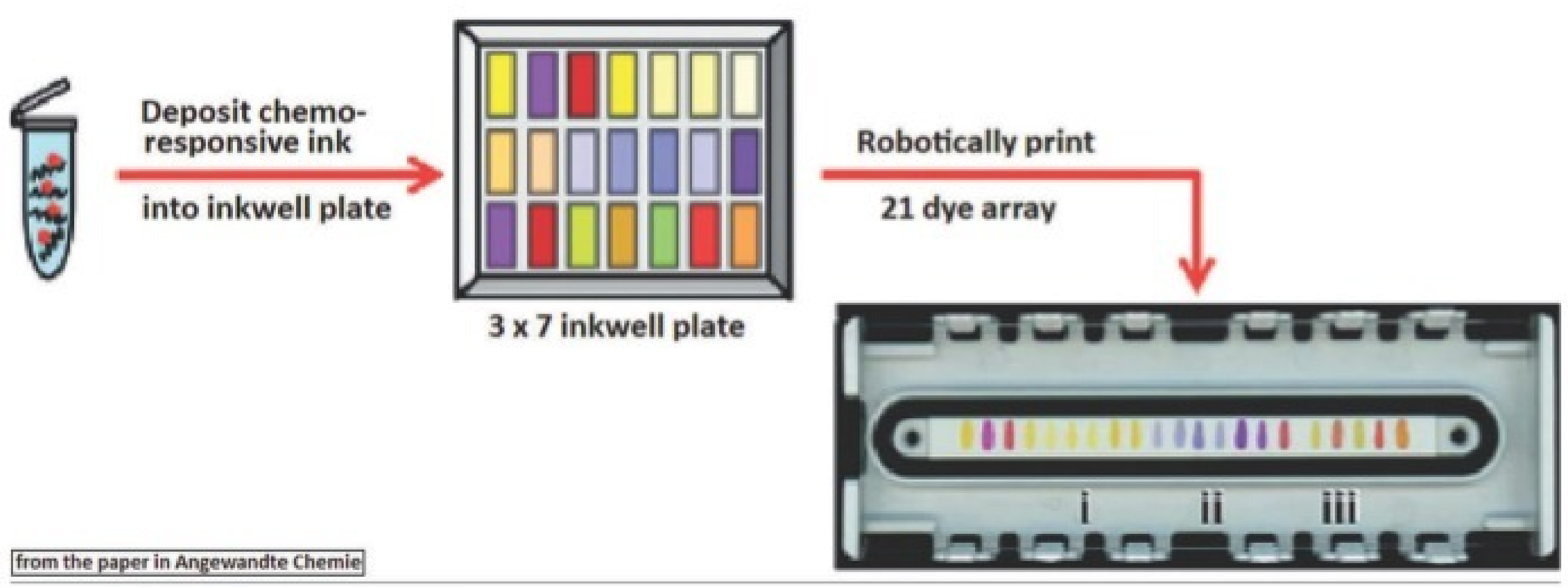
A man-made nose to sample wine

Human olfactory nerves and taste buds can make out a great number of aromas and flavours



from the paper in Angewandte Chemie

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The taste buds can tell the difference between levels of salt, sweet, sour, bitter and a broth-like feeling called umami. The great many combinations that are possible make for the variety of cuisines and the wide canvas for the chef's palette. The nerve endings in the nose, in comparison, are believed to differentiate well over a trillion kinds of odours. Smell is hence a sensitive medium of communication, and this is true of all living things.

Zheng Li, Ming Fang, Maria K LaGasse, Jon R Askim, and Kenneth S Suslick, from University of Illinois at Urbana-Champaign and National Institute of Standards and Technology Gaithersburg, US, report in the journal, *Angewandte Chemie (International Edition)*, their success in building a laboratory version of the nose — an array of sensors, which can rapidly analyse vapours and identify the sources by comparison with an odour dictionary. The method was found to work with 10 different kinds of alcoholic drinks and promises wider application.

The way taste buds and olfactory (related to smell) nerves of the body function is by being sensitive to chemicals that cause tastes or smells. The smell-sensitive tissue in the lining of the nose has six or more different cell types, which react to classes of molecules. Substances that produce odours dissolve in the mucus in the nose and their molecules attach to specific shapes presented by smell-sensitive nerve cells. This brings about reorganisation of electric charges and the nerve cell sends out a message that is received by the brain. The body keeps renewing the lining so that the nose stays sensitive to continuing or fresh smells that come to it.

