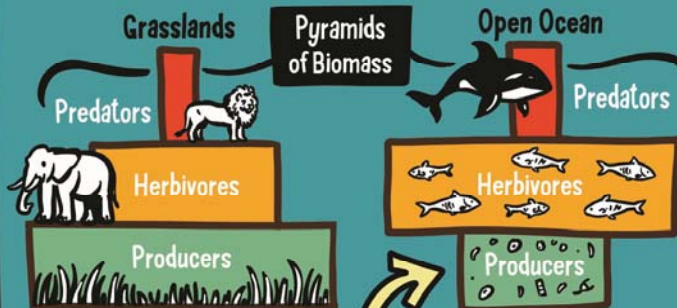


Most phytoplankton can only be seen with a microscope.

But they're incredibly important.

Unlike in other ecosystems, a small biomass of phytoplankton in the open ocean supports a large biomass above.



(This is because of the high rate at which they grow and divide.)



Some of their "blooms" are so big that they can be seen from space.

And due to climate change, the world of phytoplankton is changing fast.

Global CO₂ levels are on the rise.
That sets off different chain reactions
that can affect phytoplankton.

Increased CO₂

Higher Air Temperatures

CO₂ Influx Into The Ocean

Higher Sea Surface Temperatures

pH of Ocean Decreases
Ocean acidity increases

Increased Stratification
Formation of layers
in the ocean with a
warmer upper layer

Reduced Mixing Except During Big Storms
Free floating organisms in the surface
layer don't cross into lower layers

Increased Exposure
Cells experience greater exposure
to sunlight, which may be damaging

Calcium Carbonate
Shells Dissolve

Changes in
Uptake of Trace
Elements

Changing
Metabolisms in
Organisms

So
HOT!

burp!

It's important to note that
the effects of multiple changes
all happening at the same time
is complex to study.

The effects do not necessarily
have to be additive, not all organisms
will react to all changes in the same
ways, and the effects do not
necessarily have to be negative.

Some plants
respond to
increased CO₂
with increased
growth.



Each phytoplankton species can only survive within a specific temperature range.

35

30

25

20

15

For example, 15–30° Celsius.

Above and below that range the phytoplankton does not grow or dies.

Within this range there is an optimal temperature, such as 25° C, where the species grows best, and it grows less well at lower and higher temperatures.

The optimal temperature is usually closer to the max than to the minimum, so species can survive better under below optimal temperatures than above optimal.

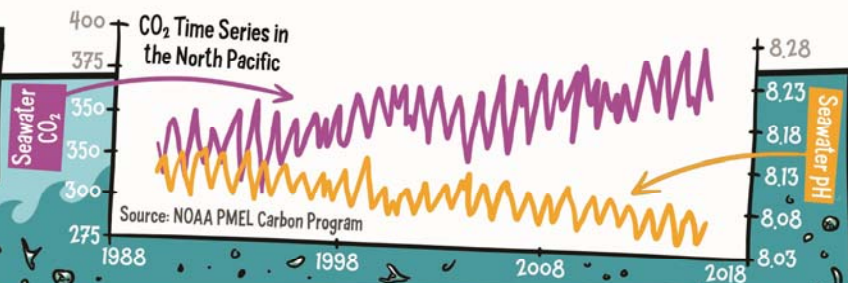
So when ocean temperatures go up, there's less wiggle room at the top of their range.

The optimum growth temperature for a given species is different at different light or pCO₂ conditions. Some phytoplankton grow faster during warmer conditions.

But maximum growth rates aren't a good indicator for cell health. Often cells that grow very fast, are stressed and can only keep it up for a short time.



More CO₂ in the air means more CO₂ in the oceans.



This decreases the pH of seawater, making it more acidic and creating a few different stressors for phytoplankton.

Some algae, such as coccolithophores, build shells with calcium carbonate.

In a low pH environment, these shells can dissolve or get harder to generate.

