08 AUGUST // 2022 // VOL

THE STEM PRESS

BREAKING NEWS: PLANTS CAN TELL THE TIME!

Log with a clock on.

Plant growing out of cup with the sun rising in the background.

Timing really is everything… especially for plants.

BOTANY SPEARS 08/08/22

Plants can tell the time using their own 24hr internal body clock, called a circadian rhythm. They know when the sun will rise, can sense when seasons are changing and even get jet lag. Moreover, they do all this without having a brain or central nervous system, making it even more impressive. Whilst photosynthesis is a key in maintaining the circadian cycle, other factors such as temperature and nutrient availability are vital. The evolution of this ability is necessary in plants as they cannot move to escape changing environmental conditions.

Although circadian rhythms are also seen in humans, it does provoke the question of whether plants are advancing towards us in terms of intelligence. Whatever next, will trees whispering have even greater truth to it than we thought?

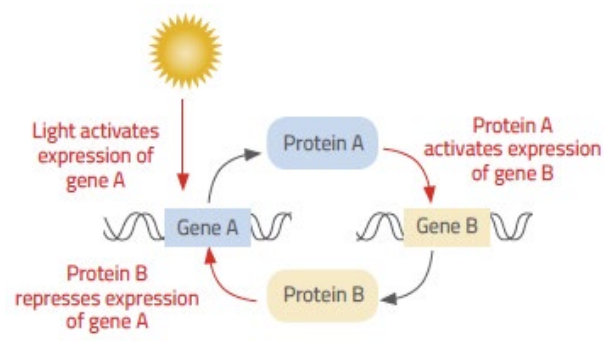

Diagram to show the simple interaction between genes and proteins in a circadian cycle.

How do plants tell the time?

HARRY POT-TER 08/08/22

The time-telling system works in a similar way to a computer with three stages: input, oscillator and output. The inputs are signals from the environment, such as light or temperature, which are translated into the plant via surface receptors. Then, via a chain of reactions, involving various biomolecules, the message reaches an oscillator, which is where particular genes and proteins are activated to regulate the circadian clock. From this, outputs are delivered to communicate the time to different parts of the plant to signal actions such as leaf movement or flowering. The timing of these physiological and biochemical processes provide the plant with a survival advantage. This clock is maintained using a negative feedback system, preventing certain proteins from over accumulating. There are built-in delays to guarantee the cycle remains 24hrs long.The circadian clock resets each day to ensure the cycle stays synchronised with the changing day length and therefore Earth's axil tilt.

It is important that plants can follow the change in day length as it varies through the year. Light is required for a fundamental process plants carry out where they convert the sun's engergy into chemical energy they can use via photosynthesis. The sugar produced from this metabolic pathway regulates key genes in the circadian rhythm and is thought to aid resetting the clock. The amount of sugar stored as starch during the day is also dictated by the length of light hours, as when dark the starch can be converted back to sugar to maximise growth and ensure all starch is used before the next cycle begins.

Even though plants do not read a clock like the image at the top of the article, they have invested time and effort into evolving an effective time-keeping mechanism. This has enabled the anticipation of predicatble changes in the environment. Many scientists are concerned about the disasterous effcect climate change could have on this remarkable system.

IN THIS ISSUE

08 AUGUST // 2022 // VOL

THE STEM PRESS

SCIENCE

The importance of plant circadian cycles

For them and for us!

FLAURA CROFT 08/08/2022

Plants require circadian cycles so a range of processes can happen. For example, photosynthesis heavily relies on the cellular clock. Imagine if you were driving a long distance, but did not work out how much petrol you needed. The likelihood is you would run out of petrol on the way and not complete your journey until the recovery vehicle arrives with more fuel. A similar scenario would happen if plants did not control their starch release overnight, as they cannot photosynthesize more sugar without the sun, so are limited to the supply they have. Therefore, the clock rhythm aids monitoring the starch reserves.

Another benefit of these cycles is the ability to respond to environmental changes affecting the stomata, which are responsible for the release of oxygen as well as unnecessary water. The ability of a plant to open and close the stomata on its own is genius ; to conserve water in arid conditions or to open to increase gas exchange. Circadian rhythms also play a key role in this as they track when drier periods in the day may be, which will vary with climate and latitude.

Similarly, certain leaf movements occur to enhance the area reached by the sun. A common example is young sunflowers which turn to face the sun, utilizing growth hormones linked to their internal clock to maximize photosynthesis.

Manipulating these cycles in crops can significantly increase yield, targeting the predicted food shortages for the future. This may also aid growth of crops in different environments, seasons and latitudes to which they are native. This use of genetics to alter the clock could make crops more accessible in certain areas, reducing hunger. It is important to maintain a temperature compensation range to deal with anomalies, to prevent processes such as early flowering. Studies have shown *Arabidopsis* plants with correct circadian rhythms for the time zone produced greater biomass and grew faster than those without, making this an appealing concept to farmers if applied to crops.

