scholarship in the sciences and facility in abstract thinking, as in mathematics.

Acuity of perception is also believed to be sharpened by practice of music, dance or the visual arts. Joseph Gal, professor at the School of Medicine, University of Colorado at Aurora, Colorado, US, describes in the journal, *Nature Chemistry*, how proficiency in drawing portraits perhaps helped the young Louis Pasteur to spot some structural features in crystals, which were missed by capable scientists before him.

Pasteur is best known for discovering the principles of vaccination, microbial fermentation and pasteurisation. His contribution, however, is also formidable in chemistry, and his discoveries about the structure of tartaric acid crystals laid the bases of understanding the structure of organic compounds. Gal, in his article, suggests that Pasteur's proficiency in art helped him visualise the geometry of crystals and identify the two forms — looking alike but distinct — that tartaric acid could take.

The background of the work with tartaric acid is the different effects that transparent materials have on light that passes through them. One effect, of course, is colour — the material allows some colours but not others. And another is the speed of light during its passage through the material. It is because light is a little slower when it passes through glass, than through air, that we have lenses, prisms, telescopes and microscopes. And because the speed of light through a material is different for different colours of light, a prism splits light into rainbow colours. Indeed, it is for this reason that droplets of water in the sky bring about the rainbow.

An important aspect of the nature of light is that it is a wave, a lot like the waves in the sea or ripples on the surface of a pond. We can readily see that these waves are not flows of water but are the regular up-down movements of particles of water that stay essentially at the same place. The light wave also consists of electric and magnetic effects that vary not in the direction of the beam of light but in the transverse plane. Unlike particles of water, which move only up and down, however, electromagnetic effects can vary up-down, right- left, or in any other direction, except along the direction of the beam itself.

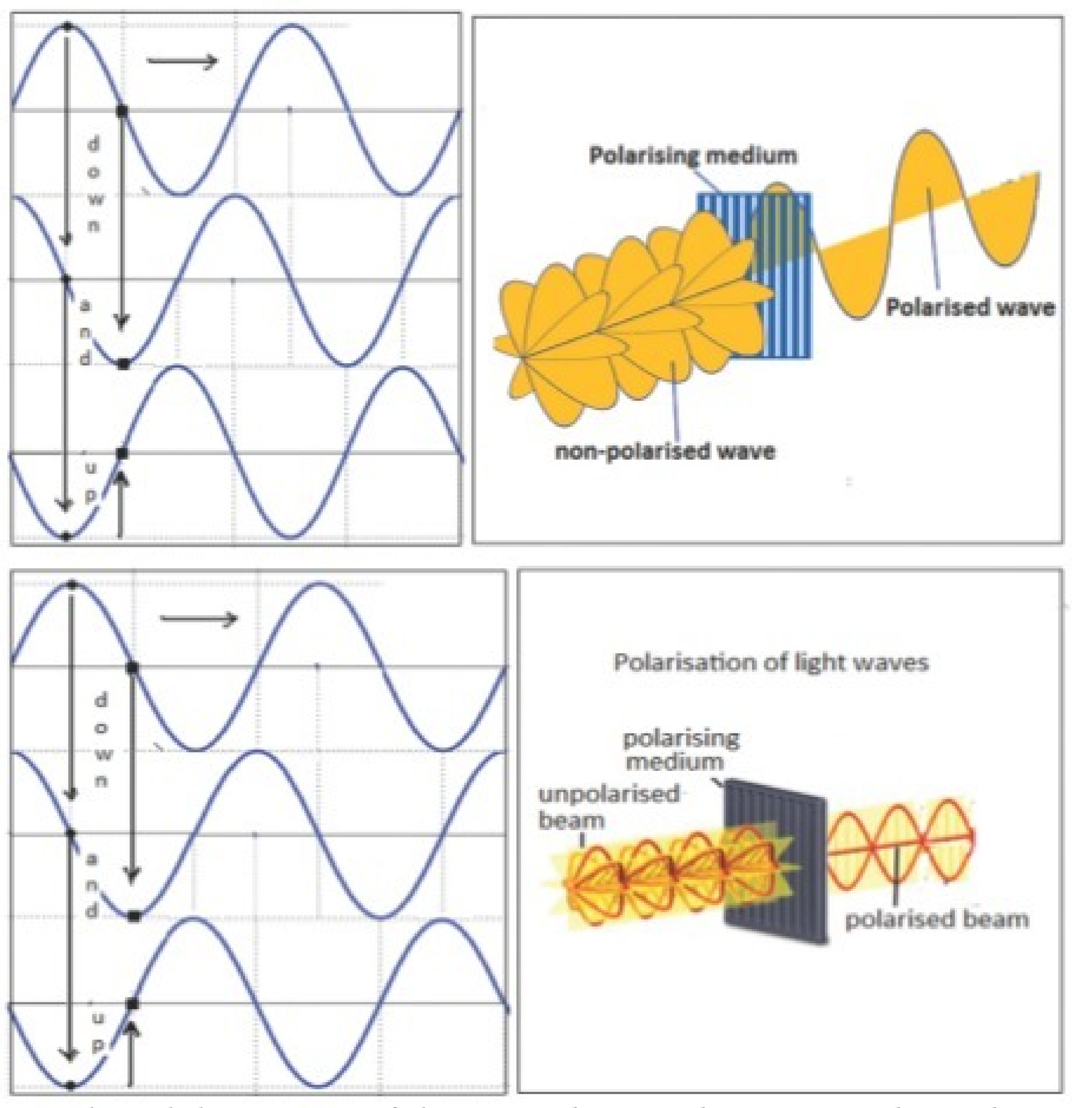
And then, there are materials in which light has a different speed for the waves whose components move up-down, as against right-left, with respect to an axis of the material. Different parts of the light falling on a sheet of such a material would hence bend by different angles and a beam could be split into two beams, each with different axes of vibration. Each such beam, with a single axis of vibration, is known as a polarised beam, as opposed to normal light, which has light vibrating along all axes.