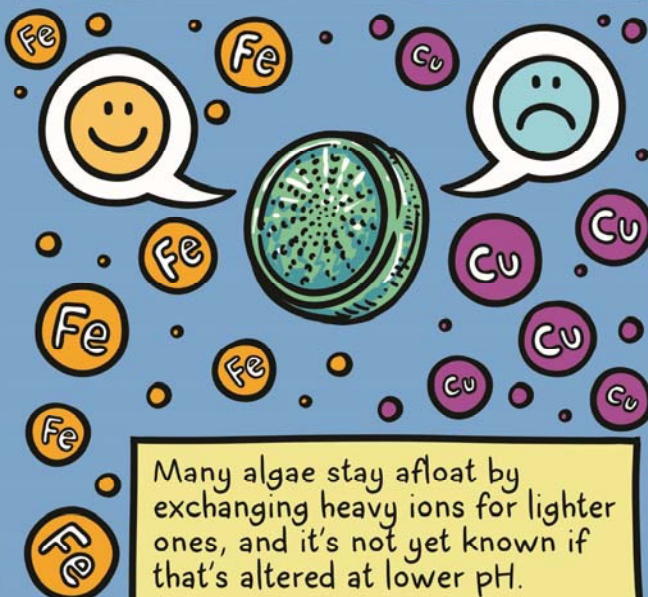
But the further effects of increased CO₂ in oceans are mixed or unclear.

For some species, an increased uptake of CO₂ can actually allow them to compete more efficiently.

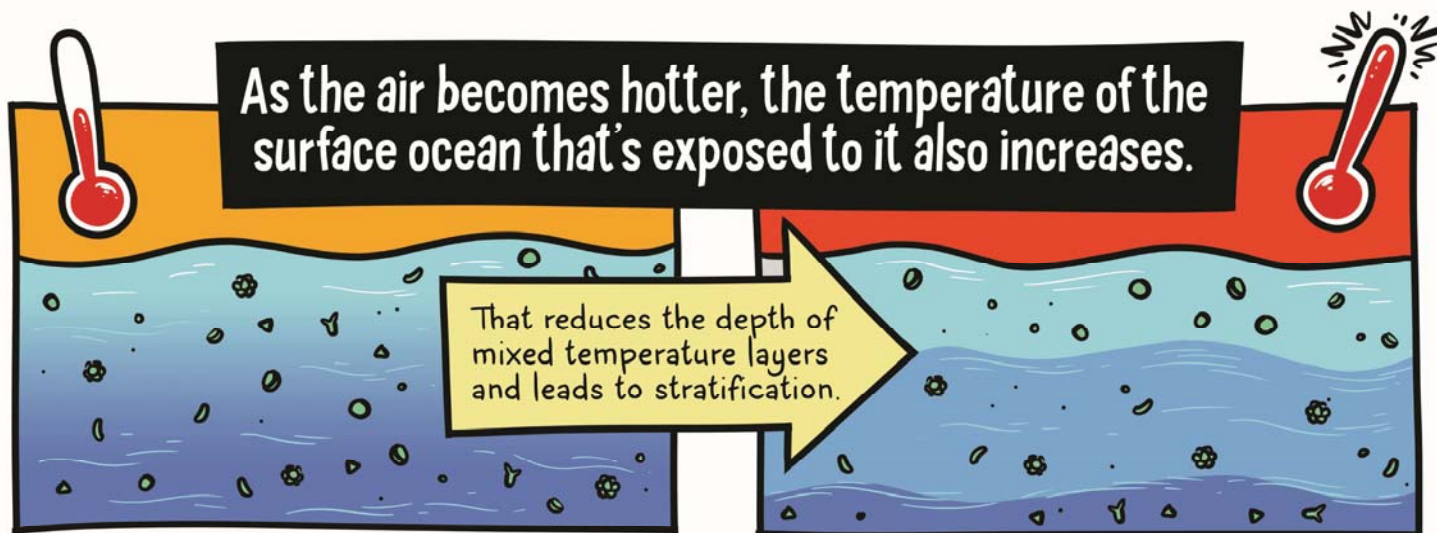


However, for algae to grow, the CO₂ uptake and light harvest need to be balanced. Keeping that balance may be tricky and all the physiological implications aren't yet known.

