ACTUALLY, IT'S

PHYTO-PLANKTON!

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The Dream Team!

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Get to know the Dream Team! Meet Dr Aimee Neeley and Ryan Vandermeulen. They are both oceanographers who are part of the field support group at NASA Goddard Space Flight Center.

How do you make an algorithm?

It's like working in a digital laboratory. Here are the steps:

1) Start with a question about how the world works.
2) Go out and collect data relevant to help you answer that question. *You can do this with data from your own field work, or use data already collected by other scientists.*
3) Begin to unscramble the data and find new patterns.

The process is like trying to decipher a secret code and that code is telling you something about how the Earth works. Easy right?

How do you make a connection between what NASA's PACE will see from space and what is really in the ocean?

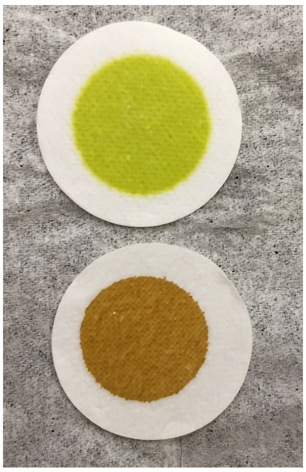
NASA's PACE will be looking at the entire surface of the ocean and will gather a very large amount of information. In order to make that information useful, scientists need to make sure the colour signature they can see from space, is the same as the one they see on the ground. First, you have to subtract away the atmosphere. This is called atmospheric correction. Second, you have to decipher exactly what is causing the ocean colour to change because it could be a lot of things (e.g. floating sea weed, microplastics, oil slicks, even an [abundance of turtles](#)). All these things have a unique optical fingerprint. Field teams help gather information from the ocean surface that allows satellite algorithm developers to finely tune NASA's PACE to detect phytoplankton.

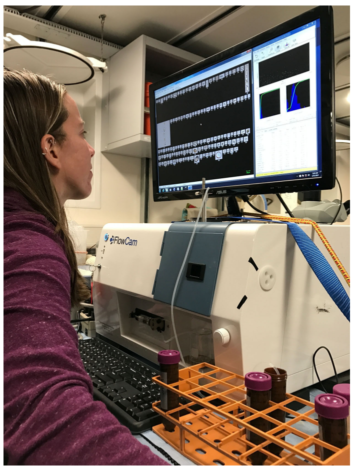
It would take roughly 11 years for a field team on a ship to map what NASA's PACE can in 2 minutes!

How would you traditionally measure phytoplankton in the ocean WITHOUT a satellite?

One way is by looking at how much phytoplankton are in the water. That is called phytoplankton biomass. You (i) take a water sample from the ocean, (ii) place it on a white paper filter pad, and (iii) extract a pigment called chlorophyll. This pigment is what land plants and phytoplankton use to harvest sunlight so they can photosynthesize. By extracting chlorophyll using this sampling technique, scientists can tell phytoplankton biomass.

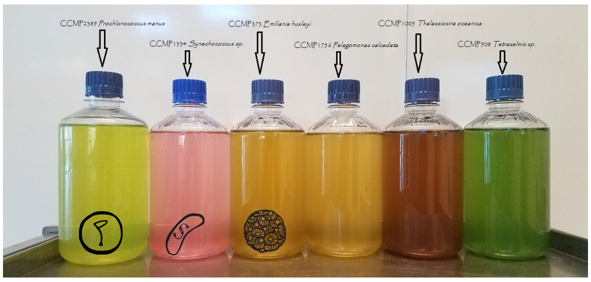
A more tedious method is to simply count them. Scientists can look at a water sample under a microscopic and count how many phytoplankton are there. Using this method, scientists can identify all the different types of phytoplankton species present in the sample too!





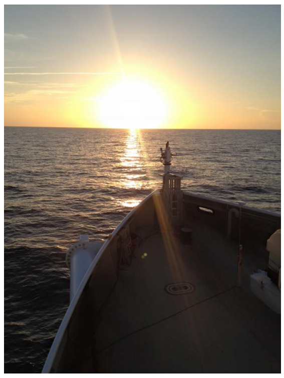
What is the story of phytoplankton pigments?

