Stiff upper lip

Drought resistance would be key to surviving global warming, says s ananthanarayanan

A WARMER and drier climate in the coming decades is the consensus. A 2011 study of drought by Aiguo Dai of the US National Centre for Atmospheric Research looked at "characteristics and trends" of the climate indicator, Palmer Drought Severity Index, during 1900-2008 and found that "all the (main) four forms of the PDSI show widespread drying over Africa, East and South Asia and other areas from 1950 to 2008, and most of this drying is due to recent warming". Global warming is expected to prolong droughts, and with the earth's grass and plant cover rapidly declining it is vital to know which plant varieties would survive the harsh conditions that are to come.

Lawrence Sack and colleagues at the Department of Ecology and Evolution, University of California, report in the journal *Ecology Letters* that their work has resolved a basic question of how a plant in arid conditions overcomes the conflicting demands of conserving water and still being open for uptake of carbon dioxide from the air.

Plants need to hold their leaves stiff and upright for the twin purposes of receiving sunlight to create food through photosynthesis and also for keeping pores, called *stomata*, open to the air so that they can take in carbon dioxide as raw material. The leaves and stems are filled with water and stay stiff, like a balloon, because of an effect called *osmosis*, where water flows in the direction of increasing concentration of salts so as to dilute the concentrated region and balance things.

This is the pressure that allows the level of ground water, as in wells, to be below sea level, as the fresh ground water feels a pressure to flow out and dilute the salt water of the sea! The sap of plants contain salts and plants draw water from the soil and from the air, to balance, dilute and reduce osmotic pressure, also called *turgor pressure*. In hot weather, the water content evaporates and if it is not replaced from the soil, the *turgor pressure* drops and the plant wilts and collapses. This closes the *stomata* and without intake of CO_2, the plant would starve.

"Drying soil may cause a plant's cells to reach the *turgor loss point* and the plant will be faced with the choice of either closing its *stomata* and risking starvation or photosynthesising with wilted leaves and risking damage to its cell walls and metabolic proteins," says Lawrence Sack. "To be more drought-tolerant, the plant needs to change its turgor loss point so that its cells will be able to keep their turgor even when soil is dry."

Plants that do well in arid conditions have small and tough leaves and it was considered that this was what helped them to hold on to water in dry periods and also allowed stomata to remain open. But there could be another effect that helps hold the cell walls stiff and rigid when water is lost. This is to make the plant draw in water with more force by making its contents more salty and increasing the osmotic pressure. That saltiness of the insides of plant cells is effective in managing the water level in the cell for different purposes is known, but was not considered to be relevant in maintaining turgor pressure.

Other examples of movement actuated by chemical regulation of turgor pressure are the twining of creepers around supports, closing of leaves on touch or the dramatic Venus Fly Trap, which snaps shut on an insect when it touches the inside. The mechanism is a rapid expelling of potassium and chlorine ions, the intake of calcium ions and the creation of osmotic gradients. There were instances of wilted leaves regaining turgor through similar processes, for instance a restiffening of wilted cabbage leaf without intake of water (Weiss, Randall and Sinclair, Agronomy Physiology Laboratory, Florida), but salinity regulation was not considered important as a response to arid weather.

Survey results

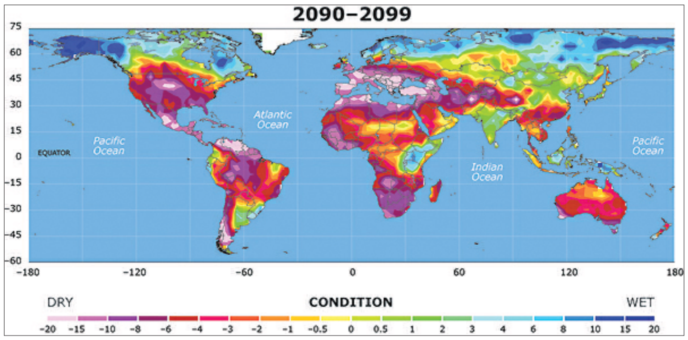
The Ucla team, funded by the National Science Foundation, carried out a survey of drought tolerance across different species and ecosystems worldwide and looked for reasons of how the most drought-resistant ones managed lower turgor loss points — or could maintain turgor for longer in drier soil. The first approach was mathematical — and solving the equations that govern wilting behaviour showed that the reason had to be the level of saltiness of the sap. The thick cell wall alone could not prevent wilting, although it did provide other protection that mattered in arid conditions.

One of these was that it prevented the cell from shrinking, which helped retain water. In fact, thick cell walls were common even in plants that did not resist drought, and the function appears to be general protection.

The second approach was empirical — based on the survey that clearly showed that across species within geographic areas and across the globe, drought tolerance was correlated, with sap saltiness and not cell wall thickness.

Lawrence Sack.

Aiguo Dai.



This chart shows widespread drought in 2099, based on current projections of greenhouse gas emissions. Credit: University Corporation of Atmosphere Research.

