Planting Science
real research for engaged education
CREATED BY THE ARC CENTRE OF EXCELLENCE FOR TRANSLATIONAL PHOTOSYNTHESIS

Planting Science

Classifying systems in cells

photosynthesis.org.au/teachers

Years 7-10: Classifying systems in cells

Unit at a glance

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Aquaporins regulate the internal systems within cells, but not many people know about them.

They are tiny little channels by which different molecules can pass through, or not.

In plants, researchers are trying to find out more about aquaporins to maximise plant water use efficiency and increase crop yields. In this lesson sequence, they're used to demonstrate the complexity of the system, and as a means for detecting and analysing traits and their corresponding DNA.

1 Food for thought

Students play a modified version of musical chairs, where chairs are food. What happens when there aren't enough chairs to go around?

2 What are aquaporins??

In this interactive experiment, students will see how aquaporins work to transport molecules across a membrane.

3 Spot the difference

Students will align aquaporin sequences and spot the differences using real research techniques and technology.

4 What came first?

Students create a phylogenetic tree using open access automated sequencing software, to determine which aquaporin came first.

5 Extract more information

Students will extract DNA from a strawberry and see what the strands look like.

Science snapshot

Meet Annamaria De Rosa. Annamaria is researching aquaporins and how they work in different plants, and in different parts of the plant.

Science snapshot

Meet Caitlin Byrt. Caitlin works to identify traits responsible for influencing cereal crop productivity, like salinity resistant aquaporins.

Virtual Plant Cell

Custom designed by the ARC Centre of Excellence in Plant Energy Biology, the **Virtual Plant Cell: Into Aquaporins 360° video** immersively shows how aquaporins are formed and where they sit in the cell. It also highlights the important role that aquaporin proteins play in shuttling water, carbon dioxide and other molecules vital to good plant health, into and out of plant cells. View video here: https://youtu.be/SJVPjrx7t-w

Science snapshot

Meet Michael Groszmann. Michael is trying to make better aquaporins.

Science snapshot

Meet Samantha McGaughey. Sam is investigating how aquaporins are linked to drought tolerance in plants.

Curriculum links and learning outcomes

Year 7
Classification helps organise the diverse group of organisms.

Year 8
Cells are the basic units of living things; they have specialised structures and functions.

Year 9
Multi-cellular organisms rely on coordinated, interdependent internal systems to respond to changes to their environment

Year 10
Transmission of heritable characteristics from one generation to the next involves DNA and genes.

Further learning
The full list of achievable outcomes are included in a table at the end of this document

Years 7-10

Classifying systems in cells

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This unit aims to achieve multiple curriculum outcomes using real research translated to the classroom for easy engagement.

About this unit

The nature of how living things work is intrinsically connected and interrelated. This unit covers a broad range of topics, from molecular aquaporins, to the global challenge of securing the worlds food supply.

At its heart, these lessons urge students to look at photosynthesis as a means to increase food supply for the worlds growing population.

This sequence is designed to be broad enough to show how all the elements fit together, but there are many opportunities for individual classroom elaboration and exploration.

About the program

These teacher resources have been prepared by the ARC Centre of Excellence for Translational Photosynthesis. The Centre is working on maximising photosynthesis inside the leaf, to translate it into higher crop yields for farmers. It's hoped that this will secure food supplies for future generations. The lessons are designed to link the research of the Centre with the Australian Curriculum, creating a direct connection between the students, the research and the scientists.

The lesson plans are based on real research techniques, modified for the classroom environment.

Budget

Lessons have been designed to maximise educational outcomes, while keeping the cost manageable for tight budgets. The cost of materials to deliver each unit is designed to average out at around $20 per lesson for the whole class.

All items used are commonly available at supermarkets, home maintenance stores (like Bunnings), health food shops or on eBay.

Copyright Information

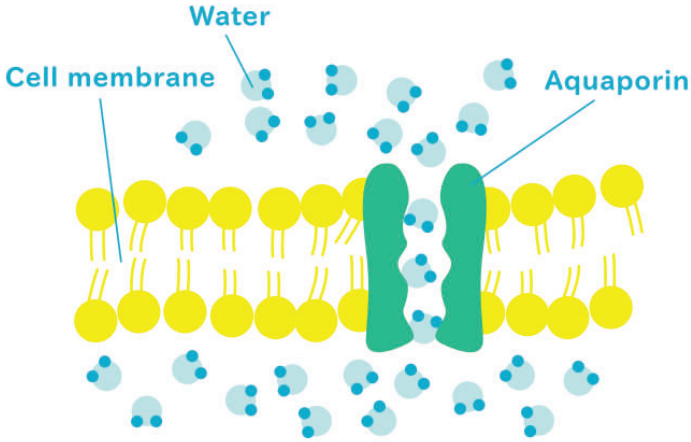
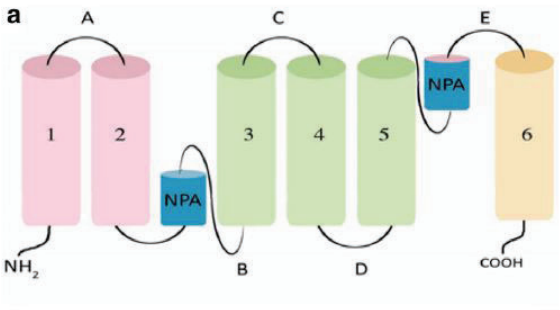
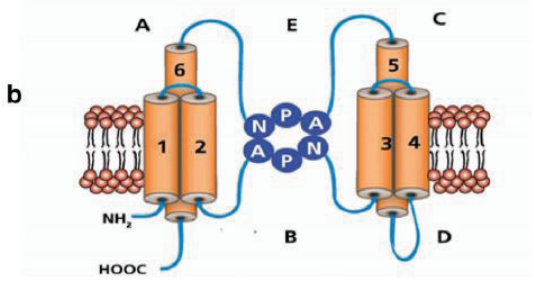


Image: water-channeling-life.com/en/themes/01.html





a) Protein arrangement showing the three dimensional structure of the protein, and the locations of NPA (Asn-Pro-Ala) motifs are at the loops B and E. The pore of the AQP is composed of two halves called hemipores. They consist of six transmembrane domains connected by five loops (A–E).

b) Functional AQP formed by the interaction of the two hemipores [30, 31]

Image: Kapilan et al. Biol Res (2018) 51:4 doi.org/10.1186/s40659-018-0152-0

Years 7-10: Classifying systems in cells

Food for thought

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This activity shows students how that supply and demand imbalance works in the real world, using a modified game of musical chairs.

Teacher information

In 2007 and early 2008 the world hit a food supply and demand imbalance. It came about for a number of reasons, including world population growth, a decrease in world food stockpiles and rising oil prices. It resulted in all time high food prices and difficulty in sourcing some kinds of foods in some areas. Researchers are working hard to ensure there is enough food for future generations. This lesson aims to increase understanding of how food shortages work in the real world.

Learning outcomes

Students will be able to :

- understand food shortages and how they work in the real world.

Teachers will be able to:

- draw out misconceptions.

Materials

- classroom chairs

Instructions

Explain to the students that they'll be playing a different game of musical chairs. In this game, the chairs represent food, and the students represent the population.

a. Start with only half the class, and around two-thirds of the class chairs.

b. It'll be easy for everyone to find a chair when the music stops.

c. Now, more people are born. Add another 2 students to play.

d. A massive weather event has hit food production hard, and 2 chairs have to be removed.

e. It's getting harder for students to find a chair (food to eat), but still, most people are getting by okay.

f. Now, more people are born, add 3 more players. Is everyone able to eat?

g. An unseasonable cold snap hits and the frost kills many crop plants, take away another chair.

h. Continue the game until there are many more students than food.

i. This gives rise to a discussion about what will happen if there isn't enough food to go around.

Researchers all over the world are working hard to solve the problem of food security. Ask the students if they know how we might grow more food? Is there a way to keep the earth's resources in balance in a changing environment?

Extension activities

Some students might be concerned about families lacking food. How could the problem be solved on a small scale? Are the students interested in running a breakfast club or school food drive? See the list of organisations below if your class would like to make a donation.

Some students in the class themselves might be experiencing hunger. If so, here's a list of organisations that might be able to help:

Australian Capital Territory

The Yellow Van

Address: PO Box 1066 Tuggeranong ACT 2901

Phone: (02) 6288 0709

Email: theyellowvan@commsatwork.org

Website: http://food-rescue.commsatwork.org/yellow-van-food-rescue

Tuggeranong Salvos

Address: Cnr Reed and Anketell Streets, Tuggeranong, ACT 2900

Phone: (02) 6293 3262

Email: tuggeranong@aue.salvationarmy.org

Food for thought

This activity shows students how that supply and demand imbalance works in the real world, using a modified game of musical chairs.