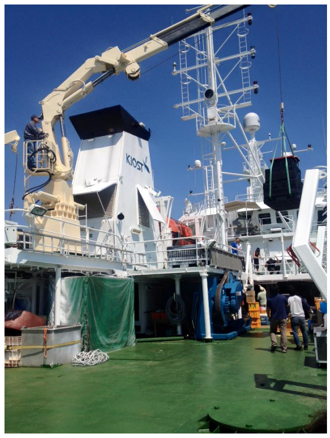
You can think about phytoplankton as being similar to flowers. A red rose and a purple orchid are both flowers, but they have some clear differences that help us to tell them apart, such as colour and shape.



Phytoplankton grown (or cultured) in the lab showing their diverse pigments.

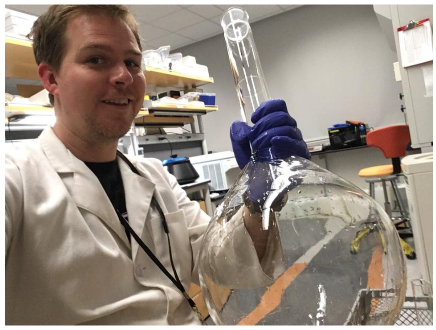
Sunlight has all the colours of the rainbow, and when sunlight touches something we see colour. In the case of flowers, it may be red light from the rose or purple light (blue & red) from the orchid. That is because all the other light colours are absorbed by their pigments and only the red or purple colour is reflected back to our eyes. The same concept can be applied to phytoplankton, because they also have pigments that absorb or reflect light. NASA's PACE satellite in space acts like our eyes. It's looking down and seeing the light that's reflected back out from the ocean. If scientists can understand what types of light are absorbed by phytoplankton and what types are reflected back out, that information can be used to identify different types of phytoplankton in the ocean.





What's life like on a research vessel?

There's great food! That's really important after working for 12+ hours in a cramped lab. It's expensive to be out at sea, so scientists work very hard, often alternating shifts to work 24hours around the clock. Everyone knows their role, and must work in a respectful, considerate and organized manner. The chief scientist leads the water sampling program. A rosette of bottles is sent down the water column, with bottles that can be triggered to close at various depths to collect samples. Scientists that collect samples for oxygen usually have first dibs. Scientists interested in optics and biology usually go last.



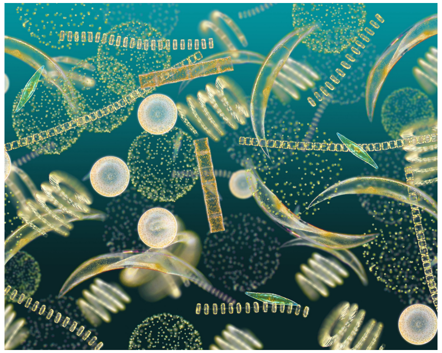
Play the Carbon Cycle Game

Print the game on the next few pages and watch this video of Ivona explaining how to play with game creator James Fox from Oregon State University (Go Beavers!)

Journey through the marine carbon cycle

Carbon is important to all life on Earth, and is cycled through the planet's atmosphere, land, and oceans. Many different organisms (bacteria, plants, and animals) collectively transport carbon from the atmosphere to the deep sea where it stays locked away for thousands of years. It all begins with the phytoplankton in the sunlit 'photic zone'. Start there and see how far you make it through the different levels of the ocean...

Start here	1	2	3 activity #1	4	5	6	7 activity #2	8	9 going down #1	10



Welcome to the Photic Zone!

At the surface of the ocean there is lots of sunlight which tiny plants called phytoplankton need for photosynthesis. Illustration: www.secchidisk.org

Which phytoplankton are you?
Take the quiz with NASA!