The sense of smell is perhaps the most sensitive of the senses that animals possess. Eyes and the sense of sight, or ears and sensitivity to sounds, mainly found in larger animals, work at fineness not much better than the millimetre. Smell, however, depends on the detection of single molecules and can hence be extremely sensitive and tuned to be highly specific. Single-celled animals, like bacteria, communicate only by exchange of chemical signals and millions of small organisms, insects and animals conserve energy by using smells to pass messages. Moths use smells to attract mates from kilometres away. Ants are well known to navigate or follow trails created by smells. The legendary capacity of the dog, which has thousands of times the number of nasal nerve endings of humans, may not rival that of many other animals in nature.

Humans too — although we do not rely on smell in everyday activities — have a sensitive sense of smell. This has given rise to the science of perfumery, on one hand, and specialisation in food and beverages, on another. This is particularly so in the fine art of wine-making and appreciation. While the alcohol in wine arises from fermentation of sugars in grapes, there are other substances which give each wine its character. Along with sugars, many other components of the fruit lead to "congeners" or other products of fermentation. These substances, although they are in traces, significantly alter the taste and aroma of the wine that lands on our table.

Different congeners arise from differences in the strain of the fruit used and depend on the yeast cells that bring about fermentation. It is the strain of yeast, in fact that decides the main mix of alcohols and some other substances produced. The fruit is also important and so is the process of fermentation and bottling. Countries like France and Italy have cultivated vineyards and processes that consistently produce well appreciated wines.

As in many arts, what the artist creates is fashioned by the consumer and the critic. Down the centuries, wine tasting has specialised and vineyards employ highly-paid experts to savour the wine at all stages of production, so that the result has the right mix of congeners. A connoisseur can thus identify a wine, maybe the group of vineyards it came from, the climate in the year of vintage and so forth.

While the wine-taster relies on the flavours, the acid of the alcohol, the astringency of the tannin, the smoothness of glycerol and many other substances, a great part of the character of wine is in the aroma, or the vapours that are released when wine is swirled, first in the glass and then in the mouth. It is with the help of the nose, or smell sensitive areas in the whole nasal cavity, that fine wines are appreciated and judged.

Identifying volatiles is generally an efficient way of analysing or detecting different substances. While one application is in analysis, to find out the proportions of the components of unknown mixtures or the intermediates in a process, another is to detect leaks or toxins or concealed substances like drugs in airline baggage. There are even applications in medicine, of detecting things that point to diseases, or in pathology.

Mechanised or laboratory arrangements for these purposes mimic the natural method by creating an array of detectors of different target volatiles. In the place of the effect of volatile molecules on cells, the method of detection is by recording changes in colour of reagents when an array of them is exposed to the vapour. The changes may happen spontaneously or on "developing", like when viewed in UV light. The patterns of colour changes, to the extent that they are unique to the volatiles, then become their "fingerprints".

The "electronic nose", as these arrangements, which can print out the name of the substance, are called, however, need to integrate the sensors of volatiles with the remaining circuitry and the sensors need to be reusable. This places a limit on what reactions are permitted and hence on the sensors' sensitivity. The arrangements are also affected by the humidity in the environment and often fail to detect closely related volatiles, the paper in *Angewandte Chemie* says.

To improve the available discriminatory power, the team explored the vista of existing reagents and zeroed in on compounds that changed colour in characteristic ways when exposed to volatiles, at levels which went down to parts per million. An array of chemically sensitive inks was then exposed to vapours containing groups of common fermentation congeners, called aldehydes and ketones. A sensor array with 21 plates threw up, within a two-minute exposure, patterns that identified the different aldehydes and ketones. Over 155 trials with random volatiles present only at parts per million, and even down to 40 parts per billion, the identification success was over 99.4 per cent.

To examine the value of the method for the food and beverage industry, it was tried out with commonly used alcoholic drinks. In the same way as vapours rise from wine, distilled spirits like Scotch whiskey also have distinctive vapour signatures. "Each type of liquor has its own distinct aroma produced during production and aging in wood barrels that arise from a highly diverse set of compounds….," the paper says.

The colour detection array used was expanded to 36 elements, with the capacity to detect more than just aldehydes and ketones and it was tried with a set of different whiskies, brandy and vodka. The successful results showed that the method had "promising applications in the food and beverage industry for quality control and assurance," the paper says.

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Cargo carriers

Microscopic versions of silkworm cocoons could help in treating diseases

Researchers have helped manufacture microscopic versions of the cocoons spun by silkworms, in order to store sensitive proteins — technology, which could be used in pharmaceuticals to treat a range of debilitating illnesses.

