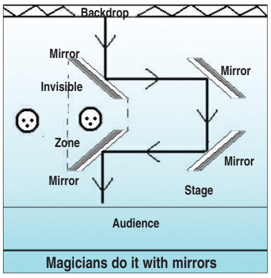
Staying out of sight

There is more than one way for things to fade from view, says s ananthanarayan

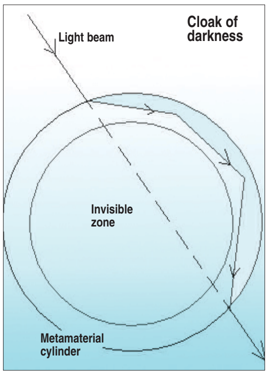
THE *Cloak of Darkness*, which makes its wearer invisible, is a common fairy tale motif. But it has now become reality through the use of materials that do complex things to light and make light go around an object, instead of being blocked or reflected. Moti Fridman, Alessandro Farsi, Yoshitomo Okawachi and Alexander L Gaeta from Cornell University, USA, report in the journal *Nature* another method of effectively achieving the same thing — by getting light to slow down, and then rushed to catch up, during an instant, to miss an event that takes place during that instant.

One way for an object to avoid being seen is to let light just pass through. But objects in general are not transparent and would interact with light that falls on them. Even if there were a transparent coat on the object, light that falls on the coat would get bent towards the object, which would then interact, generally by reflecting the light. Persons in front of the object would then see the object and persons behind would see a shadow. But if the light falling on the transparent coat could be made to turn not towards the object but away, then the light could be guided, through the coat, around the object and sent on its way from the other side of the object. If this happens, then persons in front of the object would see no reflected light and persons on the other side would see no shadow. The object would disappear!

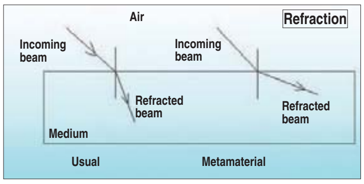
The reason that light that enters a transparent medium is turned "inward", or towards the direction along which it came to the medium, is the *refraction* of light. This is usually explained as because light travels slower in the medium than in air, and this causes a beam of light to bend inwards. But the change in direction of light is in fact concerned with the electric and magnetic properties of materials and the fact that light is a wave that consists of electrical and magnetic fluctuations. The interplay of the electric and magnetic properties of the material affect the electric and magnetic components of the light wave in such a way that for all natural materials the direction of propagation changes within the medium, and away from the surface of the medium. In theory, the nature of electric and magnetic interactions can be such as to result in the beam bending the other way, but this does not happen for natural materials.

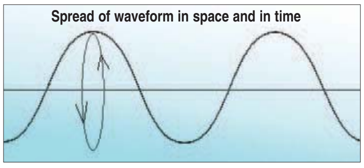


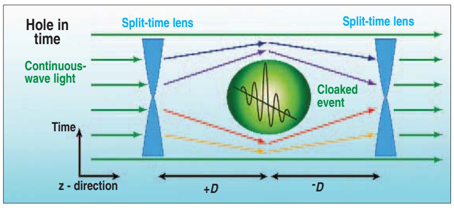
Magicians do it with mirrors



Cloak of darkness







Hole in time

Metamaterials

But artificial materials can be created that do affect light in this way. The world of *metamaterials* consists of compositions of materials designed to have more properties than the components. The components are microscopic in form and the structure has features that are of the dimensions of or lesser than the wavelength of light. Materials like this can have electric and magnetic properties, known as *susceptibility* and *permeability*, which allow for light entering the material to bend in the opposite way. A cylinder made of such material can be designed so that light falling on one side turns along the surface of the cylinder and goes all the way round, till it is allowed to escape and continue along it original path. The beam of light would then be quite unaffected by an object that is placed within the cylinder and that object, in effect, would be invisible!