11	12	13 going up #1

29	28 going up #2	27	26	25	24	23	22	21 going down #2	20	19	STOP	18	17	16	15	14

30	31 activity #3	32

Weird creatures of the Twilight Zone

There are lots of strange animals that live in the deep sea. Do you recognize any in the picture to the left?

Bucklin et al. 2010. *Environmental Science*
Photo credits R.R. Hopcroft and C. Clarke and L.P. Madin

bonus activity

Stop!! Now entering the Twilight Zone!

Here the light starts to disappear so phytoplankton can't survive. When phytoplankton die they leave the photic layer through different pathways, which one will you take?

33 going down #3	34	35 going up #3	36	37 going down #4	38	39	40	41 going up #4	42	43	44

45 activity #4

50	49 going up #5	48	47	46

Photo credit: Woods Hole Oceanographic Institute

You made it to the Deep Sea!
Here carbon is locked away for 1000's of years as it travels on deep ocean currents...

Going down…processes that take you deep into the ocean

#1 (box 9): As carbon dioxide you are captured by a diatom during photosynthesis. This phytoplankton sticks together with other diatoms making big particles called aggregates that sink through the water column quickly. **Go ahead to box 14!**

#2 (box 21): You start to stick together with other particles forming big clumps of 'marine snow'. You start to sink even faster…**Go ahead to box 26!**

#3 (box 33): You get consumed by a detritivore! These organisms hang out in the twilight zone eating sinking particles. Those particles get repackaged into even bigger aggregates which sink really quickly. **Go ahead to box 40!**

#4 (box 37): As a particle or a zooplankton, you get eaten by a fish! The fish swims all the way down to the base of the mesopelagic and excrete you as fish poop. You start to sink again…nearly there! **Go ahead to box 48!**

STOP ***Entering the Twilight Zone!***

Organic matter can make its way through the water column via a number of different pathways. Roll the dice to see which one you take!

If you roll 1-3: You start to stick together with other particles forming aggregates called 'marine snow'. **Continue to box 19**

If you roll 4-6: You are eaten by tiny animals called zooplankton that travel up and down the water column**. Start down the short cut towards box 42**

Going up…processes that slow your progress through the water column

#1 (box 13): As a phytoplankton cell, you die and bacteria in the water start to consume you. They convert you from solid 'organic matter' into a gas. **Go back to box 5 and wait to be captured by a phytoplankton again!**

#2 (box 28): Your big group of particles (aggregate) starts to fall apart and you begin to sink much slower. **Go back to box 19, hopefully there are other particles to stick to!**

#3 (box 35): As an aggregate or a zooplankton, you get eaten by a fish! The fish swims all the way up to the top of the twilight zone and excretes you as fish poop. You start to sink again but it's a long way to go….**go back to box 23.**

#4 (box 41): Bacteria in the water start to change you into carbon dioxide! You then wait to get transported to the surface by deep ocean currents and captured again by phytoplankton. **Go back to box 5!**

#5 (box 49): Not again! Bacteria in the water change you into carbon dioxide and you wait to get transported to the surface and captured again by phytoplankton. **Go back to box 5!**

Activities

#1 (box 3)

Almost all the animals that live in the ocean rely on phytoplankton to provide them with food. That's because they are at the very start of the marine food web. We can see these important microbes from space! Can you guess how?

#2 (box 7)

Phytoplankton, like plants and trees, use photosynthesis to make their food. For this they need carbon dioxide, water and lots of sunlight. As light travels through the ocean how do you think it will change? Try on the different glasses to find out!

#3 (box 31)

The picture on the right has lots of deep sea organisms in it, can you name any?

#4 (box 45)

The size of a particle or aggregate makes a big difference to how fast it sinks through the water column. Can you think of anything else that will affect how it sinks? Make your own aggregates with different materials to see how fast or slow they sink.

#5 (bonus activity)

The twilight zone is dark and cold, with very high pressure. The animals that live in these challenging conditions have adapted special features to survive. Can you think of any ways they have done so?