Wilted tree leaves in an Hawaiian forest during the extreme drought of 2010-11, which was the worst in at least 11 years and was federally designated a natural disaster. This tree is a sandalwood (Santalum paniculatum). Droughts are increasing worldwide and Ucla life sciences research shows how to predict which species will be most sensitive.

"The salt concentrated in cells holds on to water more tightly and directly allows plants to maintain turgor during drought," said research coauthor and Ucla doctoral student Christine Scoffoni. The survey actually revealed that thicker walls seemed to reduce drought tolerance, although drought-tolerant plants with salty sap also had thick cell walls. The combination — salty sap to keep up the turgor pressure and thick cell walls to provide mechanical support — seems to be ideal, but it was the high concentration of salts in the sap that was critical.

The result of the survey is that data of turgor loss point and salty cell sap formed reliable bases to predict a plant's drought tolerance. These parameters explain where different plants are found and which varieties dominate ecosystems. The pinpointing of cell saltiness as the main driver of drought tolerance cleared away major controversies and opens the way to predictions of which species could escape extinction from climate change, says Lawrence Sack. The Ucla team is now working with the Xishuangbanna Tropical Botanical Gardens in Yunnan, China, to develop methods to rapidly measure the turgor loss point of plants so that thousands of species could be assessed for drought resistance across the world.

"We're excited to have such a powerful drought indicator that we can measure easily," says lead author and Ucla graduate student Megan Bartlett. "We can apply this across entire ecosystems or plant families to see how plants have adapted to their environment and to develop better strategies for their conservation in the face of climate change."

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Awareness saves lives

The Indian public needs to be made aware of the symptoms of many kinds of cancers and physicians need to diagnose cases early in a cost-effective manner, writes binode das

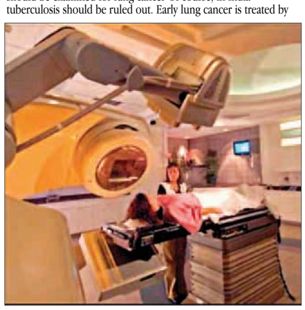
HAVING spent more than four decades in the USA treating patients and teaching young physicians, I visit Kolkata and some other parts of India almost every year and though no statistical evidence is available, I'm convinced that cancer is growing at an alarming rate in the country. Treatment is so much more advanced in the USA and longevity and quality of patients' lives have changed dramatically. I have no intention of making any comparison between the two countries but if the Indian public is made aware of the malaise and physicians try to diagnose cases early in a cost-effective way, so many patients can be saved and their quality of life improved.

On the basis of prognosis, curable cancers include:

- Hodgkin's Disease: This cancer is predominant among young adults. If standard treatment fails to work for anyone in this age group with an enlargement of lymph nodes, the individual must be referred to a surgeon for evaluation and possible biopsy. Those who cannot afford a doctor should go to a government-run hospital where good doctors are available. Treatment by a medical oncologist with combination chemotherapy can result in a complete cure.
- Testicular cancer: This affects 15- to 35-year-olds. Those with undescended testis are also prone to developing this kind of cancer. The physician must make a thorough examination. If needed, the patient must be referred to an urologist. Testicular cancer can be fully cured with proper treatment.
- Acute lymphocytic leukaemia of childhood: A paediatrician should have a high index of suspicioin to diagnose a patients with this problem as early as possible because treatment with combination chemotherapy can provide a complete cure.
- Gestational tumour: This cancer is common in childhood. If a child complains of swelling and pain, particularly in the lower limbs, he/she must be referred to an orthopaedic surgeon. This cancer is curable with surgery and chemotherapy.

Treatable cancers with good results include:

- Head and neck cancers: These are very common in India. The use of tobacco and alcohol, the chewing of *paan* with carcinogenic ingredients and infections with the HPV virus are the main causes. The general public must try to abstain from these habits. Soreness in the mouth, an unhealed ulcer of the mouth or hoarseness of voice should serve to raise suspicion of this type of cancer. An ENT specialist should see the patient to confirm diagnosis. If diagnosed and treated early, the results are good.
- Lung cancer: This is very common all over the world and incidence is high among smokers and passive smokers. If an individual has a persistent cough, chest pain and shortness of breadth, weight loss or haemoptysis (coughing of blood), he/she should be examined for lung cancer Of course, in India tuberculosis should be ruled out. Early lung cancer is treated by surgical resection. Advanced disease has a poor result.



- Breast cancer: Incidence of this is not so high, as in the USA. If a woman feels a lump in her breast, she must see a doctor who can evaluate whether she has cancer or not. If suspected, the patient must have a mammogram. A breast surgeon, an oncologist and a radiotherapist can manage the case. Good results depend on early diagnosis. If the patient's grandmother, mother or sister has cancer, she is prone to develop the same.
- Prostrate cancer: Elderly people with a history of urinary symptoms and/or haematuria (blood in urine) should be examined by an urologist to confirm diagnosis of this type of cancer. Nowadays this malaise can be well managed.

