Enzymes ride the waves

Natural systems pick random events to piggyback and save energy, says s ananthanarayanan

There is a tide in the affairs of men which, taken at the flood, leads on to fortune.
— William Shakespeare in *Julius Caesar*.

Ralph Seidel.

RALPH Seidel and his team at the Technische Universität Dresden and researchers in the University of Bristol report in the journal, *Science*, that a category of enzymes called *helicases* makes use of the random buffets from moving molecules of the fluids in the cell to move them through the length of the DNA chain without expending their sparse fortune of energy.

Helicases are proteins that move from one end to the other of the millions-of-units-long DNA double helix molecule to separate the two strands of the helix, as during replication, or for repair of damage to DNA.

The DNA molecule consists of a pair of strings made up of sugar and phosphorus compounds, to which are attached chemical groups selected out of just four distinct kinds, which are called *bases*. Each of these bases has a counterpart from among the remaining three kinds of bases and, given one string of the DNA, the other string is nothing but the sequence of bases complementary to the bases in the first string.

Any damage to one of the strands of the DNA results in a breakdown of the complementary nature of the two strands. In the repair of DNA, the action of helicases is to unpin the DNA strands for the damaged portion to be rebuilt by attachment of the correct complementary chemical groups to the strand that is intact.

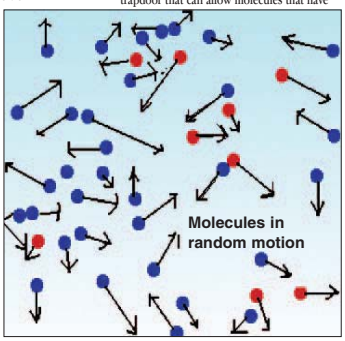
Energy to enable action within living things arises essentially from the oxidation of carbon, or sometimes from sunlight or heat. While nutrients need to move to and be consumed at the place where they are needed, energetic action is finally implemented by the transfer and expending of chemical units of energy, called *ATP*, which stands for *Adenosine triphosphate* and is a chemical unit that rapidly changes from its precursor form and back, with the absorption or release of energy. Within cells, it is used by enzymes and structural proteins for synthesis, movement and to bring about cell division.

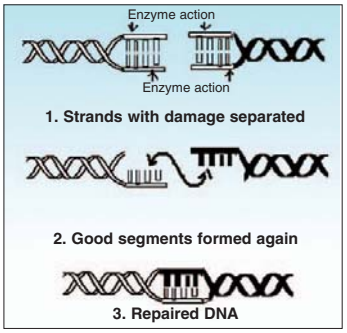
The helicase protein, too, for its work of separating the strands of the DNA, needs energy. As they are agents that use units of energy to do mechanical work, helicases have been regarded as *motors* at the molecular scale. Other *molecular motor enzymes* have been studied in some detail, but not yet the mechanism of the action of helicases. The work of the scientists at Dresden and Bristol has discovered that helicases do not actually consume ATP except for a small action of chemical rearrangement; but for motion, they piggyback on the thermal energy of the random motion of other molecules within the cell.

Random motion

There are literally billions of unattached molecules, including water molecules, within each living cell. Just as in any gas or liquid, these molecules create pressure against the cell wall through their motion. Given the large numbers, the pressure is uniform and the momentary state of motion of any given particle in the fluid is essentially random.

Random motion of the molecules of a fluid were first studied by English botanist Robert Brown, who noticed a rapid and random movement of lycopodium spores suspended in water. The motion of such very small particles, while responding to random impacts by surrounding molecules, has been mathematically studied and the probability of the particle being moved by a given distance, as a result of the random impacts, has been worked out. The conclusion is essentially that with the help of the Brownian *random walk*, the helicase protein can hope to move some small distance, but this is in a random direction, not along the length of the DNA. For being able to work on the DNA, there has to be a mechanism for the helicase protein to recognise the part of the DNA and to act by causing cleavage, and then wait till it is in the right position again, through its random meandering.