The tiny capsules, which are invisible to the naked eye, can protect sensitive molecular materials and could prove a significant technology in areas including food science, biotechnology and medicine. The capsules were made by researchers from the University of Cambridge with help from engineers at the University of Sheffield, using a specially-developed micro-engineering process that combines the power of micro-fluidic manufacturing with the value of natural silk.

The process mimics on the microscale the way in which *Bombyx mori* silkworms spin the cocoons from which natural silk is harvested. The resulting micron-scale capsules comprise a solid and tough shell of silk nano-fibrils that surround and protect a centre of liquid cargo, and are more than a thousand times smaller than those created by silkworms.

Writing in the journal *Nature Communications*, the team suggests that those "micro-cocoons" are a potential solution to a common technological problem — how to protect sensitive molecules that have potential health or nutritional benefits but can easily degrade and lose those favourable qualities during storage or processing.

The study argues that sealing such molecules in a protective layer of silk could be the answer, and that silk micro-cocoons that are far too small to see (or taste) could be used to house tiny particles of beneficial molecular "cargo" in various products, such as cosmetics and food. The same technology could also be used in pharmaceuticals to treat a wide range of severe and debilitating illnesses. In the study, the researchers successfully showed that silk micro-cocoons can increase the stability and lifetime of an antibody that acts on a protein implicated in neurodegenerative diseases.

The work was carried out by an international team of academics from the Universities of Cambridge, Sheffield and Oxford in the UK; the Swiss Federal Institute of Technology in Zurich, Switzerland and the Weizmann Institute of Science in Israel. The study was led by Professor Tuomas Knowles, a Fellow of St John's College at the University of Cambridge and co-director of the Centre for Protein Misfolding Diseases.

"It is a common problem in a range of areas of great practical importance to have active molecules that possess beneficial properties but are challenging to stabilise for storage," said Knowles, "A conceptually simple, but powerful, solution is to put these inside tiny capsules. Such capsules are typically made from synthetic polymers, which can have a number of drawbacks, and we have recently been exploring the use of fully natural materials for this purpose.

"We are particularly excited by the potential to replace plastics with sustainable biological materials for this purpose."

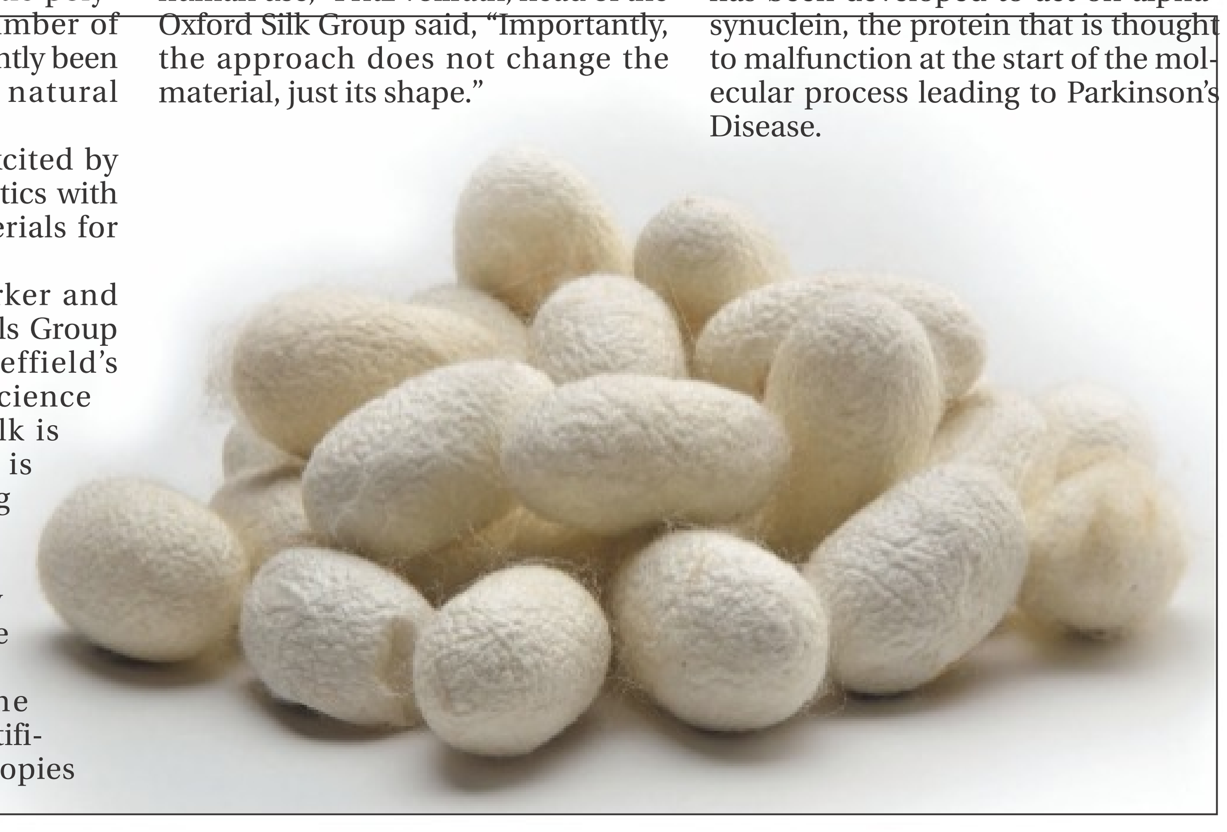
Chris Holland, co-worker and head of the Natural Materials Group from the University of Sheffield's department of materials science and engineering, said, "Silk is amazing because whilst it is stored as a liquid, spinning transforms it into a solid. This is achieved by stretching the silk proteins as they flow down a microscopic tube inside the silkworm."