New South Wales

DRUG ARM Australasia

Phone: 1300 656 800

Email: adminnsw@drugarm.com.au

Website: http://www.drugarm.com.au

Exodus Foundation

Address: 180 Liverpool Rd, Ashfield , NSW 2131

Phone: (02) 8752 4600

Email: AllanG@exodusfoundation.org.au

Website: www.exodusfoundation.net

Phone:(02) 9756 3099

FoodBank NSW

Address: 152 Newton Rd, Wetherhill Park, NSW 2164

Phone:(02) 9756 3099

Email: office@foodbanknsw.org.au

Website: https://www.foodbanknsw.org.au/want-to-help/donate-food/donatefood/

OzHarvest Newcastle

Address: PO Box 1014 Georgetown NSW 2298

Phone: (02) 4940 0767

Email: newcastle.info@ozharvest.org

Website: http://ozharvest.org

OzHarvest Sydney

Address: PO Box 7257, Alexandria, NSW 2105

Phone: (02) 9516 3877

Email: foodpickup.syd@ozharvest.org

Website: www.ozharvest.org

QMHR Ark Mission

Phone: 0414 400 028

Email: arkmission@qmhr.com.au

Website: http://www.qmhr.com.au/#!ark-mission/rxxw2

SecondBite

Phone: (03) 9376 3800

Website: http://secondbite.org/donate-food

Vinnies Van

Phone:(02) 8861 9700

Email: parradio@vinnies.org.au

Website: https://www.vinnies.org.au/page/Find_Help/NSW/Food/Penrith__Parramatta_Night_Patrol/

Queensland

Brisbane Youth Service

Phone: (07) 3620 2400

Email: admin@brisyouth.org

Website: http://www.brisyouth.org/

Capricorn Region Salvos

Address: 131-137 Park St, North Rockhampton , QLD, 4701

Phone: (07) 4923 5600

Website: https://salvos.org.au/capregion/contact/donate-food/

FoodBank QLD

Address: 179 Beverley St (off Lynton Rd), Colmslie, QLD , 4170

Phone: (07) 3395 8422

Email: admin@foodbankqld.org.au

Website: www.foodbankqld.org.au

OzHarvest Brisbane

Phone: (07) 3621 2097

Email: brisbane.info@ozharvest.org

Website: http://www.ozharvest.org

Secondbite

Phone: (03) 9376 3800

Website:http://secondbite.org/donate-food

Food for thought

This activity shows students how that supply and demand imbalance works in the real world, using a modified game of musical chairs.

South Australia

Foodbank SA

Address: 377A Cross Rd, Edwardstown, SA 5039

Phone: (08) 8351 1136

Email: office@foodbanksa.com.au

Website: www.foodbanksa.com.au

OzHarvest Adelaide

Phone: (08) 7007 0080

Email: adelaide.info@ozharvest.org

Website: http://ozharvest.org

Tasmania

Produce to the People

Address: PO Box 3097 South Burnie 7320

Phone: 0409 484 152

Website: https://producetothepeopletasmania.wordpress.com/free-food-hub/leave-your-produce-here/

Victoria

Asylum Seeker Resource Centre

Phone: (03) 9326 6066

Email: food@asrc.org.au

Website: https://www.facebook.com/ASRCFoodbank/?fref=ts

Cottage by the Sea

Address: 29 Flinders Street.
Queenscliff, Vic. 3225

Phone: (03) 5258 1663

Email: info@cottagebythesea.com.au

Website: http://cottagebythesea.com.au/

Diversitat – Asylum Seeker Food Bank

Phone: (03) 5244 0070

Website: http://www.diversitat.org.au/latest-news/56-settlement-community/1815-donations-required-for-asylum-seeker-food-bank

FareShare

Phone: 0438 560 893

Email: kellie.watson@fareshare.net.au

Website: http://fareshare.net.au

Foodbank Victoria

Address:4/2 Somerville Rd, Yarraville Vic 3013

Phone: (03) 9362 8300

Email: info@foodbankvictoria.org.au

Website: http://www.foodbankvictoria.org.au

Freedom Care Inc.

Address: 127C Northern Highway, Kilmore, 3764

Phone: 0411 794 188

Email: admin@freedomcare.com.au

Website: http://www.freedomcare.com.au

RISE

Phone: (03) 9639 8623

Email: admin@riserefugee.org

Website: http://riserefugee.org/what-we-do/food-bank

Sacred Heart Mission

Address: 87 Grey St, St Kilda, VIC 3182

Phone: (03) 9537 1166

Email: info@sacredheartmission.org

Website: www.sacredheartmission.org

Food for thought

This activity shows students how that supply and demand imbalance works in the real world, using a modified game of musical chairs.

Sea Shepherd Australia
Phone: 1300 OCEANS (1300 623 267)
Email: australia@seashepherd.org.au
Website: https://www.seashepherd.org.au

SecondBite
Phone: (03) 9376 3800
Website: http://http://secondbite.org/donate-food

Wesley Mission Victoria
Phone: (03) 03 9662 2355
Email: foodforfamilies@wesley.org.au
Website: http://www.wesley.org.au/

Western Australia
FoodBank WA
Address: 23 Abbott Road, Perth Airport, WA 6101
Phone: (08) 9258 9277
Email: wa.info@foodbankwa.org.au
Website: www.foodbankwa.org.au

Food Rescue
Address: Unit 3 / 130 Francisco Street, Belmont, WA 6104
Phone: (08) 9277 8851
Email: foodrescue@unitingcarewest.com.au
Website: http://foodrescue.com.au/

S.O.U.L. Soup Patrol
Address: 23 Keppell Mews, Rockingham WA
Phone: (08) 9277 8851
Email: soulsouppatrol@iinet.net.au
Website:Website: http://www.soulincorporated.org

Years 7-10: Classifying systems in cells

What are aquaporins?

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Aquaporins are tiny channels that let some molecules pass through membranes, making them permeable.

See for yourself in this interactive experiment.

Teacher Information

Aquaporins are proteins within the cell that form channels through membranes. Some only transport water, and some transport certain molecules selectively such as glycerol. They control what molecules go into and out of the different parts of the cell.

This interactive activity shows how pores within a zip lock bag can selectively transport molecules. This is done by showing that iodine will pass through a membrane, while the cornstarch cannot. Iodine is an indicator of starch (it turns from brown to black in the presence of starch). Students will see the flow of iodine as a colour change in the cornstarch bag.

Students may think that a zip lock bag is an impermeable membrane. But the plastic has pores in it and so acts as a semi-permeable membrane. The cornstarch particles are too large to pass through the pores in the plastic, they are large polymers of glucose. The iodine passes through easily because it is much smaller than the starch molecule. The iodine ions move about randomly, and in the course of this movement, some of them pass through the pores. The pores, similar to aquaporins, facilitate diffusion.

In plants there are five main types of aquaporins:

- Plasma membrane Intrinsic Protein (PIP)

These aquaporins reside in the plasma membrane, the outer boundary of the cell.

- Tonoplast Intrinsic Protein (TIP)

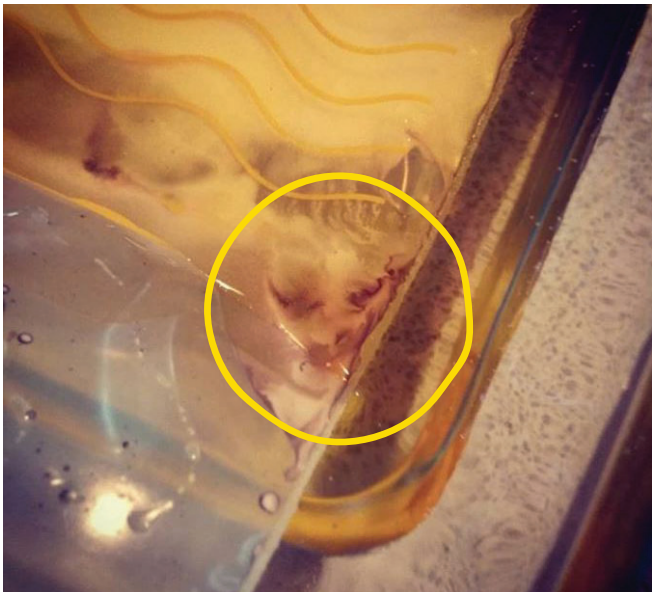
The tonoplast is the membrane surrounding the vacuole, the storage unit of the cell.

- Nodulin-26 like Intrinsic Protein (NIP)
- Small basic Intrinsic Protein (SIP)
- X Intrinsic Protein (XIP)

Learning outcomes

Students will be able to:

- see iodine travel across a membrane



The dark purple/black shows that the iodine (as Betadine) has come into contact with the starch.

Virtual Plant Cell

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Aquaporins are tiny channels that let some molecules pass through membranes, making them permeable.

See for yourself in this interactive experiment.

Materials

- Iodine as Betadine
- Zip lock bags
- Cornstarch
- Water
- Beakers

Instructions

a. Ask students to place 1-2 tablespoons of cornstarch in their bag, add around a 1/2 cup of water.

b. Close the bag after extracting as much air as possible.

c. Half fill the beaker with water.

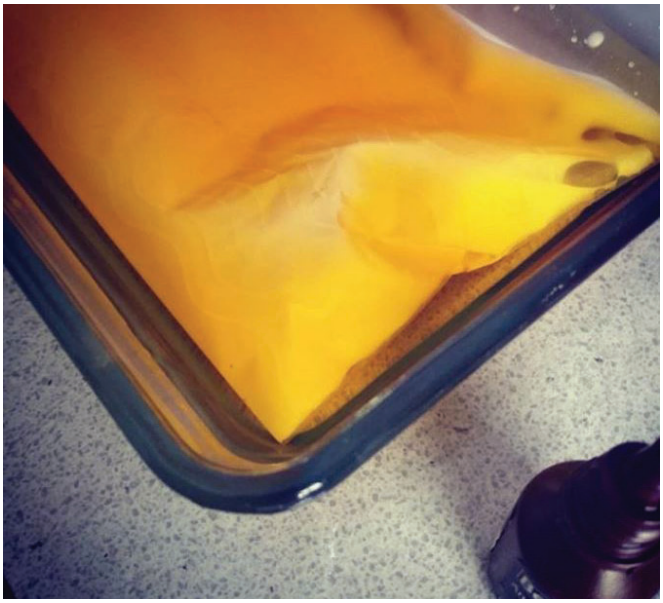
d. Add around 25 drops of iodine into the beaker. It should look dark yellow.

e. Place the cornstarch bag into the beaker with the iodine.