That random processes cannot be used to do work has been generally accepted as being against the way of nature. A gas, for instance, consists of an exceedingly large number of molecules in random motion, such that no region within the gas can be distinguished from another. If any more gas, at a higher temperature and, hence, more energetic motion is introduced, the molecules rapidly rearrange themselves and the state of motion is again uniform. Now, consider a separator dividing the gas into two regions, with a small trapdoor that can allow molecules that have more than a minimum energy on one side to move into the other side, but not the other way about. Could we expect that more such energetic molecules would then move to the other side and get trapped there? Would the result be that one side of the gas gets warmer while the other side gets cooler, as its more energetic constituents have leaked?

That such a thing will not happen is well understood. There are different ways to explain why not. One is to recognise that if a molecule on the first side knocks the trapdoor open, then the door is open for that instant for molecules to move in both directions. If the second side had collected more and faster-moving molecules, then more that one molecule may slip back to the first side during that brief open-door period. The temperature on both sides would, thus, tend to equalise and, given the vast numbers of molecules in real gases, changes in temperature through this process would be undetectable.

In the same way, one should expect that movements of the helicase protein, because of Brownian motion, cannot be of use for movement along a given path, as this would amount to extracting energy from the environment. The difference in this case is that there is intelligence in recognition and action, which does consume energy, though small. As a result of this refinement, what we are looking for, at every event of contact with DNA, is the probability of movement of helicase by a short distance to the next point of contact. Again, given the very rapid change of position, albeit small, in the *meso world*, or the intermediate world, neither of atomic or molecular structure nor of the scale of composite objects, it is a very short time before the helicase protein finds itself in the right spot!

Sidel and his team at Dresden developed a microscope that could view the length of the DNA molecule and also follow the movement of helicases, which had been rendered visible with a fluorescent label. The Bristol group, at the same time, used high-speed photography to analyse the fluorescent light to make out changes in the protein structure and the pace of consumption of ATP in the helicases. What emerged was a motion picture of helicase protein molecules moving feverishly as they got knocked about by the environment, and periodically underwent structural changes, with the ATP getting consumed only when that happened.

"This enzyme uses the energy from ATP to force a change in protein conformation rather than to unwind DNA. The movement on DNA thereafter doesn't require an energy input from ATP. Although movement is random, it occurs very rapidly and the enzyme can cover long distances on DNA faster than many ATP-driven motors. This can be thought of as a more energy-efficient way to move along DNA and we suggest that this mechanism may be used in other genetic processes, such as DNA repair," says Mark Szczelkun, professor of biochemistry at Bristol.

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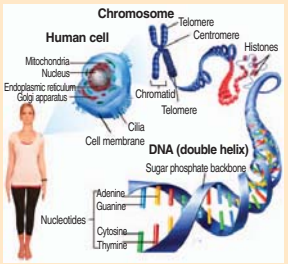
From parents to offspring

tapan kumar maitra **dwells on hereditary infectious diseases**

MOST scientists deny the possibility of hereditary transmission of infectious diseases by infected germ cells. However, the possibility of a sick mother transmitting such diseases to the foetus through the placenta (staphylococcus diseases, syphilis, enteric fever and relapsing fever, toxoplasmosis, virus hepatitis, etc) and during birth (blennorrhoea of the newborn) has been precisely established. Infections caused by latent viruses can be transmitted from parents to offspring.

There is no doubt that mechanisms of hereditary insusceptibility are connected with the occurrence of infectious diseases. These mechanisms are due to a deficiency in the macro-organism of substrates necessary for the reproduction of the causative agent and to selective specificity in relation to the substances of tissues and organs of persons with different blood groups. Numerous inhibitor-substances preventing the development of pathogenic micro-organisms are located in different tissues and organs and are inherited. They provide the organism with protection against pathogenic agents and their toxic products.