When a beam that has been polarised, or consists of waves along a specific plane, is passed through a class of "optically active" materials, the electric and magnetic parts get slowed down to different extents. The result is that the two kinds of vibration fall out of step and the axis of polarisation is turned by an angle, which depends on the material and the thickness of the sheet of the material. And then, depending on the material, the change in the axis of polarisation can be to the left or right. Materials that change the axis to the right are called "dextrorotatory" and those that turn the axis to the left are "laevorotatory".

Tartaric acid or TA is an organic acid, which is to say that it is based on carbon, like methane, benzene, and living things. Thus TA naturally occurs in plants and is found in wine lees. Jean Baptiste Biot had discovered in 1832 that tartaric acid solutions were optically active and dextrorotatory. A puzzling feature, however, was that TA, derived from natural sources like from wine lees, showed activity but TA synthesised in the laboratory did not show any.

Pasteur, then just 25 years old, took the work forward and began to examine the crystals of tartaric acid and its salts. He found that the crystals were not completely symmetric, but displayed "handedness". This is like our right and left hands, which are built in the same way and match when they are placed against each other, but not if placed one on the other. This is not to say that one hand cannot be re-oriented, or turned around, so that it appears to be the same as its mirror image.

Pasteur found that synthetically formed crystals of tartrate salts could be distinguished as two distinct types, and one crystal type was the mirror image of the other. Painstaking separation of the crystals and testing their effect on light that was passed through their solutions revealed that one kind was dextrorotatory, the other kind was laevorotatory, and a mixture of the two, which had equal portions of the two kinds of tartrate, was not optically active!



The subtle property of the two forms of crystals of the same substance — that they formed in the same way — but were still non-super imposable, except through a mirror, led Pasteur to the conclusion that molecules themselves had two forms — not symmetrical but mirror images of each other. This was in 1849. A whole 25 years later, in 1874, van't Hoff and Le Bel proposed a mechanism and the structure of the two molecular forms is now well known.

The science of these alternate forms of molecules is now an important field of stereochemistry and is applied in designing drugs or reagents, which retain the properties of one form but avoid shortcomings, like side effects because these cannot arise in the alternate form. Today, we have sensitive methods to measure wavelengths of infra-red light that molecules absorb or emit, or to investigate crystals by interference of X rays. But Pasteur worked out the basics of asymmetric molecules from just visual examination of crystals, "with tweezers and a magnifying glass," at a time when modern methods were not there. And almost as soon as he entered the field of study, in which others had been long immersed, he observed a feature that had eluded them.

Gal has studied Pasteur's work in detail and has written extensively on the subject. He says in the paper that Pasteur was as much an artist as he was a scientist. Till the age of 20, Pasteur was a committed artist who created portraits and lithographs. While creating an accurate likeness sensitises the creator to symmetries, shades and proportions, creating prints using lithography calls for the original impression on the lithograph to be a mirror image of the subject. The practice surely enabled Pasteur to visualise shapes and structures and to see how a detail of asymmetry could be the reason for differences in optical activity.

The well-known example of the artist-scientist is Leonardo da Vinci, with interests in painting, sculpting, architecture, literature, anatomy, cartography, history and writing, apart from the sciences. And there are more instances — Albert Einstein was trained in the violin since the age of five.

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PLUS POINTS

Good genes to thank

In the sun-kissed village of Anogia in northern Crete, people live long and healthy lives. But this is not further evidence of the benefits of a Mediterranean diet as they enjoy food rich in animal fat that would otherwise be expected to cause high levels of heart disease and premature death.