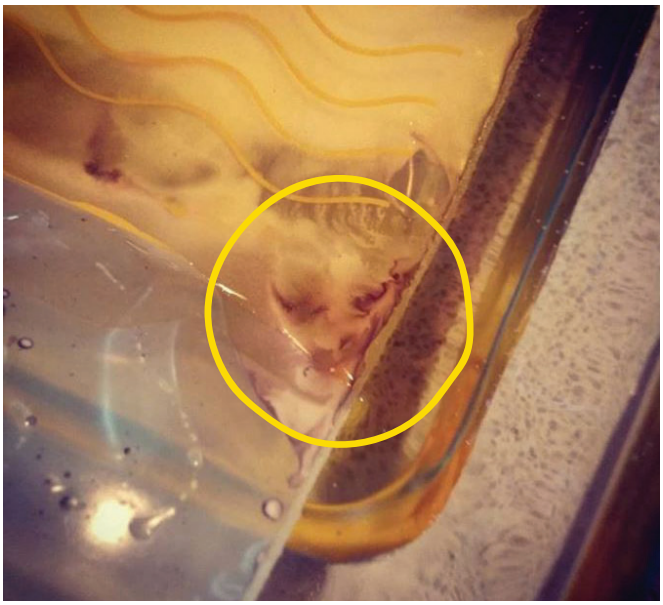
f. Watch what happens next. Students should see results within the hour, showing as a colour change inside the zip lock bag. This result is shown in the image on the right.

Further information

Aquaporins play a key role in water regulation in plant cells. While the aquaporin channels can transport water and other molecules, they can also 'close the gate' and stop passage of water or solutes through a process of phosphorylation. Without the ability to allow rapid water exchange across membranes, cells wouldn't be able to fill up, and plants would wilt (if they were able to grow at all!).



Cornstarch and water inside a sealed ziplock bag, inside a water and iodine (as Betadine) mix.



The dark purple/black shows that the iodine (as Betadine) has come into contact with the starch.

Cornstarch and water in a ziplock bag.

Years 7-10: Classifying systems in cells

Spot the difference

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Researchers use software to align sequences of DNA so they can spot the differences. In this lesson, students will be able to follow the easy-to-use guide to spot the differences themselves!

Teacher Information

The DNA of different organisms are different, but there are usually blocks of the sequence that are similar, and will line up. When the sequence is lined up, the differences are easier to see.

In how an organism looks, the similarities and differences can be seen as traits. For example, people have noses, there are blocks of DNA that code for having a nose. However, those sequences will be slightly different, which contributes to variation in nose shape, e.g. large, short, flat etc.

In this lesson, students will align the protein sequences from a plant aquaporin.

Important to note: the sequences provided for this unit are protein sequences, not DNA. DNA in the cell is transcribed into RNA, and the RNA is translated into long chains of amino acids to create a protein e.g. an aquaporin.

Aquaporins are encoded by a family of genes. The sequences for these genes are much smaller and more manageable to manipulate, align and identify than a whole organisms DNA sequence. For comparison, tomato plants have almost 32 000 genes in total, of which 47 genes have been found that code for aquaporins.

For simplicity's sake, not all 47 aquaporin sequences have been included in this activity, but full information can be found here: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0079052. The sequences provided in this unit have been adapted from what the authors have provided as supplementary evidence for their published article.

The software MEGA (short for Molecular Evolutionary Genetics Analysis) is used by researchers in a number of ways. In this series of lessons, students will align sequences, and spot the differences.

Learning outcomes

Students will be able to:

- use MEGA to align genetic sequences

Materials

- computer(s)
- MEGA software (free download from www.megasoftware.net)
- aquaporin sequences, as provided

Virtual Plant Cell

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Note:

Computers don't need web connection for the MEGA software to align. The internet is only required during download.

Years 7-10: Classifying systems in cells

Spot the difference

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Instructions

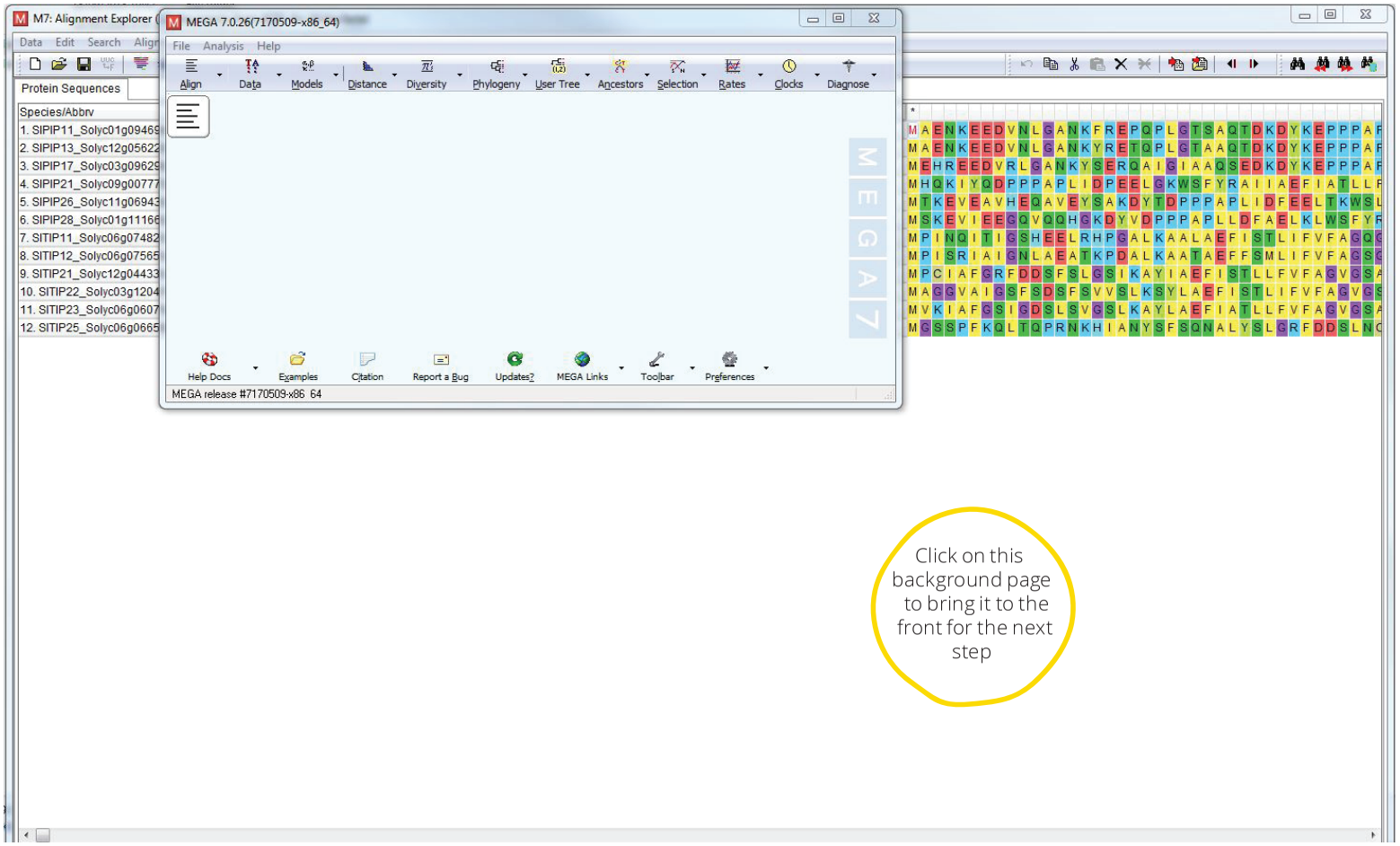
1. Download and install the MEGA software from www.megasoftware.net

2. Have the sequence files downloaded and ready to use.

3. Start by opening the file - double click it or right click and 'Open With' MEGA.

4. Click on the background page to bring it to the front for the next step (see note to the right)

5. Click on 'Alignment'. In the drop down menu, select 'Align by Muscle'



Lesson 3

Spot the difference

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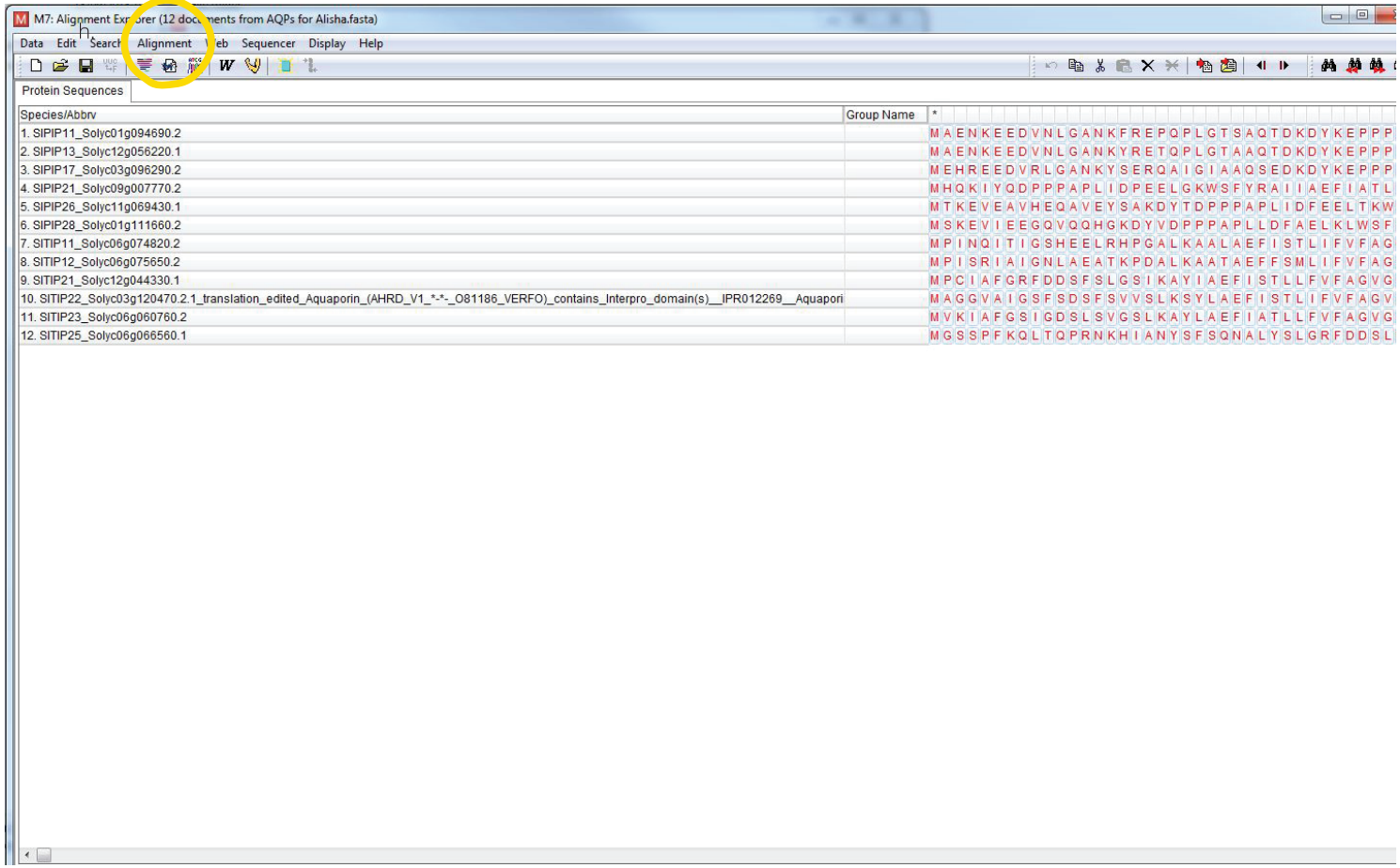
Instructions cont.