In nature, infectious diseases are subdivided into exogenous and endogenous. During exogenous



infections, the causative agent penetrates the macro-organism from the environment (from patients, carriers, from foodstuffs, water, objects, air, soil, etc, which have been contaminated by them). Endogenous diseases (autoinfections) originate as a result of the activation of the indigenous microbes of the body (microflora of the skin, mucous membranes, respiratory and digestive tract, urogenital tract, eye conjunctiva) due to disturbances of the internal medium of the macro-organism as a result of external factors and social conditions.

The state of autoinfection is quite a widespread phenomenon. With a decrease in temperature, the microflora of the upper respiratory tract is activated, which causes a different kind of inflammatory process. Quite often, the development of herpes is observed, the virus of which under normal conditions is inactive in the body but, during cooling, menstruation, disturbances in diet, it becomes active and causes an infectious process. A certain role is played by radiation sickness in activating normal microflora; it is accompanied by bacteraemia.

Radiation lowers the bactericidal properties of blood resistance and production of antibodies, inhibits phagocytic activity and inflammatory reaction and aids in sensitising the body with products of tissue decomposition. Auto-infections include nasopharyngitis, tonsillitis, appendicitis, conjunctivitis, pyogenic infections of the skin, otitis, cholecystitis, osteomyelitis, etc.

Under the influence of inflammatory-necrotic processes, a C-reactive protein appears during the acute period in the patient's serum. It is produced as a result of tissue decomposition during inflammation, necrosis and, in particular, during myocardial infarction and tumours. The discovery of this protein permits the differentiation of a number of acute inflammatory diseases and necrotic processes. Primary infection in such diseases as tuberculosis and brucellosis is exogenic, but the causative agent may remain in the body for a long time and not cause a disease. With the advent of unfavourable conditions for the macro-organism, the latent form of the disease becomes typical and causes relapses.

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What do locals gain?

In the fourth part of his series on the wind energy sector, aritra bhattacharya **reports on what happens when a developer acquires land from unwilling landowners and how much employment such activity generates**

ACCORDING to figures with the Union ministry of new and renewable energy, more than 50,000 direct jobs were created in the last three years in the new and renewable energy sector. The catch in the figure, however, lies in the fact that these jobs were created in off-grid projects, whereas the thrust in wind energy, which accounts for nine per cent of the country's total installed power capacity, with other forms of renewable energy contributing just 3.5 per cent, has been on large, grid-connected projects.

Suzlon's wind farm in Dhule is one such project. Touted as the largest wind farm in Asia by the wind turbine manufacturer, the facility provides a glimpse of the kind of jobs created for locals in grid-connected projects. For one, not a single local was absorbed into the workforce of the wind farm. Some found contractual employment as security guards, manning the base of wind turbines. Armed with rifles, around eight of them who are employed now each receive around Rs 1,500 per month.

The economics of Suzlon's Dhule plant is astounding: rough estimates indicate it bought over 40,000 hectares in 40 villages of Nandurbar and Dhule districts at Rs 25,000 per acre for the 1,000 MW wind farm and sold the same to celebrities and corporates who wanted to own "green energy" initiatives at high prices totalling over Rs 5,000 crore. The company's land acquisition was carried out in hush-hush manner. "They acquired tribal land through a third party and, in most cases, tribals were not even aware of the land deals," said Pratibha Shinde of the Lok Sangharsh Morcha, a grassroots organisation that works in Nandurbar district.

Since 1980, tribals in the area had been demanding the regularisation of land in their names, but successive governments did nothing regarding the matter. However, the same land was given to Suzlon in a matter of days in the 1990s. It included 340 hectares of forest land in Sakhri *taluka*, large patches of which were being used by tribals in the area since generations. The diversion of forest land was done under Maharashtra's Renewable Energy Comprehensive Policy of 2005, which allows diversion of forest land for establishing wind farms, with the rider that "tribals will be suitably compensated and their ownership protected".