Metamaterial invisible cloaks have been implemented only for specific bands of light in the microwave region and are far from perfect. The dimensions of the objects that can be cloaked are also very small. Recent reports are of cloaks made not of bulk metamaterial but an "ultrathin" cloak, which works by creating waves that interfere with reflected waves and prevent reflection from emerging from the object. This cloak is able to conceal larger objects, again in the microwave region. Professor John Pendry of the Imperial College, London, who pioneered the work, however, cautions that a practical invisible cloak is still a far cry. It works with objects a few centimetres across but it is not a cloak you can drape on anything, he says.

Hole in time

These methods of turning a light beam to flow around an abject use ways of dealing with spatial properties of light waves to create, as it were, a hole in space, where an object can hide without being seen. But the mathematical equations that deal with the way electromagnetic waves behave allow nearly the same manipulation that is possible with space to be carried out with the time dimension. A wave on the water, for instance, has the form of a snake, to show the height of the water along a line in space, at any moment. But if we consider a single point on the surface of the water, the water level at that point also rises and falls, as time goes on, in the same way as it does along a line on the surface, at a given instant.

Using this parallel, another approach to invisibility is to slow light down for an instant, and then to speed it up again to catch up with the time that has passed, so that there is a gap in the time for which the wave has been there. An event that occurred during that instant would then have avoided being detected by the light wave. The method makes use of the idea of a "time lens", which could expand and magnify a short pulse of time to become detectable, just like a glass lens can magnify fine print. This concept was first developed to help detect electrical pulses that were very close together, in time.

The way it works is that an external light wave, with a varying frequency, is added to the first light waveform. The external wave creates combined waves with the original wave. If there are two closely placed peaks in the original wave, there are two different combined frequencies created, as the external wave interacts with each peak at a different time. These waves of different frequencies can then be separated and the two peaks get prised apart.

The same idea is implemented with a light wave, again in the microwave region. A pair of time lenses splits the light wave into a higher and a lower frequency component. Now, a prism is able to split light into the colours of the rainbow because different frequencies travel at different speeds and hence bend in different ways in the prism. In the same way, the light beam that is passed through the pair of time lenses splits into a "fast" component and a "slow" component and they separate.

The two components then reach another, complementary pair of time lenses, which reverse the speed changes to restore the light wave to the way it was at the start. But in the gap between the two sets of time lenses, there was a part of the beam that was "fast" and a part that was "slow", with a gap in between. If an event that affects the light beam occurs in the "time gap", it would have no effect on the beam.

Artworks in museums are sometimes protected by laser beams. If a burglar could create a time gap, he could slip in undetected. This was tried out by the Cornel University team, using three different lasers for the main beam, the varying frequency addition and the "event". The "event" beam became undetectable every time the lime lens was switched on, but the time gap they created was very brief, just 40 trillionths of a second. That burglar would have to be quick!

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So who cares?

david phelan sums up the high points of the Apple World Wide Developers Conference

IN one of the longest keynotes from Apple for years — two full hours — Tim Cook and colleagues tried to fight back after a tough year. Would this be enough to put the gloss back on Apple? Apple needed to show it could innovate, have fresh and appealing ideas — and lots of them. The key to the show was the iOS reveal, the new, flatter design of iPhone and iPad software created by Jony Ive. Sir Jonathan Ive is the Brit behind the iconic designs for the iPhone, iPod and more. But could he change the existing software into something classier?

The problem with iPhone and Apple Mac software is that it pretended to be something else. So the calendar has a border designed to look like stitched leather, a corner of torn paper visible where last month's calendar had been torn off. This is what's known as skeuomorphism, where one thing is made to look like another.

The new software gets rid of all these. Time and again at the keynote, presenters went out of their way to decry the current styling – "No virtual cows were killed in the making of this software" was followed by "Even thought there's no stitching on the calendar, it still stays in place".

And the results for the Mac software looked good. This will be released in the autumn and be called OSX Mavericks in a move away from names of big cats and towards Californian locations. But the transformation of iOS was stunning. There were eye-popping effects that made the background images seem to sit behind the app icons, so that when you tip the phone, the two move separately. The redesign is absolutely from the ground up and looks as fresh as paint. It may not mean that the Apple system is far ahead of its rivals but it's definitely better looking.