6. Click on 'Alignment'. In the drop down menu, select 'Align by Muscle'

7. It will say 'Nothing has been selected', would you like to select all'. Click 'Yes'.



Spot the difference

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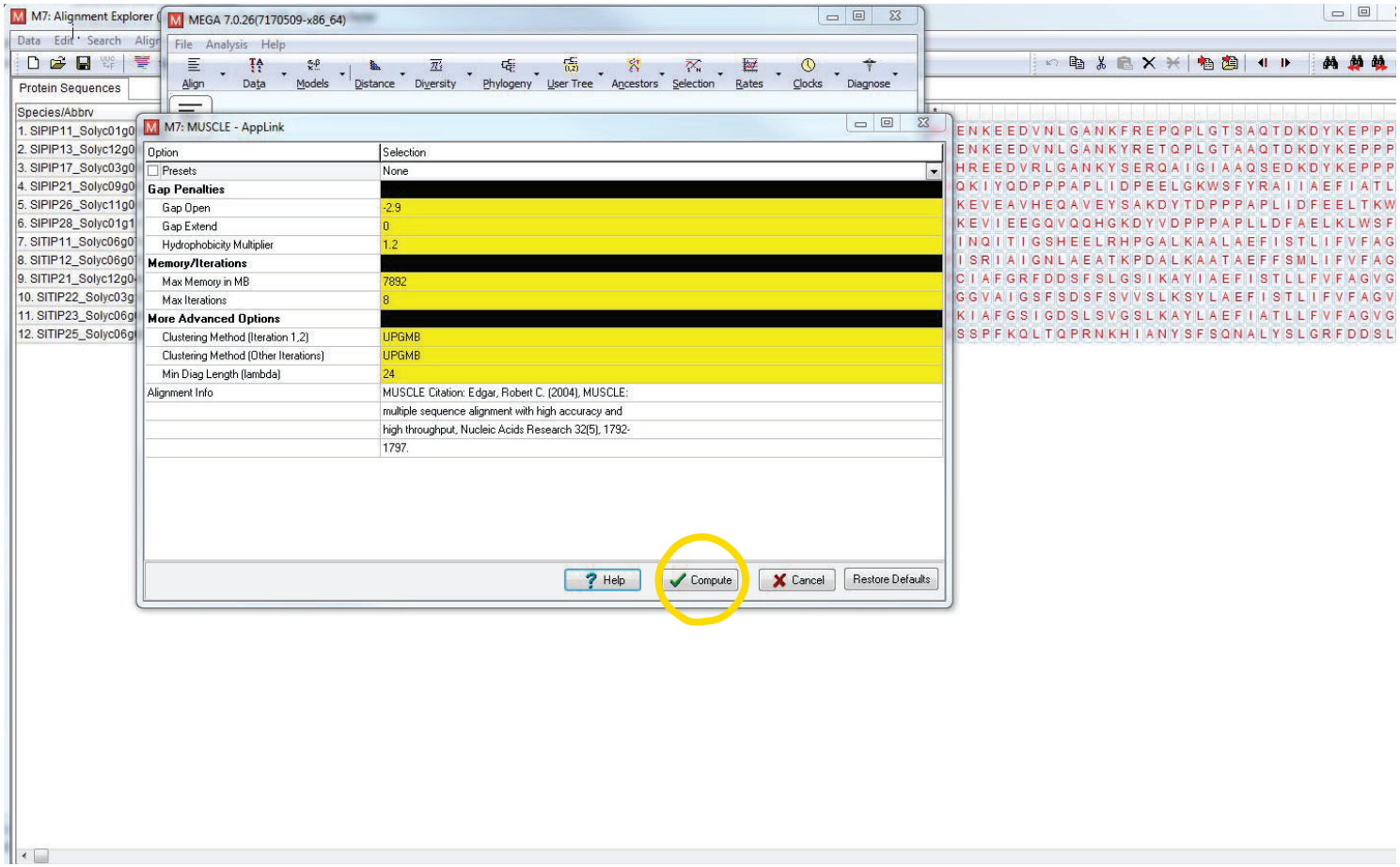
Instructions cont.

8. Keep all the pre-filled options and click 'Compute', circled here in yellow.



Spot the difference

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Instructions cont.

9. You'll see now that there are gaps in the sequence, caused by the alignment.

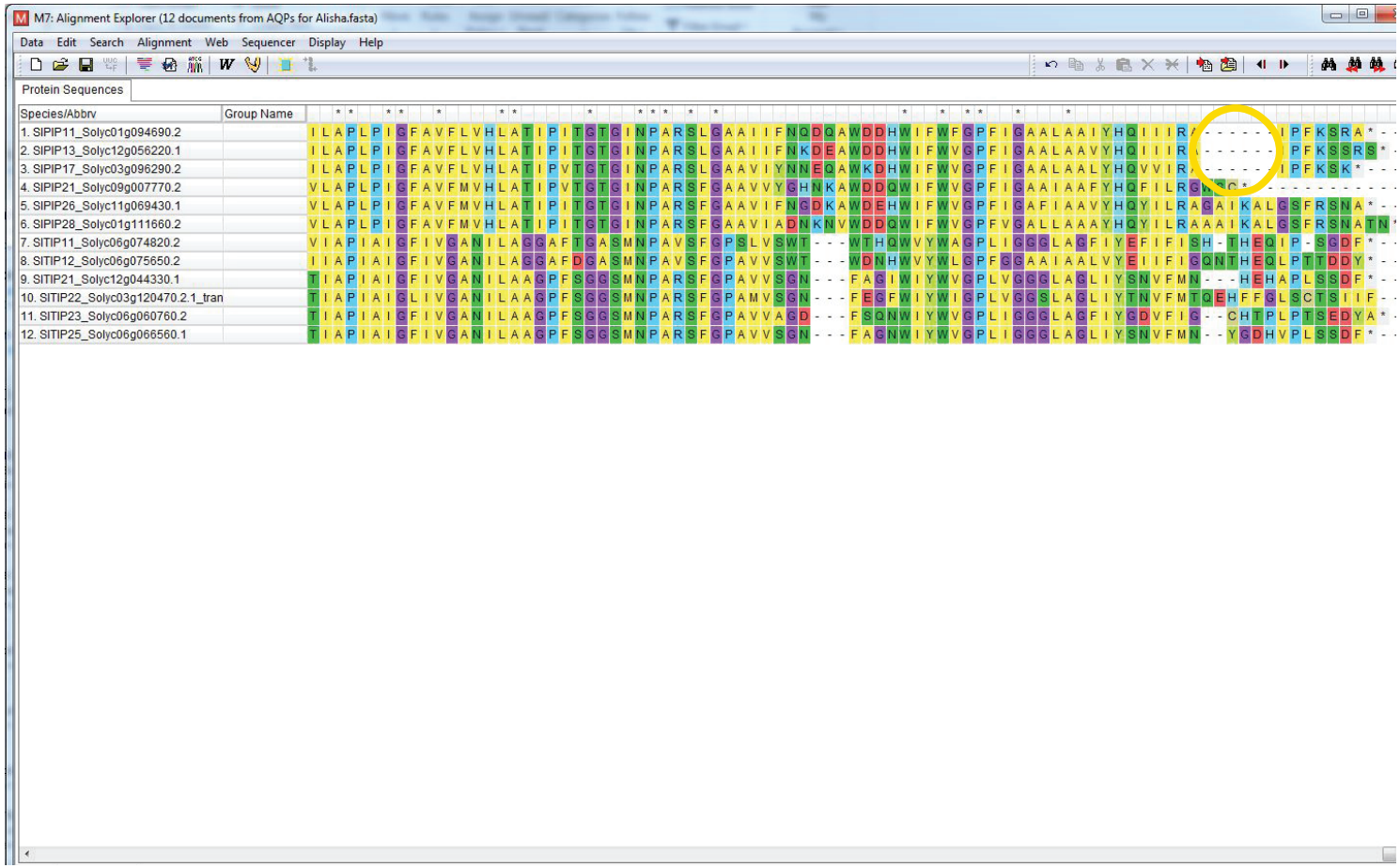
10. One of the defining features of the aquaporin protein sequence are two separate 'NPA' sequences. the 'NPA' is an abbreviation of the protein molecules apparent in the sequence and stand for:

N: Asparagine

P: Proline

A: Alanine

11. Can students find the two separate NPA sequences?



Spot the difference

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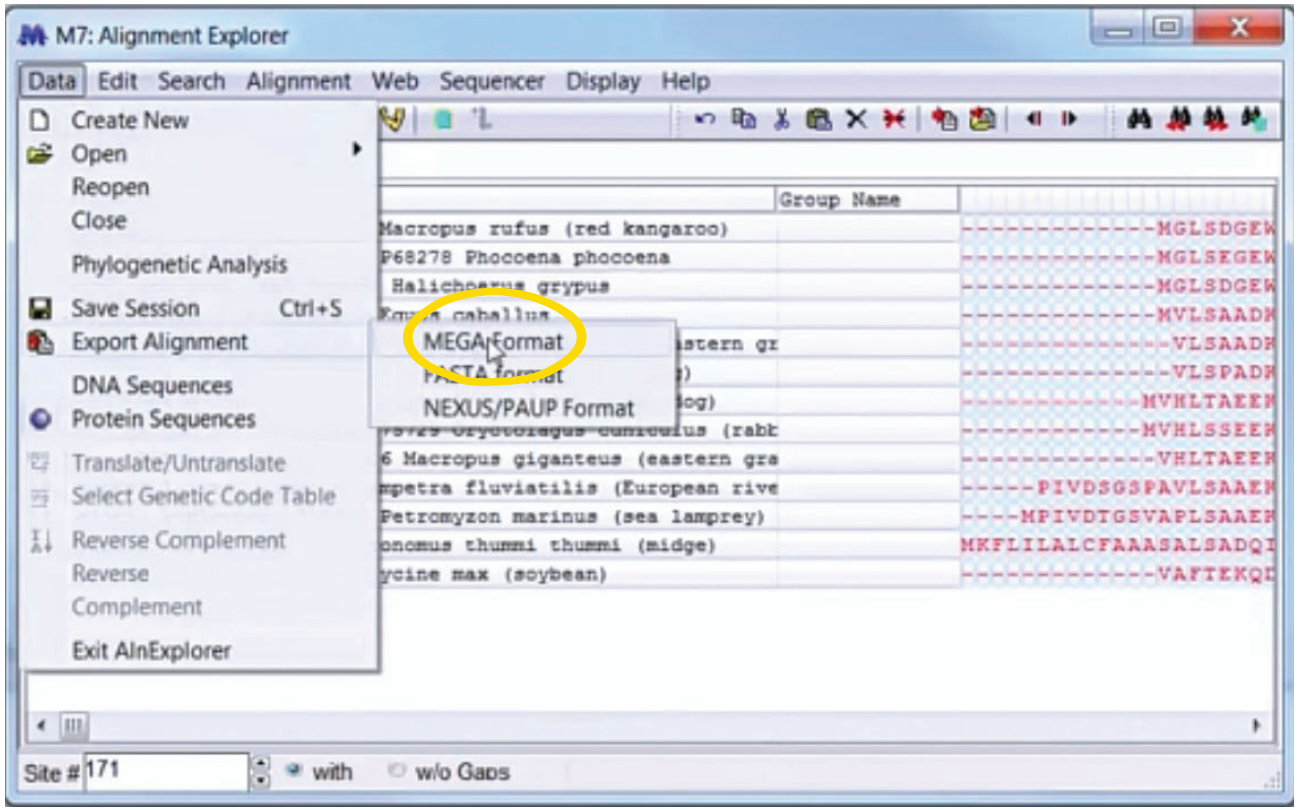
Instructions cont.

12. To finish the current task, students will need to export the alignment by clicking on the 'Data' tab, and exporting in MEGA Format.

13. Give it a name and save the file to where you'd like.



Years 7-10: Classifying systems in cells

What came first?

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Now that the sequences are aligned, students can run an analysis on the data to show which aquaporin came first!

Teacher Information

The way classification takes place has historically been by assessing the anatomy of a plant or other organism.

The discovery of DNA and the way it relates to a plant's structure has given rise to a new way of classification.

The cost of gene sequencing and analysis tools has greatly reduced while the accuracy has increased, increasing their viability as a tool to classify organisms

Software is now freely available allowing the user to align sequences, and then analyse how closely related they are, by assessing how much of the sequences match, and how many are unique to the organism.

In this lesson, students will create a phylogenetic tree based on the alignment they've already made.

Note:
Computers don't need web connection for the MEGA software to align. The internet is only required during download.

Learning outcomes

Students will be able to:

- create a phylogenetic tree using MEGA software
- hypothesise which aquaporin came first

Materials

- computer(s)
- MEGA software (free download from www.megasoftware.net)
- aquaporin sequences, aligned in the previous lesson

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Years 7-10: Classifying systems in cells

What came first?

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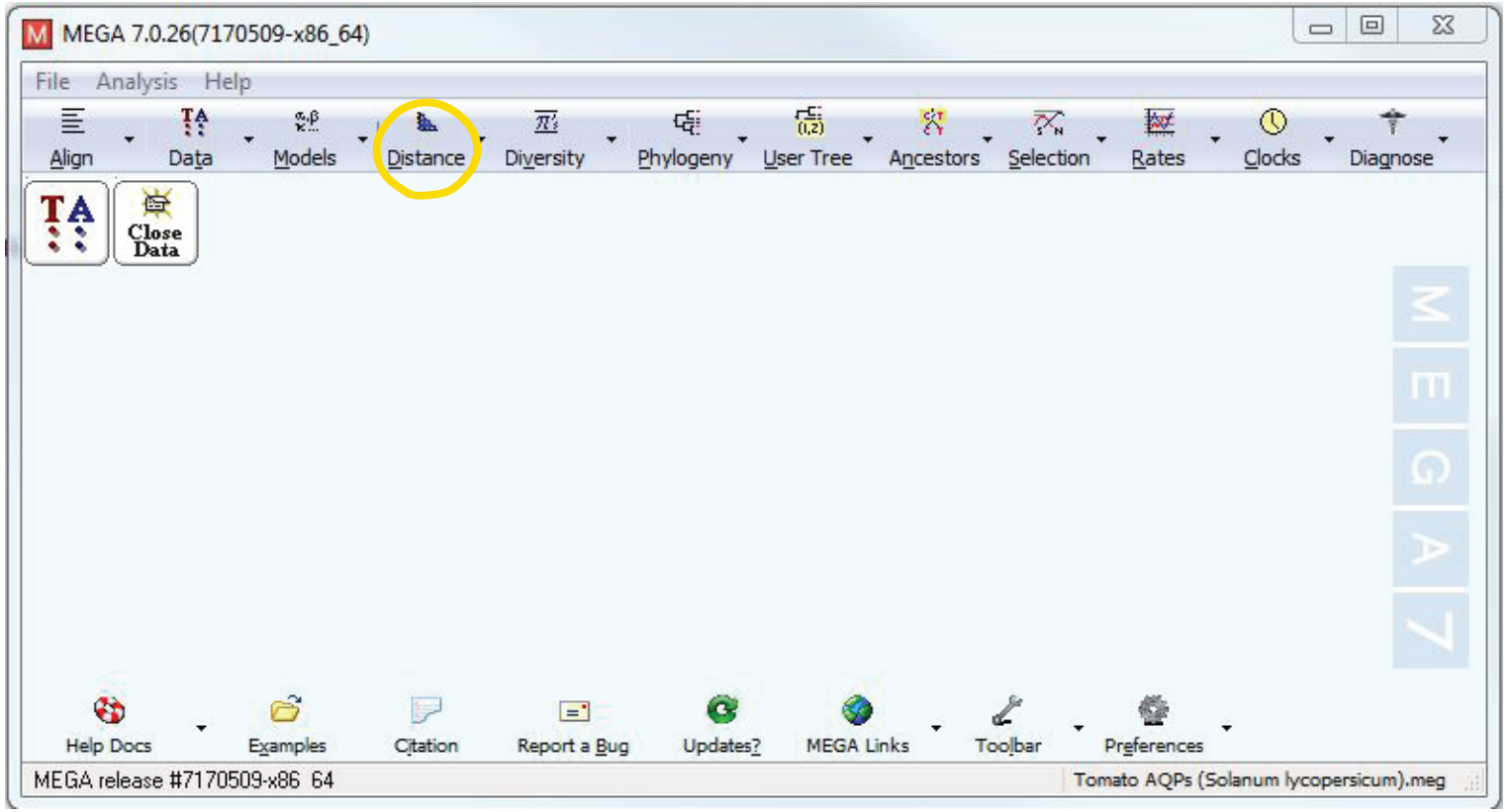
Instructions

1. Before creating the phylogenetic tree, students will first measure the differences between the different sequences.
2. In MEGA, click on the 'Distance' option.
3. From the dropdown menu, select 'Compute Pairwise Distances'.
4. You can either use the current data or open the previously used data.
5. Students can keep the default settings and click on 'Compute'



What came first?

