Rediscover JUNKAN

Monthly JP pavilion

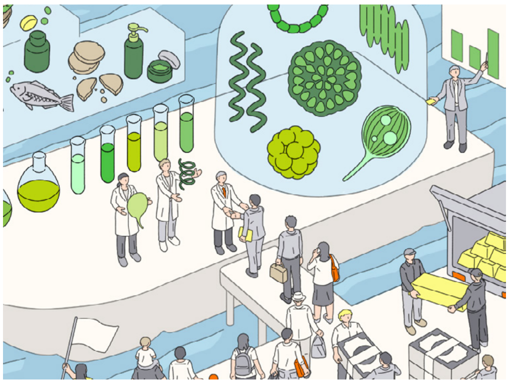
Issue

06

Feature

Can Algae Save the Earth!?

Feature



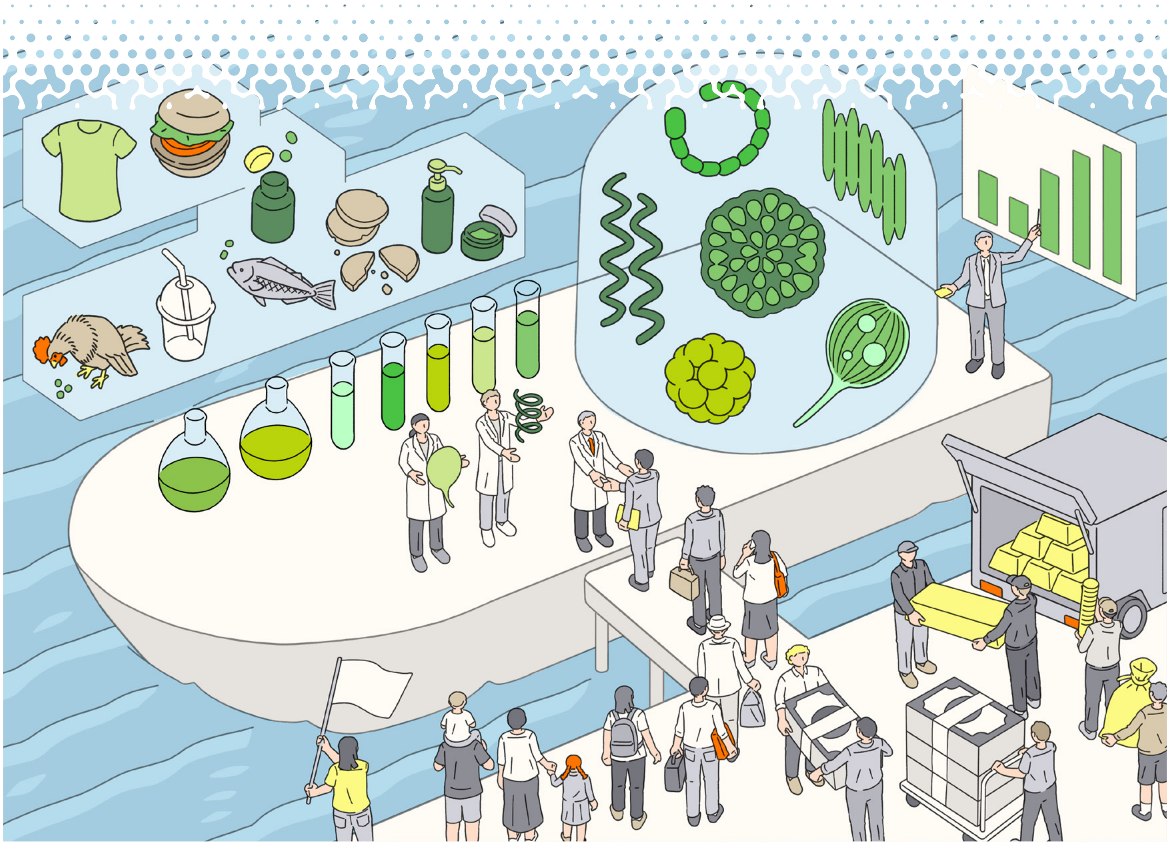
The Future is Green: How Algae Can Change the World (and It’s Easy to Understand)

Algae, the foundation of our current ecosystem. Un-veiling the mechanisms behind this remarkable entity.