This is all it needed to be. Windows Phone and BlackBerry offer radically more modern interfaces but nobody is buying into them because they have smaller, less comprehensive app stores. If Apple users looked longingly at other operating systems, they won't any more. In a few months they will have the familiarity of their current phones with gorgeous new effects.

Style over substance? Maybe so, but with this much style, who cares? And there will be plenty of innovations when the software launches, including features from the Mac moving to the iPhone and vice-versa.

There was lots more announced, from the sneak peek at the professional quality hardware, the Mac Pro to new versions of the MacBook Air with exceptional battery life. But the biggest cheers of the show and the most eye-catching looks were the iOS redesigns from Jony Ive, Craig Federighi and their teams. These will be enough to keep Apple iPhone users loyal when the next handset is released later in the year.

the independent

Biological and biochemical factors

tapan kumar maitra explains the resistance of harmful organisms to pesticides

THE resistance of an organism to a pesticide stems from a biological property it possesses to withstand the latter's poisoning action. A resistant organism functions, develops and reproduces normally in a medium containing a poison. The phenomenon of resistance and the reverse phenomenon of sensitivity are closely related to the toxicity of the relevant poison, especially to its selective toxicity, because all the factors causing toxicity also act on the resistance or sensitivity of an organism.

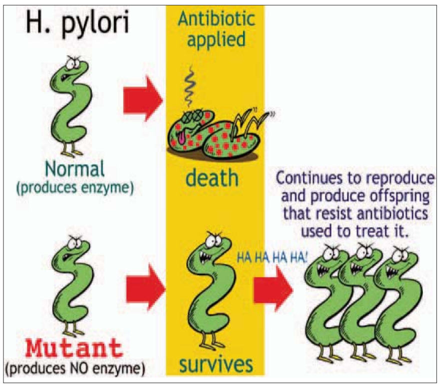
There is distinguished natural resistance based on the biological and biochemical features of an organism, and acquired, or specific, resistance appearing only because of interaction with the poison. Natural resistance is subdivided into specific, sexual, phase (stage), age, seasonal and temporary. This kind of resistance appeared and exists independently of the use of chemical means for plant protection.

Specific resistance is due to the features of the biology of definite species of harmful organisms (insects, mites, rodents, etc). To overcome it, special pesticides are synthesised and used that have a selective toxicity (insecticides against insects, fungicides against the causal organisms of fungal diseases). The chemicals for plant protection include pesticides both with a narrow selectivity acting only on one species of harmful organisms or on several species of the same genus (pirimicarb against aphids, barban against wild oats) and with a broad spectrum of action (phosalone against insects and mites, DNOC against wintering forms of insects, fungi and bacteria, and also against weeds). Hence, specific resistance can be successfully controlled by selecting the appropriate pesticide.

The resistance of organisms fluctuates greatly within a single species, which must be taken into account when using pesticides. In a number of cases, female specimens of insects and animals have a higher resistance to poisonous substances. Such sexual resistance is overcome by choosing the relevant doses. Changes in the resistance of harmful organisms are also noted in ontogeny, depending on the phase of development. The most sensitive to poisons are larvae and adult insects, fungal conidia at the time of growth and plants in the germinating stage. High resistance is a feature of insects in the egg and chrysalis stages and during the diapause, of wintering spores of fungi and bacteria and of the seeds of plants.

The resistance of harmful organisms to poisons within a single phase of development changes, depending on the age, time of day and year (season). The larvae of insects are more sensitive to insecticides at an early age, while toward the time of moulting their resistance increases. The resistance of plants and rodents also grows with their age. Insects wintering in the phase of imago or larva are characterised by seasonal resistance. At the end of summer or autumn, these species are more resistant to pesticides because they accumulate a considerable amount of fat and do not eat much. In the spring, they are more sensitive to poisons because their organism is weakened by the prolonged wintering. The main way of controlling seasonal, temporary and age resistance is the proper choice of pesticides and strict observance of the optimal periods for treating agricultural objects.