Instructions

6. From the dropdown menu, select ‘Compute Pairwise Distances’.

7. You can either use the current data or open the previously used data.

8. Students can keep the default settings and click on ‘Compute’

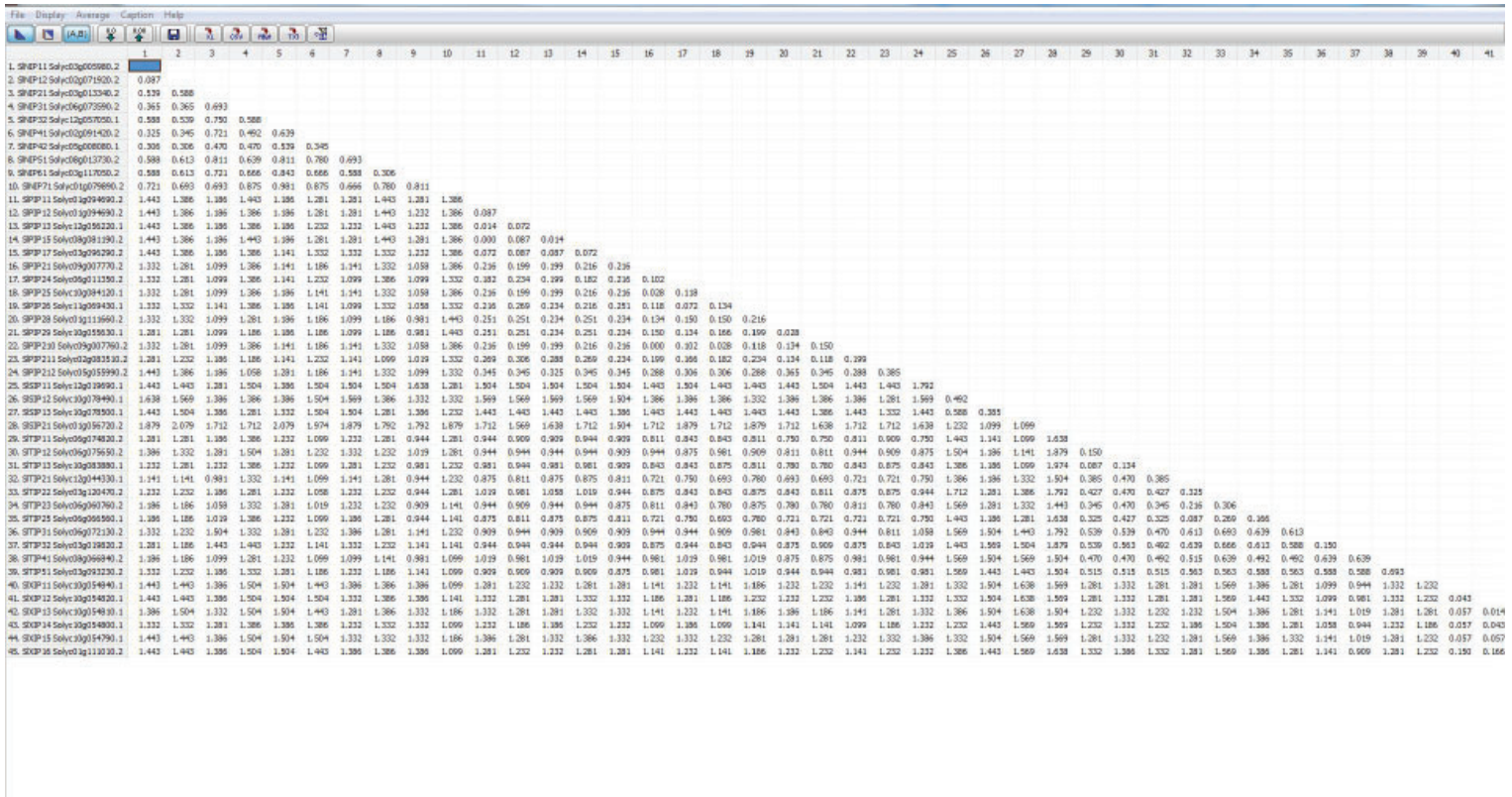
9. They will end up with a display that looks something like this.

10. The aquaporin at the top and the one below have the least number of substituted amino acids in the sequence.

11. The aquaporin at the bottom has the greatest number of substituted amino acids from that at the top.

12. Next, this information can be represented visually as a phylogenetic tree.

13. Close down the distance graph (saving if you choose).



What came first?

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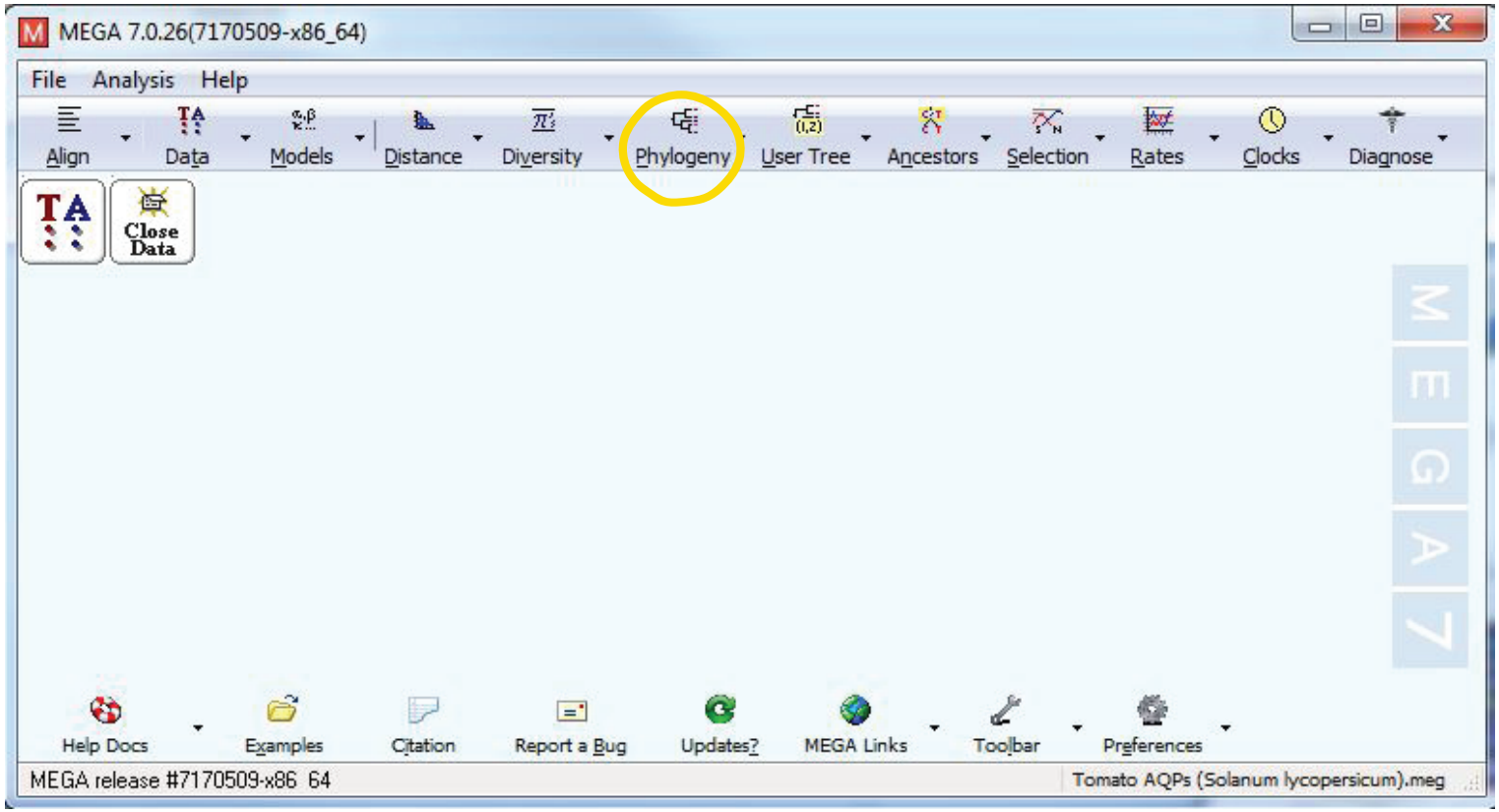
Instructions

14. Click on the 'Phylogeny' tab and from the drop down menu, select 'Construct/ Test UPGMA Tree'

15. Use the active data or open the previously used file.

16. Keep the system defaults and click 'Compute'.



Years 7-10: Classifying systems in cells

What came first?

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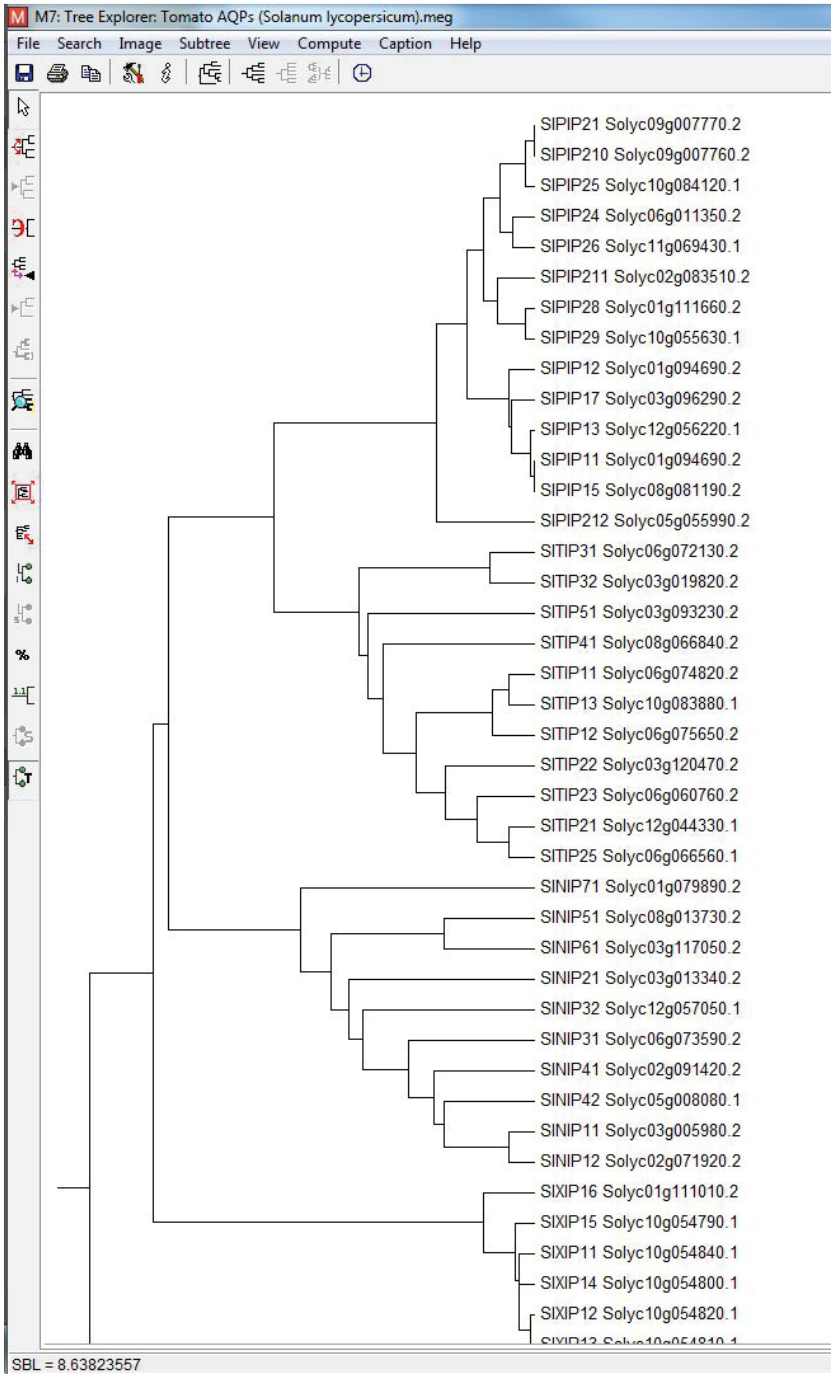
Now that the sequences are aligned, students can run an analysis on the data to show which aquaporin came first!

