‘Plants embody math — they are little calculators, producing Fibonacci sequences’

***Christophe Golé** is Professor of Mathematical Sciences at Smith College and co-author of ‘Do Plants Know Math?’ Speaking to **Srijana Mitra Das** at **Times Evoke**, he discusses plants — and their number games:*

What is the core of your research?

■ It is around phyllotaxis — this has roots in the Greek word ‘phyllo’ which means ‘leaves’ and ‘taxis’ meaning ‘order’. This is the ordering of leaves and by extension, any organ around the stem of a plant. These usually form a sort of spiral lattice, with theoretical properties that have been puzzling people for centuries, from Leonardo da Vinci to Johannes Kepler and Charles Darwin.

What is the Fibonacci phenomenon you study in plants?

■ I mentioned the spirals leaves and other organs form — think now of a pineapple, pinecones or sunflowers. They all have certain packed organ structures, be it seeds or scales, which form a very regular arrangement of spirals — these can be two intersecting sets, going in opposite directions. If you count these spirals, very often, you’ll find those numbers are two successive Fibonacci numbers — these are numbers you get recursively, starting with 1 and 1. Then, you add those two and you get 2. Then you add the last two or 1 and 2 — you get 3. Again, you add the last two or 2 and 3 — you get 5. You add 3 and 5 and get 8. You add 5 and 8 and get 13 and so on.

Plants show Fibonacci numbers going upto 233 in sunflowers. It’s a very striking phenomenon — Alan Turing wrote computer programs seeking to understand this.

Why does this Fibonacci sequence occur in plants?

■ Scientists are figuring out whether this is an optimisation of resources. What we know for certain is the root mechanism that generates these patterns is somewhat of local optimal packing — a new organ occurs where there is the most space left by others. In 1868, Werner Hoffmeister, a botanist, discovered this. It was confirmed later by biochemistry and biomechanics. This seems like a local phenomenon which has global repercussions on the structure of a plant that take place microscopically. Some biologists argue this could be plants trying to maximise their exposure to the sun while others state — and I quite like this idea — this helps plants pack many organs onto a small bud. If a plant wants to protect its early organs, it’s easier if you pack more into a small area.

Consider the Romanesco broccoli — this exhibits both spirals and a fractal structure, its florets splitting into baby florets which themselves split more and more. This is a wonderful example of math in the plant kingdom. There are also many plant organs which don’t show Fibonacci structures — corn is an example. These have spirals but those are not organised in Fibonacci sequences. Instead, these are often close to one another — instead of having 8-13, for instance, you’ll have 6-7 or 7-8.

We’ve been using a dynamical model which thinks about these new organs like disks on a cylinder or cone — you pile these in the smallest possible place and you can observe most of the patterns occurring in plants. Interestingly, decreasing the radius of these disks has the same effect as enlarging the tip of the plant where the structure is born — so, if you imagine a strawberry plant, a few leaves emerge and suddenly, there is an explosion of fruit. The advantage of having this sequence could be the plant saying, ‘Ok, I’m going all out for reproduction now.’ The change of parameter is crucial in these structures.

So, do plants know math — and how to use this?

■ In a sense, plants embody math — they are constantly doing this. Plants actually are little geometrically calculating machines, small calculators which create these structures and have done this for millions of years. Evidence shows us early plants weren’t Fibonacci but quasi-symmetric though — so, clearly, plants have evolved to do this.

Climate change is causing huge shifts among plants now — is the Fibonacci sequencing likely to change?

■ We have circumstantial evidence of changed phyllotaxis in stressed plants. My colleague, Stephane Douady, once collected a bunch of pinecones from a particular tree — these were around 95% Fibonacci. Next year, they were much less so. A farmer told him someone had cut some branches of the tree — that would have changed the tree’s parameter, causing stress and altering the phyllotaxis. Climate change could induce similar stress — this needs more research.

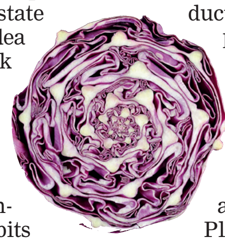
Do plants respond to change, using math, biology, physics and chemistry?

■ There is growing evidence that plants have far more developed sensory systems than thought earlier — those systems work at many levels, from biochemical to physical. There is evidence that trees can hear sounds in some capacity and scientists find one part of a plant can sense what’s happening in another part. Plants adjust very fast to their environment and change structure — plants that love light can evolve within one generation to those which sustain shade. They are extremely adaptive but some are perishing now under great pressure.

Photos: iStock

NATURE’S GOLD MEDAL: Tiny blooms at a sunflower’s heart follow the Fibonacci pattern — studies surmise this could maximise exposure to light and provide ample space for bees, thus increasing pollen transfer and seed production

IT’S STRAWBERRY FIELDS FOREVER! Try counting these ‘achenes’ or seeds



SPIRALLING: The red cabbage’s inner world is fascinating

MATH IN BLOOM: The dahlia arranges petals in Fibonacci spiral sequences

READERS WRITE

Dear Times Evoke,

Anthony Acciavatti in TE (3rd May) highlighted a critical geophysical impact of excessive groundwater extraction — shifting Earth’s rotational axis. Scientific studies, including NASA’s 2023 findings, confirm that massive groundwater withdrawal redistributes mass on Earth’s surface, altering the planet’s ‘polar motion’. India, the US and parts of China are major contributors. This underscores the need for sustainable groundwater management which integrates geophysical feedback into water policy. This article raised awareness about water overuse indeed having planetary-scale repercussions.

— Dr RBS Rawat, Dehradun

Who knew the humble tubewell could cause such havoc! Anthony Acciavatti’s research in TE was both exciting and sobering. Then, Peter Clift took us readers on a fascinating journey to the origins of the Indus River. Reading his gorgeous TE article, I got the vibe of a brilliant history professor. A big salute!

— Dr Soumya Saha, Kolkata

‘The Colour of Water’ TE editorial was so beautifully written. Anthony Acciavatti on groundwater and Peter Clift on how the Indus River was created were fabulous to read. These insights show how humans worldwide must stop dissipating the very source of life. Thank you for this wonderful page, TE.

— Venkatesan VS, Chennai

Peter Clift’s research on how tectonics helped build the Indus River 50 million years ago was amazing! This beautiful TE spread featured excellent information about aquatic life in the Indus which is, of course, much discussed in India currently. We only studied the Indus Valley civilisation in school though and not much about the Indus itself. Thanks, TE, for this brilliant page!

— Vedansh Awasthi, Lucknow

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