To imitate this, the researchers created a tiny, artificial spinning duct which copies the natural spinning process to cause the unspun silk to form into a solid. The researchers then worked out how to control the geometry of this self-assembly in order to create microscopic shells.

Making conventional synthetic capsules can be challenging to achieve in an environmentally friendly manner and from biodegradable and biocompatible materials. Silk is not only easier to produce; it is also biodegradable and requires less energy to manufacture. "Natural silk is already being used in products like surgical materials, so we know that it is safe for human use," Fritz Vollrath, head of the Oxford Silk Group said, "Importantly, the approach does not change the material, just its shape."

Silk micro-cocoons could also expand the range and shelf-life of proteins and molecules available for pharmaceutical use. Because the technology can preserve antibodies, which would otherwise degrade, in cocoons with walls that can be designed to dissolve over time, it could enable the development of new treatments against cancer, or neurodegenerative conditions such as Alzheimer's and Parkinson's Diseases.

To explore the viability of silk microcapsules in this regard, the researchers successfully tested the micro-cocoons with an antibody that has been developed to act on alpha-synuclein, the protein that is thought to malfunction at the start of the molecular process leading to Parkinson's Disease.



Cellular processing

Ribonucleic acid molecules must undergo chemical changes before they can function in the cell

TAPAN KUMAR MAITRA

ARNA (ribonucleic acid) molecule newly produced by transcription, called a primary transcript, must frequently undergo chemical changes before it can function in the cell. We use the term RNA processing to mean all the chemical modifications necessary to generate a final RNA product from the primary transcript that serves as its precursor. Processing typically involves removal of portions of the primary transcript, and it may also include the addition or chemical modification of specific nucleotides.

For example, methylation of bases or ribose groups is a common modification of individual nucleotides. In addition to chemical modifications, other post-transcriptional events, such as association with specific proteins or (in eukaryotes) passage from the nucleus to the cytoplasm, are often necessary before the RNA can function.

Ribosomal RNA, or rRNA, is by far the most abundant and most stable form of RNA found in cells. Typically, rRNA represents about 70-80 per cent of the total cellular RNA, tRNA represents about 10-20 per cent, and mRNA accounts for less than 10 per cent. In eukaryotes, cytoplasmic ribosomes contain four types of rRNA, usually identified by their differing sedimentation rates (denoted by S values) during centrifugation. The smaller of the two ribosomal subunits has a single 18S rRNA molecule; the larger subunit contains three rRNA molecules, one of about 28S (as low as 25S in some species) and the other two of about 5.8S and 5S. In prokaryotic ribosomes, only three species of rRNA are present — a 16S molecule associated with the small subunit and molecules of 23S and 5S associated with the large subunit.

Most eukaryotic genomes have multiple copies of the pre-rRNA transcription unit arranged in one or more tandem arrays, facilitating production of the large amounts of ribosomal RNA typically needed by cells. The human haploid genome, for example, has 150-200 copies of the pre-rRNA transcription unit, distributed among five chromosomes.

After RNA polymerase I has transcribed the pre-rRNA transcription unit, the resulting pre-rRNA molecule is processed by a series of cleavage reactions that remove the transcribed spacers and release the mature rRNAs. The transcribed spacer sequences are then degraded. The pre-rRNA is also processed by the addition of methyl groups. The main site of methylation is the 2-hydroxyl group of the sugar ribose, although a few bases are methylated as well. The methylation process, as well as pre-rRNA cleavage, are guided by a special group of RNA molecules, called snoRNAs (small nucleolar RNAs), which bind to complementary regions of the pre-rRNA molecule and target specific sites for methylation or cleavage.