Instructions

17. The resulting phylogeny tree should look something like the image opposite.

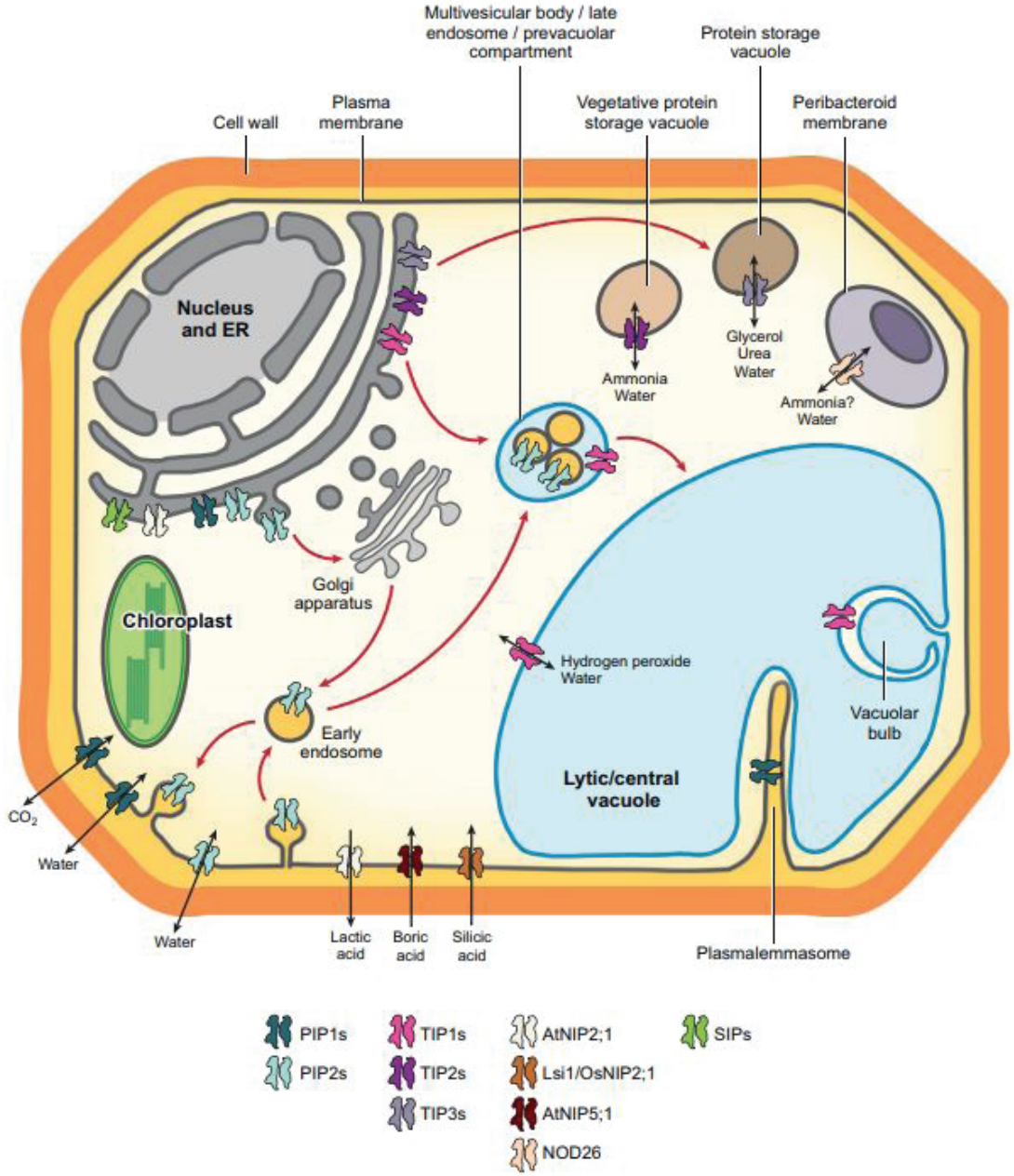
18. There are five main types of aquaporins:

- Plasma membrane Intrinsic Protein (PIP)
- Tonoplast Intrinsic Protein (TIP)
- Nodulin-26 like Intrinsic Protein (NIP)
- Small basic Intrinsic Protein (SIP)
- X Intrinsic Protein (XIP)



What came first?

This image shows the different aquaporins and their expected solute specification.



Plant Aquaporins: Membrane Channels with Multiple Integrated Functions

Image courtesy: Maurel, C, Verdoucq, L, Luu, D, and Santoni, V, 2008.

Extract more information

Extract DNA from a strawberry using everyday items.

Teacher background

The protein sequences the students have worked with have been translated from DNA. In this practical experiment, students will extract DNA from a strawberry.

Learing outcomes

Students will be able to:

- extract DNA from a strawberry.

Materials

For the class

- 900ml water
- 100ml dishwashing detergent
- 2.5 teaspoons salt

For each small group or individual

- half a strawberry
- a zip lock bag
- 10ml of extraction solution (made by mixing a teaspoon of salt and 5 teaspoons of dishwashing liquid with 25ml of water)
- 2 x 50 ml test tubes or clear plastic cups
- a chux cloth or muslin cloth
- funnel
- a permanent marker
- ethanol

Strawberries ready for DNA extraction.

Extract more information

Extract DNA from a strawberry using everyday items.

Instructions

a. Pre-make enough extraction solution for the class, ahead of the lesson.

b. Each individual or small group will extract their own strawberry DNA.

c. Give each individual or small group a half strawberry and a zip lock bag.

d. Add 10mL extraction solution.

e. Squish the strawberry and extraction solution together with hands.

f. Leave the bag aside for 5 minutes. In the meantime, get ready for the next step!

g. Line a funnel with the chux or muslin cloth, on top of a 50ml tube marked as 'Strawberry DNA'.

h. Filter the fruit mash through the cloth.

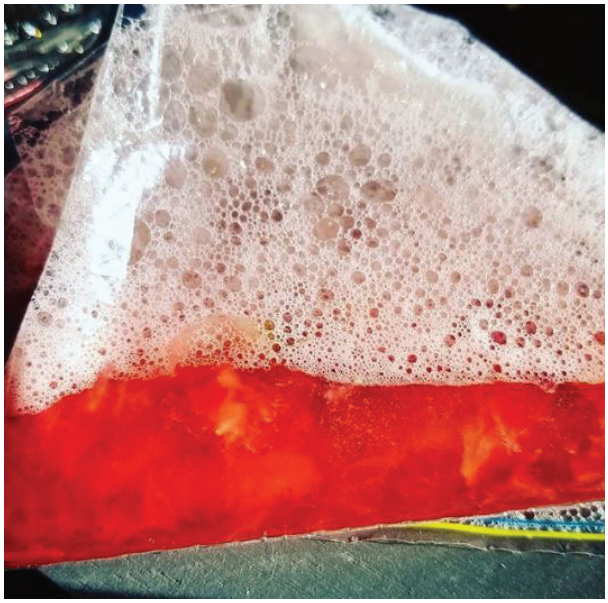
i. Remove the funnel.

j. Slowly add an equal volume of ethanol down the side of the 50mL tube to form a separate layer on top of the fruit solution. Do not mix.

k. Replace the lid and gently swirl the tube a few times.

l. Look at where the two layers meet.

m. There will be a small amount of strawberry DNA where the two layers meet.



Squashed strawberries with extraction solution.

Notice the fine white lines between the ethanol and the strawberries and solution. The white parts are the strawberry DNA!

Science Snapshot
Annamaria De Rosa

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Annamaria knows all the cutting edge aquaporin research and represents the next generation of plant physiology researchers.

Meet Annamaria De Rosa.

Annamaria loves plants. She loves them so much that she studied botany at the University of Melbourne for her undergraduate degree. She continued on to complete a Masters in Plant Biotechnology before realising that she wanted to explore the communications side of science and set about moving locations to work at the renowned National Science and Technology Centre, Questacon.

After some time working at Questacon, a group of researchers from the ARC Centre of Excellence for Translational Photosynthesis convened on one of the Questacon lab spaces to share their experiments and experiences with members of the public, staff and students. It turns out Annamaria was working that day and met now-supervisor John Evans.

John is an engaging, enthusiastic communicator and a world renowned plant physiologist. He and Annamaria started talking plant physiology during that event, they continued talking after the event, and now Annamaria's well on her way to completing a PhD in John's lab.

A bit about Annamaria's research

For Annamaria's project, she's focusing on the emerging field of aquaporins and has provided a lot of the background information for this unit of work. Given that:

a. Not a lot is known about aquaporins, and

b. They represent a huge opportunity for raising yield and increasing plant resilience,

Annamaria has found herself in a unique and valuable position within the field of plant physiology.

More about Annamaria

What got you into science?