Gastroentestinal cancers include:

- Esophageal cancer: Those with dysphagia (difficulty in swallowing), particularly solid food, should be diagnosed for this type of cancer.
- Stomach cancer: This is fairly common in India. An individual complaining of upper abdominal pain, nausea, vomiting, hematemesis (vomiting of blood), fatigability due to anaemia, needs to be treated by a GI specialist for endoscopy. Prognosis depends on the stage of the disease.
- Colon cancer: Fatigability due to anaemia, melena (blood in stool) or altered bowel movement in an elderly person should be examined by a GI specialist with colonoscopy. A rare type of colon cancer known as Familial Adenomatous Polyl occurs in early adulthood.
- Thyroid cancer: Except for anaplastic cancer, which is the disease of the elderly, other thyroid cancers have a good prognosis with treatment.

Cancer treatment would be incomplete if they do not address the "End of Life" issue of patients. Those with incurable cancers, whose treatment has totally failed and life expectancy is considered less than a year, fall into this "End of Life" phase. Healthcare providers must devote time to making these patients comfortable for they need the human touch. They must be administered narcotics (morphine, or oxycodone) with an escalating dosage to alleviate their pain, suffering and apprehension. Constipation should be relieved by laxatives and supportive care must continue.

The innovation of less expensive gene therapy is in progress and it is hoped that better days are ahead for cancer patients. For the present, efforts should be exerted to save many lives through alertness and early diagnosis.

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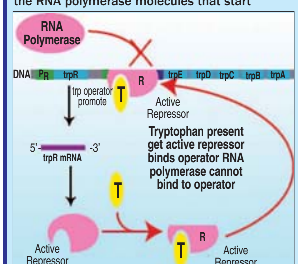
Repressible systems

tapan kumar maitra **explains the working of the tryptophan operon**

THE tryptophan operon codes for the five enzymes that are required for the synthesis of tryptophan, an amino acid needed for normal growth in infants and for nitrogen balance in adults. It has been known for many years that the expression of this operon is regulated by the availability of tryptophan in the culture medium, and that the presence of tryptophan represses the synthesis of *trp* enzymes. Regulation by enzyme repression is also found in many other anabolic systems involved in the synthesis of amino acids or nucleic acid precursors, in which the synthesis of the enzymes of a metabolic pathway is selectively inhibited by the end product of that metabolic chain. This is another mechanism that enables E. coli to synthesise enzymes only when they are required.

Enzyme repression can also be explained on the basis of a model similar to that depicted for enzyme induction in the lac operon. In enzyme repression, the regularity gene products a repressor protein which is normally in the inactive form. The repressor, upon binding with a metabolite called a co-repressor (in this case, the amino acid tryptophan), undergoes a conformational change that enables it to bind to the operator and thereby inhibit the binding of RNA polymerase to the trp promoter. The affinity of the repressor for binding to the operator is normally low, but it is increased by the action of the co-repressor. (This is in contrast to the situation in the lac operon, in which the repressor is active on its own and loses affinity for the operator when bound to the inducer.)

The tryptophan operon also has a second mechanism of regulation, which operates at the level of RNA synthesis. Normally 90 per cent of the RNA polymerase molecules that start



transcription at the promoter terminate at a nearby attenuator site, yielding a short RNA (140 nucleotides) that does not code for trp enzymes.

Only 10 per cent of the molecules continue on to produce a full-length trp mRNA increase. Termination at the attenuator site is regulated by the level of tryptophan in the cells. When the tryptophan level is low, the proportion of RNA molecules yielding full-length trp mRNA increases. When it is high, most of the mRNAs terminate prematurely. Other repressible operons, such as those for histidine (his) and phenylalanine (phe) biosynthesis, also show similar regulation at the level of RNA termination.

The mechanism by which the metabolic end products regulate transcription termination became apparent when the nucleotide sequence of the short "leader" RNAs was analysed. The three leader RNAs of the trp, histidine and phenylalanine operons code for a short peptide between 14 and 16 amino acids long. Their striking feature is that many of these amino acids are the same as the one whose synthesis is directed by the corresponding operon; for example, the histidine operon leader has seven histidine codons in a row.

In these operons, transcription termination is regulated by the ribosomes, which, in prokaryotes, translate nascent RNAs simultaneously with transcription. The natural tendency of RNA polymerase is to terminate transcription prematurely at the attenuator site, but when the cells are starved for amino acids, this termination signal is ignored. This is because a ribosome remains attached to the leader RNA (instead of completing the synthesis of the short peptide) due to the insufficient concentration of trp (or histidine, or phenylalanine). The presence of an attached ribosome interferes with transcription termination by preventing the formation of a hairpin loop in the nascent RNA (required for termination) and the long mRNA that codes for the biosynthetic enzymes is produced.

In summary, E.coli uses two distinct mechanisms to ensure that the trp enzymes are not synthesised unless tryptophan is required. The use of two mechanisms which operate at different levels of tryptophan probably allows a finer control of trp enzyme synthesis over a wider range of tryptophan concentrations than would be possible with the repression mechanism alone.

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