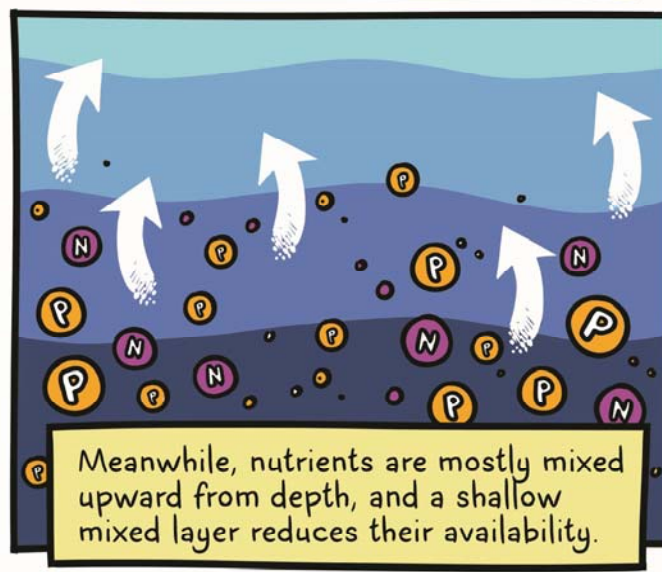
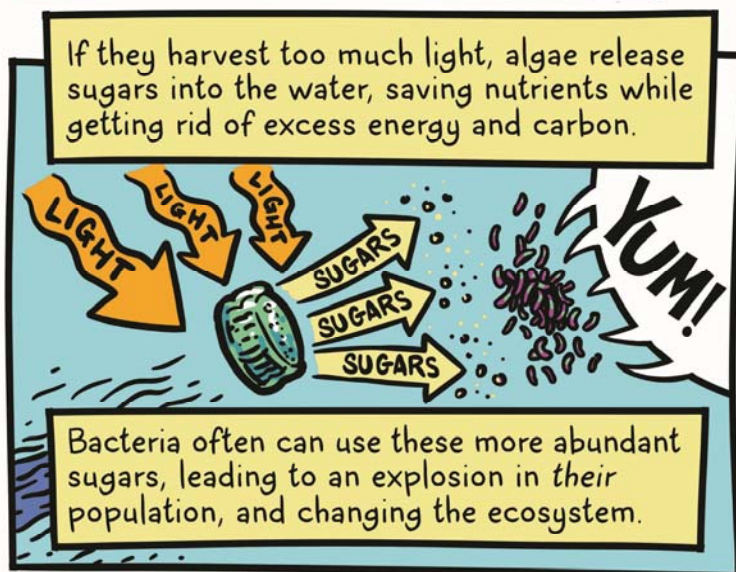
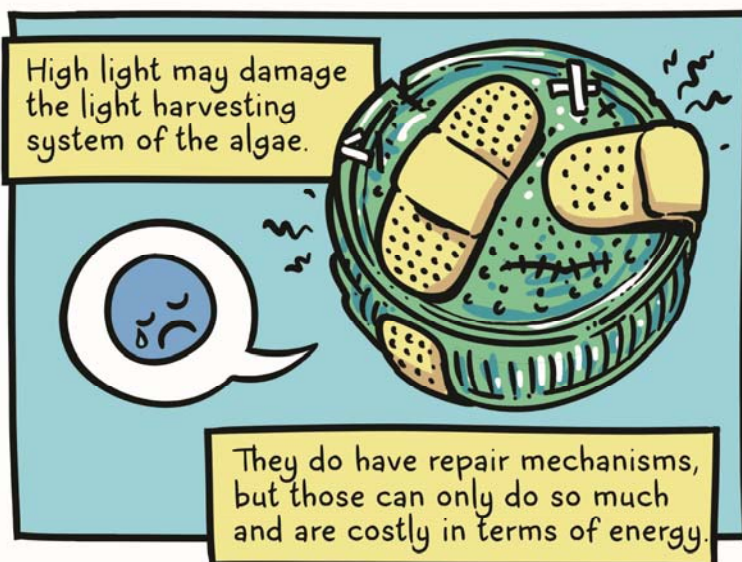
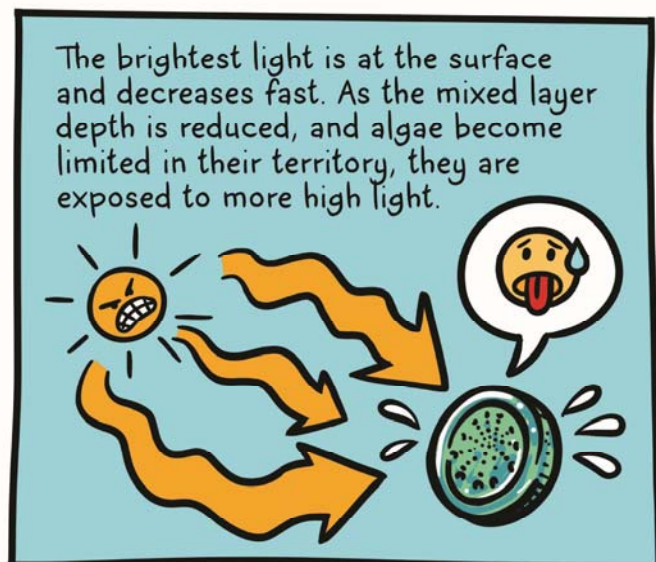
A pH decrease also changes the ionic state of all elements, with mixed results. Iron, which algae need, may become more available. But so will copper, which is toxic in most cases.