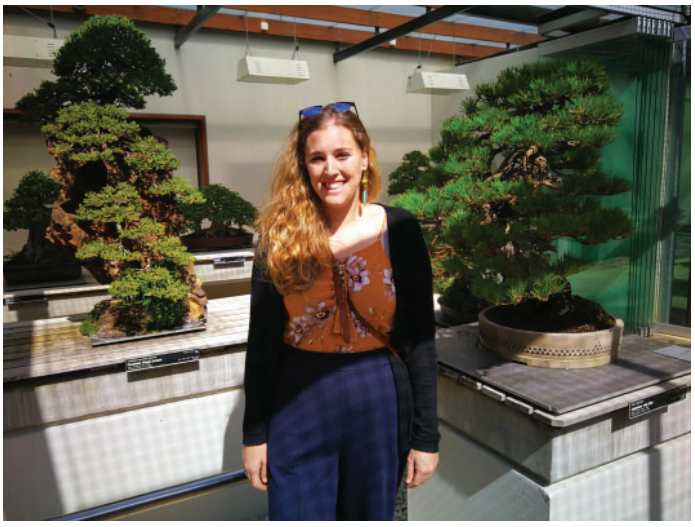
Since moving from Italy to Melbourne with my family as a 10 year old, I remember noticing and being fascinated by the amazing plants found in Australia. I've always wanted to learn more about different types of plants, their functions and the processes they're involved in. In my Undergraduate degree I got to learn about how central plants are to addressing food security challenges and since then I have been interested in how Plant Biotechnology can be used to improve food production for a growing global population.

What do you see as challenges for your field of research?

Aquaporins are exciting proteins to work with; they facilitate the diffusion of a range of small molecules across cell membranes and their interaction with each other can impact their efficiency and function. We are working towards deciphering the complexities of aquaporins to identify ideal engineering targets for improving plant photosynthetic efficiency.

What else do you have underway?

I enjoy bike riding, I love cooking and growing plants!



Annamaria at the National Bonsai and Penjing Collection

Science Snapshot
Samantha McGaughey

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Sam is studying water and ion movement within plants!

Meet Samantha McGaughey.

Samantha is a PhD student at the University of Adelaide looking at the role of plant water channels, or aquaporins, in water and ion movement in plant cells.

Samantha's passion about plant biology started in her high school science class and was inspired by a great biology teacher to study plant biology at university. She completed a Bachelor of Biotechnology with Hons where her Honours research project introduced her to the fascinating world of aquaporins.

A bit about Sam's research

Samantha's research for her PhD has primarily been focussing on a type of plant aquaporin that is permeable to both water and ions (like sodium) and how they function in plant cells. She has been working on uncovering the features of these aquaporins that enable it to conduct both water and ions and on how these aquaporins are regulated by the plant cell.

Her hope is that through her research a greater understanding of how these water and ion permeable aquaporins work could lead to improving crops to better cope with stressful environments like drought and salinity.

A bit more about Sam.

What got you into science? For as long as I can remember I've had an interest in science, but was inspired to study biology at university by my high school biology teacher. I got into plant science because they were by far, in my opinion anyway, the most interesting subjects in my degree! Plants are amazing!

What do you enjoy most about research? I really enjoy being able to pursue the questions that interest you most. I also love that being a scientist allows you to think creatively and analytically to solve problems.

What do you see as challenges for your field of research? A major challenge I see for the field of plant science is communicating to the general public and also to policy-makers and stakeholders how important this research is, especially considering the threat of climate change to global food security. Another big challenge will be to translate what we learn in the lab into real crop improvements in the field.

What else do you have underway? In my spare time I enjoy reading, walking by the beach or in the bush and listening to all sorts of podcasts.

Sam working in the glasshouse.

Science Snapshot
Michael Groszmann

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Michael's working to make better aquaporins

Meet Michael Groszmann.

Michael investigates ways of making it easier for carbon dioxide to enter the cells of the inner leaf, thereby increasing photosynthesis.

Michael has always been interested in understanding how things work and ways of making improvements. He believes there is no more complex challenge than understanding biological systems. His interest in plant sciences stems from his Year 9 high school science teacher, who among other things ran practical classes on photosynthesis, and a third year lecturer and eventually honors and PhD supervisor, who got him interested in plant developmental biology.

A bit about Michael's research

Michael started his research career examining developmental patterning genes and the genetic interactions that govern the identification and growth of cells into various floral organs and tissues. After his PhD, Michael shifted his research focus into the hormonal regulation of plant fertility, seed set and fruit development for both the development of (seedless fruit) as well as a means for generating sterility for weed eradication. Michael then shifted fields and started working on the genetic and epigenetic mechanisms driving the crop yield boosting phenomenon of hybrid vigor. Michael now continues his research passion to develop strategies to increase crop production through his work in the CoETP.

Michael's primary focus is understanding the biology of the channel proteins known as aquaporins that help facilitate the transport of water, carbon dioxide and range of other substrates, important for plant growth, across cell membranes. He studies a special type of aquaporins termed PIPs, which among other substrates also facilitate the transfer of carbon dioxide across the membrane. His main goal is to develop and engineer better CO2 transporting PIP variants that enable more efficient carbon dioxide diffusion and higher photosynthetic rates. He examines PIP aquaporins from a range of plant and non-plant species examining their transport properties and identifying those that are capable of improving photosynthesis and growth in transgenic plants.

As part of his research, Michael has also identified PIP aquaporins that transport other substrates essential for optimal plant growth and performance. Engineering of these PIPs may also help improve crop production and Michael examines these alternative pathways in collaboration with researchers from the University of Adelaide, University of Queensland, Louisiana State University and University of Illinois.

A bit more about Michael.

What got you into science? An interest in wanting to know how things work and to see if they can be improved. Some passionate and inspiring teachers and lecturers.

What do you enjoy most about research? Unravelling and shedding light on the unknown. The opportunity to work on something I'm passionate about. Being surrounded by intelligent and enthusiastic people and being able to engage in stimulating conversations and sharing science.

What do you see as challenges for your field of research? Generating and building on opportunities for further fundamental and translational outcomes through new techniques and educating the broader community of what has and is being achieved.

What else do you have underway? I enjoy partaking in recreational sports; I'm an avid basketball fan. I also like gardening and undertaking home renovation projects.

Michael working on Arabidosis plants in the lab.

Image: Charles Tambiah

Science Snapshot
Caitlin Byrt

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Caitlin's figuring out how aquaporins work during drought.

Meet Caitlin Byrt.

Caitlin is a research fellow studying the function of water channels called aquaporins towards understanding their roles in helping plants grow and adjust to environmental changes such as drought and salinity. She will commence an Australian Research Council Future Fellowship with the Australian National University in 2019.

Plant productivity is tightly linked to water availability and uptake, and rapid movement of water across cell membranes is facilitated by aquaporins. The information Caitlin's research team is gathering in their investigation of aquaporin function is increasing our understanding of how cells regulate solute transport, which is relevant to agricultural productivity and food security.

A bit about Caitlin's research

Caitlin's work involves profiling the permeability of types of aquaporins that transport both ions and water, and she investigates the signalling steps that control the function of these proteins. Understanding how plants regulate aquaporin transport functions to manage cell expansion and osmotic adjustment will unlock powerful means for optimising crop productivity. The research being undertaken in Caitlin's laboratory has the potential to lead to improvements in crop-plant solute transport traits, and increase yield stability in saline and water limited environments.

A bit more about Caitlin.

What got you into science? I love food. It is important to me that we have access to healthy, fresh, delicious produce. I started thinking about a career related to agriculture in high school. My year 11 physics teacher suggested it is an area where there are interesting career opportunities, and she was correct.

What do you enjoy most about research? The great surge in excitement and adrenaline when you discover something that no-one has ever found before.

What do you see as challenges for your field of research? Dissemination of information. As researchers we prioritise reporting our findings in scientific journals. The information in journal papers reaches other scientists. We are building our skills and experience in finding ways to reach a broader audience, for example by contributing information in blogs, social media and public talks.

What else do you have underway? I enjoy parenting and running. I would love to be able to carve out more time for hiking and camping.

Caitlin working in the field.

Caitlin working in the lab.

Years 7-10: Classifying systems in cells

Curriculum outcomes and teacher information

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Lesson	Short description	Delivery	Science understanding	Science as a human endeavour	Science inquiry skills
Food for thought	Students play a modified version of musical chairs, where chairs are food. What happens when there aren't enough chairs to go around?	Interactive activity			
What are aquaporins?	In this interactive experiment, students will see how aquaporins work to transport molecules across a membrane.	Experiment	Cells are the basic units of living things; they have specialised structures and functions, ACSSU149, Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment, ACSSU175		
Spot the difference	Students will align aquaporin sequences and spot the differences using real research techniques and technology.	Dry lab activity	Transmission of heritable characteristics from one generation to the next involves DNA and genes, ACSSU184	Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries, ACSHE158	Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate, ACSIS129, Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence, ACSIS130, Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies, ACSIS169
What came first?	Students create a phylogenetic tree using open access automated sequencing software, to determine which aquaporin came first.	Dry lab activity	Classification helps organise the diverse group of organisms, ACSSU111, The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence, ACSSU185	Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries, ACSHE158	Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate, ACSIS129, Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence, ACSIS130, ACSIS145, Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies, ACSIS169
Extract more information	Students will extract DNA from a strawberry and see what the strands look like.	Experiment	Transmission of heritable characteristics from one generation to the next involves DNA and genes, ACSSU184		

Years 7-10: Classifying systems in cells

Materials list

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What you will need

Lesson	Materials required
Food for thought	• Classroom chairs
What are aquaporins?	• Iodine as Betadine • Zip lock bags • Cornstarch • Water • Beakers
Spot the difference	• computer(s) • MEGA software (free download from www.megasoftware.net) • aquaporin sequences, as provided
What came first?	• computer(s) • MEGA software (free download from www.megasoftware.net) • aquaporin sequences, aligned in the previous lesson
Extract more information	**For the class** • 900ml water • 100ml dishwashing detergent • 2.5 teaspoons salt **For each small group or individual** • half a strawberry • a zip lock bag • 10ml of extraction solution (made by mixing a teaspoon of salt and 5 teaspoons of dishwashing liquid with 25ml of water) • 2 x 50 ml test tubes or clear plastic cups • a chux cloth or muslin cloth • funnel • a permanent marker • ethanol