A further agricultural benefit is the application of circadian rhythms to agrochemicals. Chemicals in certain herbicides are able to interact with the rhythm, resulting in certain times during the day when the plant is more responsive to the herbicide. Subsequently, less can be applied, reducing the amount which damages local biodiversity and waterways. Similar research is being conducted into pesticides. If these conclusions are consolidated with further evidence a significant reduction in agrochemicals may be possible.

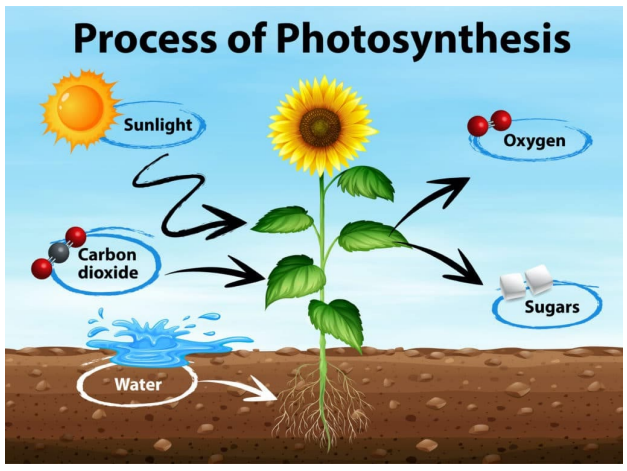

Diagram to show the process of photosynthesis.

Sunflowers turning to face the sun.

The harvesting of a field.

There is also speculation within the medical field of utilizing these cycles regarding plant-based drugs. The outputs from the circadian system result in large scale production of specific compounds at a certain time, some of which may have significant known or undiscovered medical value. Alongside exploring the therapeutic effect of these compounds, being able to harvest these at greater concentrations, using the circadian cycles, would be a great benefit.

INTERVIEW WITH HUGH PLANT

Can plants get jet lag?

NATALEAF PORTMAN 08/08/22

Last week I met a client, Mr Hugh Plant, with a very curious tale regarding his trip from London to Sydney. As an award winning gardener and businessman he was going away ‘to visit family for the holidays’ but was unable to ‘leave [his] precious plants behind’. So decided to take them on his flight. After he ‘carefully wrapped, supported and packed’ his vast jungle of plants, he got on his flight and began reading his Gardeners’ World magazine.

Whilst he expected that ‘they may be a little bashed and thirsty from the flight’, he was very surprised to discover his plants were not ‘growing as well in Australia’. As Mr Plant measures his plants extremely regularly he was able to notice this slight difference and may have put it down to climate, but the most surprising of all was that his daisies were not facing the sun. This left him ‘baffled and confused’ as these flowers were his ‘pride and joy’ and always flourished this time of year.

Mr Plant was feeling ‘tired and frustrated’ as he had been ‘very excited to show his family his work’, but thought, as he was very tired from all the travelling and the time difference, it would be best to rest. At this point he twigged ‘perhaps the plants have jet lag’ thinking ‘what a ridiculous thought!’. He hopped onto Google, as most of us do when we have a question we do not know the answer to, and began to search.

After rigorous trawling he came to the conclusion ‘it actually IS possible for plants to get jet lag’, which is in fact correct. This is because their circadian rhythm does not match that of the environment. Fortunately for Mr Plant, his flowers were able to combat jet lag much more quickly than he could, as each cell contains it’s own circadian clock, making it easier to adjust to new time zone. In comparison, the human circadian clock relies significantly on hormones, which travel relatively slowly through the body, so it takes longer to adjust.

While Mr Plant came to this conclusion, it is also possible that his flowers travelling in the dark for 24hrs, without water, could have stunted their growth …

A plane flying through the sky.

CONCLUSION

Time is of the essence

Whilst circadian rhythms are present in many eukaryotes and prokaryotes, the clock architecture and components are not conserved across kingdoms. Therefore, these rhythms may have evolved separately. Despite this, it has enabled the harmonious living between all species. For example, plants rely on insects as pollinators, so it is vital they have interacting circadian rhythms.

This coordination of daily processes in response to the environment enables plants to survive whilst being unable to move. Think about how long you would last outside glued to one spot! As science and technology continue to develop, the exploitation of this natural process will grow to benefit both the agricultural and medical field.

Whilst plants are often forgotten, merging into the background of our daily lives, it becomes easy to forget how impressive they are. From the ability to get energy from the sun, to being able to outsmart predators and the environment, to surviving without movement and even being able to tell the time!

Small plant growing from a mound of soil in the sunlight.

Further reading

https://www.cam.ac.uk/research/news/researchers-show-how-plants-tell-the-time

https://www.jic.ac.uk/blog/how-do-plants-tell-the-time-introducing-dr-antony-dodd/

https://www.youtube.com/watch?v=3jIW5wW2WC0

https://pursuit.unimelb.edu.au/articles/how-plants-tell-time

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1479754/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3358969/