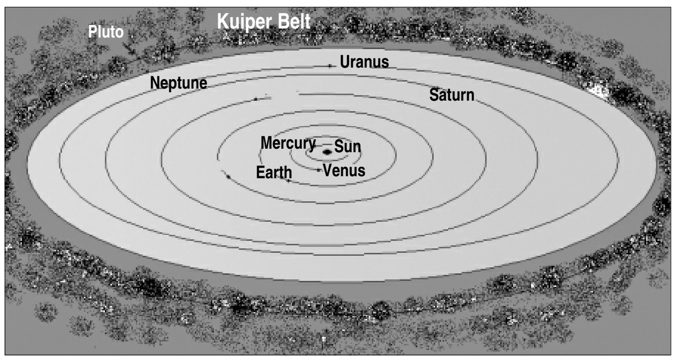
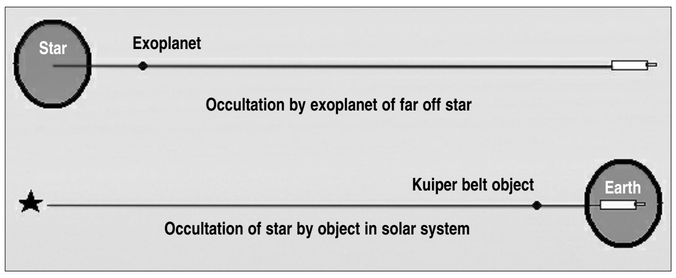
Sighting shadows in the dark

Methods of recent vintage used to study planets of distant stars have helped provide a very close look into the solar system, says **S Ananthanarayanan**



IT is difficult to view a planet of a distant star because of the glare of the star's own light, which is what is reflected off the planet. The planet's existence has then to be deduced by indirect methods. But one partially direct method is to spot the planet as it passes in front of the star. When this happens, a bit of the star's light is blocked by the planet and the drop in intensity can be detected.

It is also possible to collect information about the kind of light that the atmosphere of the planet absorbs and this helps make conjectures about the planet's composition. In order to refine how this is done, a team of scientists at the Institute of Astrophysics in La Laguna, Tenerife, in Spain has studied the kind of sunlight that the earth's atmosphere transmits. To do this, the scientists had to wait for a lunar eclipse and examine the light transmitted through the earth's atmosphere, to the moon, and reflected back!



The occultation

An object coming between a star and the observer is an occultation. The object, which *hides* the star is said to *occult* the star. The observer, on whom the shadow of the object is cast, is said to be *eclipsed*. The moon coming between the earth and the sun is an occultation. When the earth is between the sun and the moon, to hide the moon in the earth's shadow, it is an eclipse of the moon.

Occultation is an event that enables a sensitive study of the object in the middle. In the case of the total eclipse (actually occultation) of the sun by the moon, we are able to study the sun's corona undisturbed by the glare of the sun. But in all other occultation, the star is much larger than the object in between and it is the object that comes under the "microscope".

When a planet is moving across the face of its star, or the moon before the sun, the event is well understood and there is ample time to study what is happening. But if a distant star is occulted by a small object on the outskirts of the solar system, which is at a tiny fraction of the distance from the star, it is both difficult to know when the event will happen and also difficult to observe it.

A large group of 41 astronomers has published a paper in the journal *Nature* of accurate measurements of an object only 143 km across through observation of just this kind of occultation. The object studied is one in the *Kuiper Belt*, a collection of particles and small objects, perhaps planetary debris, in orbit around the sun, outside the orbit of Neptune. Pluto, the outermost planet is, in fact, a Kuiper Belt object.

The nature and composition of these objects have been of interest as these relate to the origin of the solar system. Observation using occultation in this region greatly supplements what can be seen using conventional direct observation.

James Elliot.

James Eliot & Co

James Elliot, the inspiration behind the work, first made news by discovering the rings around Uranus though methods of stellar occultation. The rings around Saturn are well known, having been discovered with a rudimentary telescope by Galileo in 1610. But the rings around Uranus are much fainter and had not been viewed till 1977, when they were spotted by chance.

Elliot and others were working with the occultation of a distant star by Uranus to study the planet's atmosphere. But the data surprised them, in that the star seemed to disappear from view a few times before the occultation and again in the same way after the occultation. They concluded it must be a ring system and this has since been confirmed by the *Voyager* spacecraft in 1986.

The occultation method has been refined and is now an exceedingly sensitive means of measurement. Not only are dimensions accurately revealed, variations in the intensity of light transmitted enables measurement of the pressure of gasses in the occulting object, to the accuracy of millibars, which is a thousandth of atmospheric pressure on the earth's surface.