Now scientists have discovered the Cretan villagers' secret — they have a genetic variant that protects them against the harmful effects of "bad" fats and "bad" cholesterol. It is thought this particular genetic make-up may be almost unique to the population of Crete's Mylopotamos area.

Previous genome sequencing of thousands of Europeans found just one copy of the variant in a single individual in Tuscany, Italy. A separate variant in the same gene has also been found to be associated with lower levels of bad fats in the Amish population in the US.

This is obviously good news for people concerned, but it could also lead to new ways to treat cardiovascular disease in those not fortunate to be blessed by a similar genetic inheritance.

One of the researchers, Eleftheria Zeggini of the Wellcome Trust Sanger Institute in Cambridgeshire, told The Independent, "This gives us an increased understanding of the biological processes behind the regulation of cholesterol levels in the blood that we know are bad for you." However, she added that this would be sometime "further down the line" with more research needed.

"This is the start of a long journey," Zeggini said. And she was clear that this would not lead to a happy future when people could gorge themselves on a high-fat diet without consequences. "Absolutely not," she said. "This is not a licence to eat and drink as much as one likes because cardiovascular disease is a combination of environmental and genetic factors.

The research was published in the journal, *Nature Communications*.

Ian Johnston/The Independent

Our remarkable brain

A study of women in India who learned to read in their 30s shows the human brain's incredible capacity to reorganise and transform itself, researchers said recently.

Researchers recruited women in India to see what they could learn about the areas of the brain devoted to reading. At the start of the study, most of the women could not read a word of their mother tongue, Hindi.

But after six months of training, the women reached a level comparable to first grade proficiency.

"This growth of knowledge is remarkable", said Falk Huettig from the Max Planck Institute for Psycholinguistics, lead author of the study in the journal, *Science Advances*.

"While it is quite difficult for us to learn a new language, it appears to be much easier for us to learn to read. The adult brain proves to be astonishingly flexible."

Specifically, researchers found that the exterior of the brain — known as the cortex, which is able to adapt quickly to new challenges — was not the main area where transformation occurred.

Instead, researchers found that reorganisation took place deep inside the brain, particularly in the brainstem and thalamus, a walnut-sized structure that relays sensory and motor information. Researchers found that the more signals aligned in the affected brain regions, the better the women's reading skills became.

The finding could also have implications for the treatment of dyslexia, which some researchers have blamed on a malfunctioning thalamus. Co-authors on the study came from the Centre of Bio-Medical Research, Lucknow and the University of Hyderabad.

The Jakarta Post/ANN

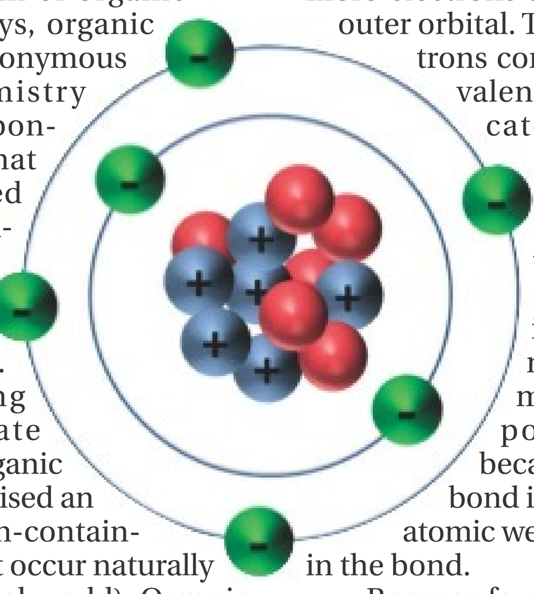
The importance of carbon

Both its valence and low atomic weight confer unique properties on the element

TAPAN KUMAR MAITRA

The chemistry of cells is essentially the chemistry of carbon-containing compounds because the carbon atom has several unique properties that make it especially suitable as the backbone of biologically important molecules. To study cellular molecules really means to study carbon-containing compounds. Almost without exception, molecules of importance to the cell biologist have a backbone, or skeleton, of carbon atoms linked together covalently.

Actually, the study of carbon-containing compounds is the domain of organic chemistry. In its early days, organic chemistry was almost synonymous with biological chemistry because most of the carbon-containing compounds that chemists first investigated were obtained from biological sources (hence the word organic, acknowledging the organismal origins of the compounds).



The terms have long since gone their separate ways, however, because organic chemists have now synthesised an incredible variety of carbon-containing compounds that do not occur naturally (that is, not in the biological world). Organic chemistry therefore includes all classes of carbon-containing compounds, whereas biological chemistry (biochemistry for short) deals specifically with the chemistry of living systems and is, as we have already seen, one of the several historical strands that form an integral part of modern cell biology.