Specific (acquired) resistance signifies the ability of a harmful organism to survive and reproduce in the presence of a chemical substance that previously suppressed its development. The first reports on the appearance of races of pests that resist the action of chemical formulations relate to 1915-1916, when a race of red wild orange scale-resisting hydrocyanic acid was discovered in California. Later, the appearance in other insects of a specific resistance to inorganic compounds — lead arsenate and sulphur — and to pesticides of a vegetative origin — pyrethrum — was noted. Up to the 1940s, no importance was attached to this phenomenon because pests became accustomed to poisons quite slowly and they were controlled successfully.



With the appearance of new synthetic pesticides, their acquired resistance began to develop rapidly and at present this is noted in over 200 species of insects. Specific resistance appears in the fifth to 10th generation of the harmful organism and develops to such an extent that in some regions it becomes impossible to use certain pesticides. It has been found that upon the perennial application of the same fungicide, for instance benomyl, the resistance of fungi spores may increase from three to 12 times. It has been established that the phenomenon of specific resistance is based on the selection of specimens having increased resistance from genetically heterogeneous populations of specimens having increased resistance.

The selecting factor is the pesticide. The effectiveness of this selection depends on the initial material (insects, mites, etc), the number of treatments, the pesticide dose and the genetic heterogeneity. Specific resistance appears more rapidly when a harmful organism produces more generations during a season, its heterogeneity is higher, and the dose of the pesticide is smaller. The selected race of the pest, however, in the majority of cases is less adapted to the conditions of existence, and after discontinuation of the chemical treatments the population in a certain time returns to its initial state. But when treatments with the same substance are renewed, the specific resistance appears more rapidly.

Specific resistance may be individual, group and cross. Individual resistance (only to one pesticide) is encountered quite rarely and is due to the activity of narrowly specialised enzymes decomposing the toxic substance. For example, the resistance of insects to malathion is explained by the fact that this pesticide is rapidly decomposed in the organisms of resistant insects by the enzyme malathionoxidase. Group resistance involves two or more pesticides that are related in their structure and mechanism of action and that belong to one group, appearing after the use of a substance of this group. For example, after treating insects with formulations of HCH, a race of pests appears that resists all organochlorine insecticides. The group resistance of insects or mites is due to the following reasons:

- Slower penetration of a poison into an organism and faster excretion of it. Resistant specimens excrete from two to three times more toxicant than sensitive ones.
- Rapid detoxication of a poisonous substance because of a higher activity of the enzymes or the appearance of specific enzymes. In races of insects resisting organophosphorus compounds, the activity of aliesterases and phosphatases is higher than in sensitive ones. As a result, an insecticide rapidly decomposes. Some species of insects have a set of specific enzymes that actively decompose insecticides (for instance, malathionoxidase in insects resisting malathion).
- A different penetrability of the shells of nerve cords. In the organism of resistant insects, the insecticide penetrates poorly into the nerve cells (established for polychlorocyclodienes).
- An increased lipid content in the body of resistant specimens. The result is that lipid-soluble poisons are retained in the fat layer in a considerable amount and are removed from the sphere of action.

Cross resistance involves two or more pesticides of different groups as regards both chemical structure and the mechanism of action that appears after the use of one pesticide. Such resistance is encountered rarely and has been studied very little. This phenomenon is apparently explained by the fact that a previously used insecticide increases the activity of the non-specific enzymes of the endoplasmic reticulum of the fat-body. Consequently, the new insecticide is rapidly decomposed into non-toxic products.

To manage resistant races of harmful organisms and prevent the appearance of specific resistance to pesticides, it is essential to strictly observe the rates of use of the formulations and the periods of their application. The basic factor in controlling acquired resistance is the alternation of pesticides with a different mechanism of action, both during a season and from year to year.

For example, phosalone is recommended for the first treatments of orchards against apple worms, and carbaryl for the following ones. In controlling mites, the use of dinobuton is alternated with dicofol treatment.

Specific resistance can be overcome by adding synergists to pesticides — ie, substances that amplify their action. The integrated method of protecting plants is effective in combatting specific resistance. This makes it possible to prevent the appearance of resistance of harmful organisms to pesticides, diminish the danger of affecting entomophags and lower the contamination of the environment with the toxic residues of pesticides.

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