Pre-rRNA methylation has been studied by incubating cells with radioactive S-adenosyl methionine, which is the methyl group donor for cellular methylation reactions. When human cells are incubated with radioactive S-adenosyl methionine, all of the radioactive methyl groups initially incorporated into the pre-rRNA molecule is eventually found in the finished rRNA products, indicating that the methylated segments are selectively conserved during processing.

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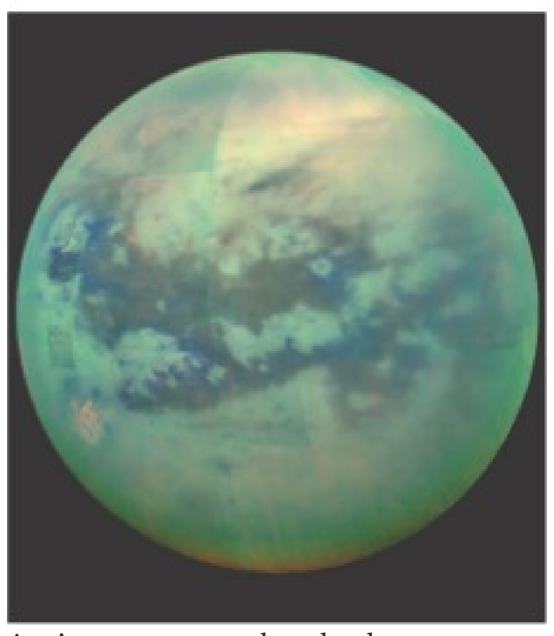
PLUS POINTS

Titanic possibilities



An important molecule that can produce life and organic material has been found in our solar system. Scientists have been shocked to find that the Cassini spacecraft spotted the chemicals, central to pre-biotic chemistry, on Saturn's moon Titan. And it could mean that we are getting an up-close view of the very beginnings of life.

Cassini is conducting the grand finale before it plunges to its death, which will see it dive into the surfaces of Saturn and destroy itself, ensuring that it can't spread around our solar system. But before then, it's doing some of the most important work it has done — flying close to Saturn and its moons and studying them.

It found in one of those flyovers that Titan appears to host carbon chain anions. Those are the building blocks of more complex molecules, and could have served as the beginning of life on Earth.

As well as lifting hopes for the chances of finding life in our own solar system and elsewhere, the discovery is re-shaping scientists' understanding of the mysterious moon. They didn't expect to find the molecules there at all because negatively charged carbon chain anions are so reactive, they don't last long in the atmosphere.

The chemicals are very basic, and are far from suggesting life. But they suggest that Titan might be far more developed — and better at hosting life — than we had ever realised before. They also mean that other atmospheres that are like Titan's could be capable of hosting their own life.

Ravi Desai, study lead author and PhD student at University College London, "This is a known process in the interstellar medium — the large molecular clouds from which stars themselves form — but now we've seen it in a completely different environment, meaning it could represent a universal process for producing complex organic molecules. The question is could it also be happening at other nitrogen-methane atmospheres like at Pluto or Titan, or at exoplanets with similar properties?"

Titan is similar to what we think our own Earth was like in its early stages. As such, it could be an important way of watching how life might have developed on our planet.

The independent

Just as accurate

Spiders have surprisingly human traits, with personalities that determine if they make decisions hastily or cautiously. But while a person who rushes into a decision might be more likely to make a mistake, an impulsive spider is just as accurate as a docile one, a study by researchers at the National University of Singapore has found.

The study was conducted on Portia labiata, a species of jumping spider — an invertebrate known for its high cognitive ability. It found that aggressive individuals made decisions three to four times faster than their docile counterparts, but were just as accurate in hunting down their prey.

The researchers distinguished the spiders' personalities by stroking them with a brush. Those that attacked the brush were categorised as aggressive, while those that avoided the brush were categorised as docile.

The findings of the study were published recently in the scientific journal *Behavioral Ecology*. In another study on Portia labiata, aggressive and docile spiders had varying success in catching prey that displayed predictable and unpredictable traits. "The results showed that aggressive predators fared better when catching prey with unpredictable behaviour, while docile predators performed much better when catching prey with predictable behaviour," said Chang Chia-chen, a PhD student from NUS, who is the first author of both studies.

The straits times/ann