The carbon atom is the most important in biological molecules. The diversity and stability of carbon-containing compounds are due to specific properties of the carbon atom and especially to the nature of the interactions of carbon atoms with one another as well as with a limited number of other elements found in molecules of biological importance.

The single most fundamental property of the carbon atom is its valence of four, which means that the outermost electron orbital of the atom lacks four of the eight electrons needed to fill it completely. Since a complete outer orbital is required for the most stable chemical state of an atom, carbon atoms tend to associate with one another or with other electron-deficient atoms, allowing adjacent atoms to share a pair of electrons. For each such pair, one electron comes from each of the atoms. Atoms that share each other's electrons in this way are said to be joined together by a covalent bond. Carbon atoms are most likely to form covalent bonds with one another and with atoms of oxygen, hydrogen, nitrogen, and sulphur.

The electronic configurations of several of these atoms are such that in each case, one or more electrons are required to complete the outer orbital. The number of "missing" electrons corresponds in each case to the valence of the atom, which indicates, in turn, the number of covalent bonds the atom can form. Carbon, oxygen, hydrogen, and nitrogen are the lightest elements that form covalent bonds by sharing electron pairs. This lightness, or low atomic weight, makes the resulting compounds especially stable, because the strength of a covalent bond is inversely proportional to the atomic weights of the elements involved in the bond.

Because four electrons are required to fill the outer orbital of carbon, stable organic compounds have four covalent bonds for every carbon atom. Methane, ethanol, and methylamine are simple examples of such compounds, containing only single bonds between atoms. Sometimes, two or even three pairs of electrons can be shared by two atoms, giving rise to double bonds or triple bonds. Ethylene and carbon dioxide are examples of double-bonded compounds. Triple bonds are found in molecular nitrogen and hydrogen cyanide.

Thus, both its valence and its low atomic weight confer on carbon unique properties that account for the diversity and stability of carbon-containing compounds and give it a pre-eminent role in biological molecules.

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Ability to proliferate

Scientists have revealed that limitless blood supplies are 'tantalisingly close' to becoming reality

IAN JOHNSTON

Scientists believe they are "tantalisingly close" to being able to make a "limitless supply" of blood to treat people with blood disorders and immune condition and help give transfusions.

For nearly 20 years, researchers have been trying to find a way to turn stem cells — which can create any kind of cell — into blood artificially. Now a team of researchers has managed to create a mix of different types including blood stem cells that produced various different kinds of human blood cells when put into mice.

Ryohichi Sugimura, a postdoctoral fellow at the Daley Lab in Boston Children's Hospital in the US, said, "This step opens up an opportunity to take cells from patients with genetic blood disorders, use gene editing to correct their genetic defect and make functional blood cells.This also gives us the potential to have a limitless supply of blood stem cells and blood by taking cells from universal donors."

And fellow researcher George Daley, who heads the lab and is also the dean of Harvard Medical School, added, "We're tantalisingly close to generating bona fide human blood stem cells in a dish. We're now able to model human blood function in so-called 'humanised mice'. This is a major step forward for our ability to investigate genetic blood disease."

A second team of researchers, led by Professor Shahin Rafii, of Cornell University, also managed to turn adult mouse cells into mouse blood stem cells. And when mice whose immune system had been removed were given the blood stem cells, they regained immune blood cells. If this could be reproduced in humans, it could provide a way of treating a range of immune disorders.

Both studies were described in separate papers in the leading journal *Nature*.

One potential problem with using stem cells in this way is the chance they could become cancerous. Caroline Guibentif, an expert at Cambridge University, who co-wrote a commentary in Nature about the two research papers, stressed that both represented "a huge breakthrough".

"People have been trying to do this for 20 years unsuccessfully," she told The Independent, "This is the first time … They have got cells that can self-renew and give rise to all sorts of blood cells, so of course it's a big step towards the goal, but we are not quite there yet." She said both teams had turned ordinary cells into blood stem cells using genetic techniques.

One key property of stem cells is the ability to self-renew, to make copies of themselves. But Guibentif explained, "Self-renewal, this ability to proliferate is also a characteristic of tumours. You are introducing in a cell genes that induce the ability to proliferate."

Neither team found evidence of cancer being caused by the technique but because mice are relatively short-lived compared to humans, there is a need to do more research to establish if this might become a problem at a later stage.

"When you use mice, they only live up to a year and a half or so. Humans develop cancer partly because they have a long lifespan. We are talking about different timescales," Guibentif said, "Whatever works in a mouse, this is one of the reasons we need to double check it in a more thorough way."

The technique used would also have to be made more efficient, she suggested, saying it would be "years, definitely" before it could be used to treat humans.

The Independent