Many algae stay afloat by exchanging heavy ions for lighter ones, and it's not yet known if that's altered at lower pH.



To make a big biomass of algae, cells need light and nutrients like nitrogen and phosphorous. Stratification affects their availability.



Of course, the oceans have changed before.

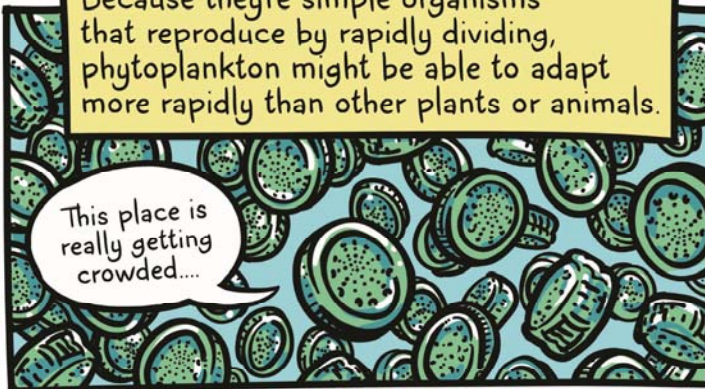
On geological time scales oceans have changed drastically many times before. Species have adapted or gone extinct.

But this time is different.



What we are experiencing is much more rapid than previous known changes, which gives species less time to adapt.

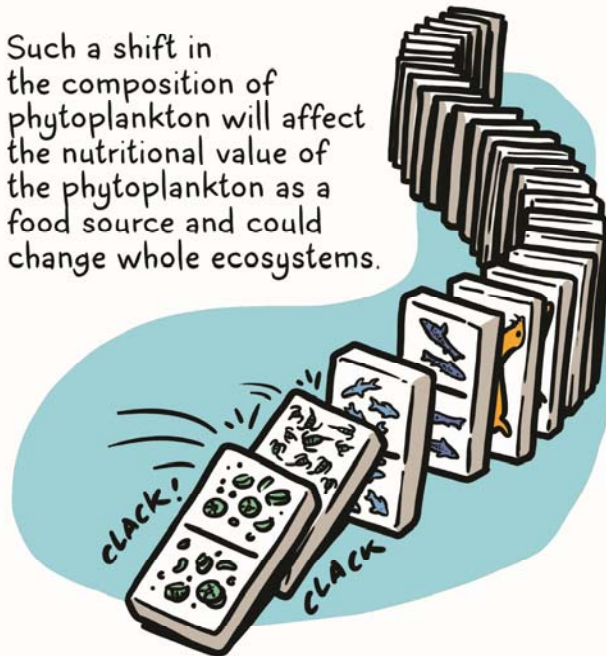
Because they're simple organisms that reproduce by rapidly dividing, phytoplankton might be able to adapt more rapidly than other plants or animals.



Nevertheless, it is likely that the ongoing change in the oceans will lead to different types of phytoplankton thriving than in today's waters.



Such a shift in the composition of phytoplankton will affect the nutritional value of the phytoplankton as a food source and could change whole ecosystems.



It will also alter the ocean's ability to act as a store for CO₂ originating from the atmosphere, which means things could heat up even faster for the rest of us.



Sometimes the biggest changes start with the smallest things.