When locals received wind of the land deals between the government and the company, they agitated. In a pacificatory gesture, Suzlon initially promised them a clinic and power supply to the villages/hamlets wherever towers were being constructed. Almost a decade later, all such promises have soured. Not only have locals not found employment, save as contractual security guards, their villages continue to remain in the dark for most of the day. In the intervening period, the local administration, in collusion with the company, has sought to browbeat the agitators. In the area of the wind farm, allegations regarding Suzlon's use of muscle power to suppress the Adivasi campaign abound.

A fact-finding committee looked into the police excesses on 14 July 2007 — on that day, they used tear-gas and lathi-charged protesting villagers, injuring many, and 18 people, including a girl, were detained for three days — and noted that the administration and police officials were hand in glove with Suzlon. The report from the Committee for Protection of Democratic Rights noted, "The SP, Dhule, told us that police protection was given to Suzlon on (a) paid basis. Was the police therefore acting at the behest of Suzlon? One would not like to consider such (a) possibility… we tend to believe that the sole purpose of the police force descending upon the Adivasis was to terrorise them."

A fact finding committee hearing.

The issue of the local police's collusion with the company is shady and secretive. While cops claim that the company pays them for protection and security, a Right to Information application by grassroots organisation Satyashodhak Grammen Kashtakari Sabha that spearheads the agitation revealed that payments had not been made by the company. "For instance, police was supposed to receive Rs 91,000 for giving protection to the Suzlon plant in July 2007; they were also supposed to get paid for maintaining vigil on the facilty by pitching a tent in front of it. But the RTI showed that no payment was made," says Kishor Dhamale, coordinator at the SGKS.

Owing to this, there are allegations of underhand dealing between the police and the company. In fact, around four years ago, Suzlon gifted a car to the local police station, prompting people in the area to refer to the cops as "company ki police" in "company ki gaadi". Villagers here also accuse Suzlon of forging documents and signatures of village leaders. For instance, according to Dhamale, the document that bears the sign of approval for the wind farm by the *gram sabha* has the signature of the *sarpanch* in English, whereas she is illiterate. Locals say that *gram sabhas* were never consulted in the matter, compulsory under the Panchayat Extension to Scheduled Areas Act; instead, their assents were forged, helping the company make a quick buck without entangling itself in negotiations. Activists also allege huge tracts were deforested; close to 35,000 trees were cut in a matter of a few days when the facility was being set up.

Despite the strongarm tactics of the company, locals continued their agitation and managed to shut the operations of some turbines. The latest in their "victories" was the shutting of a workshop in the plant area, which was a major inconvenience. However, many issues still cry out for intervention. "For instance, on paper, the space between windmills is being used for the cultivation of medicinal plants by the company. On the ground, however, there is nothing. It is a ploy adopted by the company to prevent the right of way of locals through the plant area. Given the huge area of the farm, cattle have to take a long detour to reach grazing lands," says Dhamale. People also point out that the farm has engulfed religious spots inside what was once the forest.

Apart from all of this, no one quite knows how much power is generated by the facility —turbines were sold to private entities that availed of 80 per cent accelerated depreciation on their investment. "The windmills are there, and they are running. They generate maximum power during the monsoon months. But during those months, electricity is available from the Centre at rates of Rs 1.50-1.75 per unit. Why would the state electricity board buy power from the wind farm at rates of Rs 5 per unit or thereabouts at that time?" asks a source.

The Dhule wind farm is a perfect example of all that has gone wrong with the story on wind energy. Even though the same model — with emphasis on large turbines, diversion of forest land and violation of tribals' rights — is being repeated across the country, could it be that smaller, decentralised projects offer a better alternative?

Anupam Boral, managing director of Kolkata-based Gitanjali Solar Enterprises, which works on installation and maintenance of small wind turbines, thinks so. "Small decentralised projects are necessary," he says. They can help in providing power to rural areas and places where the national electricity gird is either absent or cannot possibly reach. In doing so, they can help reduce the dependence on fossil fuels and make a difference to people's lives in a direct manner, rather than remaining rarefied in the citadels of "green energy" plagued by the kind of problems this and the previous part highlighted.

Next week: Wither avenues for small wind turbines?