During the past few years, the method of occultation has been used for extensive studies of Pluto, our outermost planet, and Charon, its moon. After successful mapping of Pluto, a group working in William's College, Massachusetts, and others turned their gaze towards other objects in the Kuiper Belt. It was found that one large object known as *2002 TX300* was to occult a distant star and the group prepared to observe the event. This

object was barely 200 km across, before a star many light years away casts a shadow only of its own size on the earth. And with the earth itself moving around the sun at a speed of some 30 km a second, it is challenging to make sure of an effective observation of the occultation. The team had thus to distribute itself at different places over the part of the earth facing the event. The best observations were from Las Cumbres Observatory Global Telescope Network located at an altitude of 10,000 feet at Haleakala Crater on Maui, Hawaii.

Object 2002 TX300

The object viewed is also visible through telescopes and has been studied earlier by conventional methods. It is a remarkably bright object and its size had been estimated at some 200 km. But the occultation method gave a very precise 143 km, give or take just five kilometers. With this reduced size, the brightness of the object indicates that it is highly reflective. The Kuiper Belt is believed to be the remnants of the original orbiting matter from which the planets formed. The object that was viewed by the Williams College team belongs to a group that arose from collisions more than one billion years ago. This antiquity implies that the surface of the object should have weathered and darkened to reflectivity far lower than what is seen.

For the object still to be so reflective suggests that our ideas about the history of the Kuiper Belt need revision. There are thus probably more frequent collisions, or low temperature volcanic activity, and condensation of ices, all of which can make for a shiny surface.

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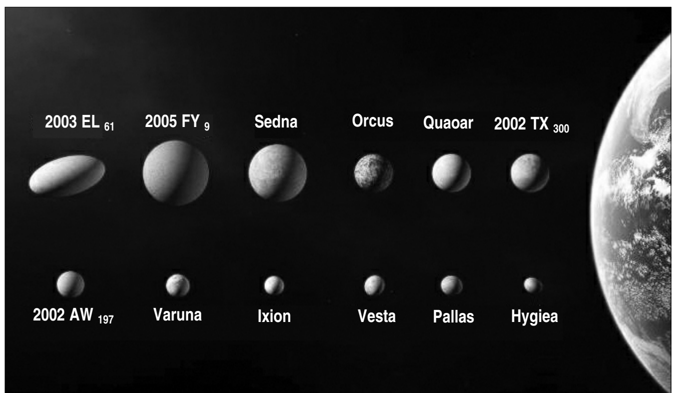
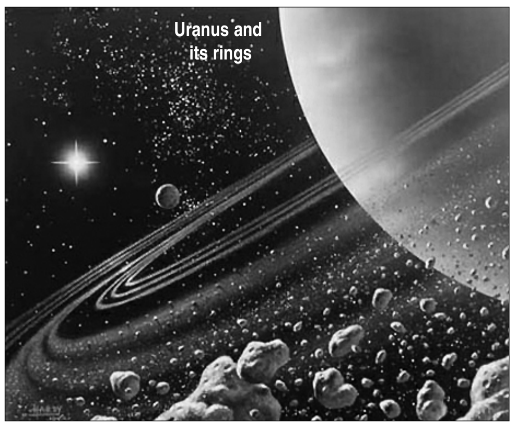


An artist's impression of planet candidates in the solar system



Change and continuity

Current theories of the molecular basis of heredity can be traced back to a long and conflicting history, says **Tapan Kumar Maitra**

IN the modern context, cytogenetics extends beyond an understanding of the transmission and continuity of genes and chromosomes. It is also concerned with the molecular architecture of the chromosome and the terms of genetic function.

The Sutton-Boveri theory makes it evident that there is a striking parallel between genes and chromosomes in the transmission of hereditary potentialities and that each chromosome plays a particular role in its development. It is believed that a parallel must also exist between gene action in the cell and the molecular organisation of the chromosome.

Current understanding of the molecular basis of heredity has a long and conflicting history. As we now know, deoxyribonucleic acid — or DNA — is a key molecule of hereditary uniqueness. As befits its role, it is the only permanently conserved molecular species in the chromosome; the proteins and RNA of the chromosome are transitory.

This molecule, DNA, together with its associated proteins, was discovered in 1890 by the German chemist Miescher, in the nuclei obtained from pus. In 1924 Feulgen demonstrated through specific staining procedures that DNA was localised in the chromosomes. It was not until 1944, however, that DNA was shown to be the crucial molecule of heredity by Avery, McCarty, and McLeod, and it was not until 1953 that its structure was made clear by Watson Crick and Wilkins.

How DNA accomplishes its central role in heredity calls for a protracted analysis; here I need only to caution the reader that it does not perform its genetic functions individually, but only in concert with other nuclear and cytoplasmic constituents. The recent discovery of DNA in plastids and mitochondria has made possible the understanding of cytoplasmic inheritance and the initiation of what might be called cytoplasmic cytogenetics.

Although we should add that we have no knowledge of how DNA is organised and replicated in these organelles; the cell, nevertheless, still remains the smallest indivisible unit capable of displaying all the attributes that, collectively, constitute life.

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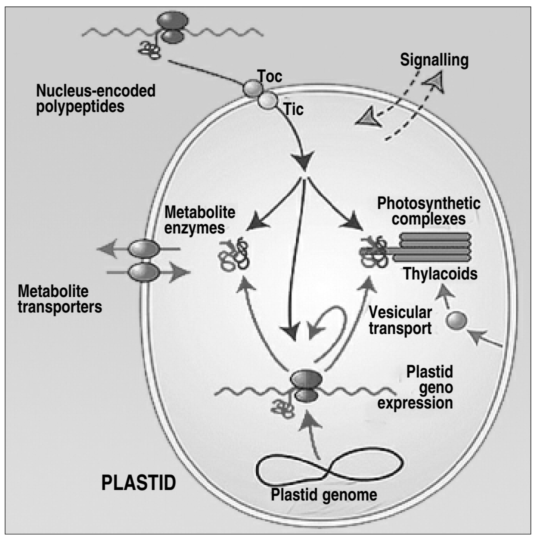

Plastid DNA exists as large protein-DNA complexes.

Why do we enjoy music?

John Powell, a visiting professor of Materials Science at the University of Nottingham, takes **Holly Williams** through the paces

THE sounds of music are not the same as noises. Your ears are there to make sure you stay alive: they're a warning system, designed to analyse sounds for danger. But we can quickly recognise that a musical instrument is unlikely to be lethal. When you hear music, your ear drum moves in and out in a regular, repeated way, many times a second. We recognise that it's not dangerous, so we can focus on the harmonies and tunes – and enjoy them.

If you twang a string, it gives off several related frequencies at the same time. If you twang a second string, and organise it so that some of the frequencies of the two strings are the same, you get a very pleasant sound. We don't always want notes to agree in this way, but we do most of the time. We appreciate a little bit of tension, but then you need to get some sort of resolution through pleasant combinations of sounds.

There is a physical basis behind the punctuation we feel in the phrasing of melodies and harmonies. The enjoyment of music is largely down to the building up and release of tension. In a piece of music, there is a key note which is "home". We arrive home at the end of many of the musical phrases. Also, the note just before the home note gives us an "almost there" feeling. An easy-to-follow tune is often very clearly punctuated, meaning we can almost anticipate the notes – and follow the "conversation".

There are many sorts of music, and we enjoy them in lots of different ways. In films, music echoes the action. Several clichés have been built up – like strings and piano for romantic moments – but we enjoy them. In some cases, the music builds tension and we enjoy guessing what's going to happen next. If you look at "serious" music, like classical or jazz, anticipation and release are a major part of our enjoyment. The composer or improviser will set up expectations and then either reward or frustrate them. It's like telling a joke where the punch line either fits the story or is a surprise: in both cases, we get pleasure.

Boogie wonderland: a regular beat reassures and encourages us to dance.

Drumming was probably the first sort of music; hitting things with a stick is fairly easy. Rhythm is good for dancing or entering hypnotic states, so that's an ancient response that we have to music. Our enjoyment of dance music is simple to understand: you can't really dance without it, and we enjoy dancing. Pop music involves short, ear-catching, easy-to-remember melodies. It's like eating sweets: instant gratification.

Musical systems are learned at an early age. Babies will sing several hundred different notes over a few minutes. But that song can't be repeated, so it's not much fun. The baby then listens to its parents singing nursery songs which only have a few notes, so the baby can learn to remember them and enjoy them.

Western music uses a lot of harmonies, where all the notes used at any one time agree with each other to some extent. Other musical systems are slightly different.

Think of a team of five planes doing an aerobatic display. They have two ways to impress the crowd below. They can all follow a sequence of complicated, but carefully organised, patterns, or four can follow a very simple pattern while one soars above very freely. They can't all go free or it would be messy chaos.

Western music has chosen the former system, with everyone playing a limited selection of notes. Indian traditional music is of the latter type, which is why you often have drums and a simple drone accompanying a soloist who has a wide range of notes and flourishes.

There is no scientific reason at all why you'll prefer one type of musical to another. Everybody could enjoy more kinds of music if they gave them a chance – but sadly we tend not to do so. With food, if you try something properly 10 times you'll probably come to like it. It's the same with music, but people often close up their range of musical appreciation by the time they're about 25. But it's easy to increase your enjoyment of life by listening to a lot of different types of music. Mozart and the Arctic Monkeys and Dolly Parton. Go on – I dare you.

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