Hello! Choose Your Favorite “Algae × Hello Kitty Encyclopedia”

Hello Kitty becomes algae! Star-shaped, clo-ver-shaped... Algae actually come in many forms. Follow your intuition and nd your favorite one!

The Future is Green: How Algae Can Change the World (and It's Easy to Understand)



Humans have been around for about 2 million years.
But long before that, an incredible organism has existed for over 2 billion years, helping to shape the Earth as we know it—algae.
Algae are masters of photosynthesis, converting carbon dioxide into oxygen and serving as an essential energy source in our modern world. In this issue and the next, we'll explore the amazing secrets of algae and their remarkable potential.

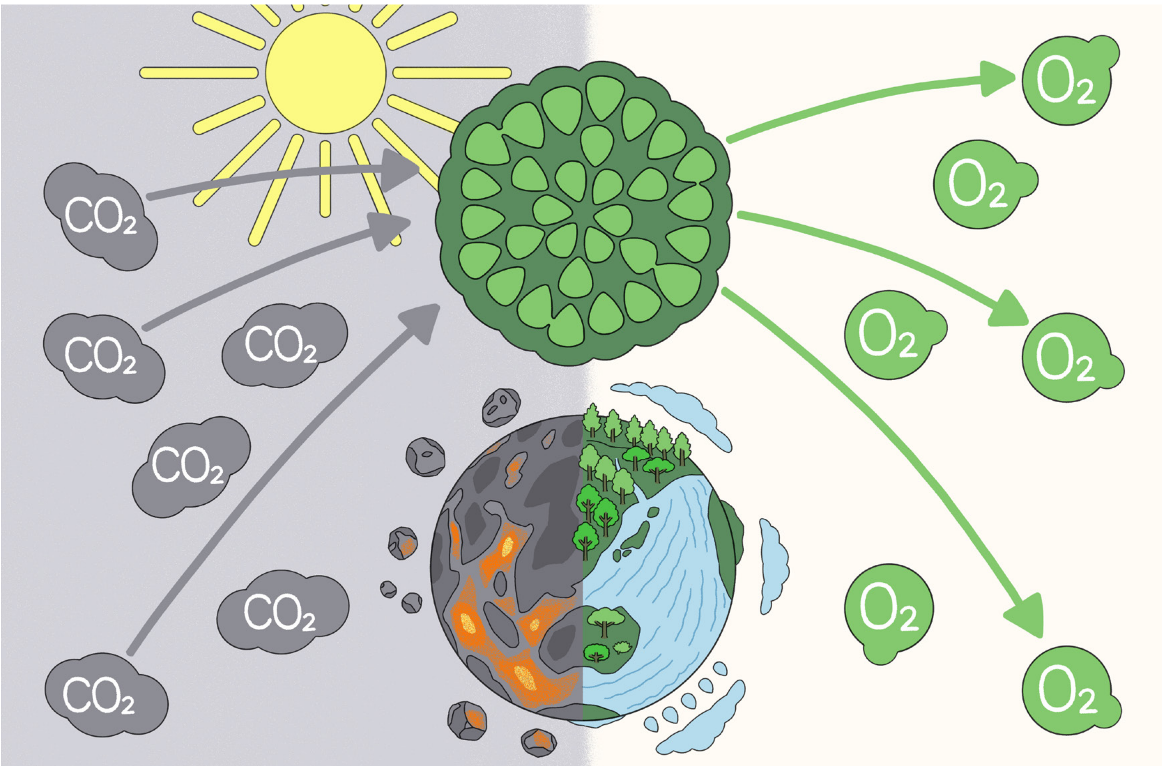
In Japan, the company leading the charge in tackling the world's energy challenges with the help of algae is the CHITOSE Group. We spoke with Tomohiro Fujita, the company's representative, to learn more about the excitement, potential, and fascinating science behind algae. The extraordinary power of these green pioneers, combined with the efforts of each one of us, may help secure a brighter future for the Earth.

— To start, could you explain what role algae play on Earth?

Fujita Algae is a broad term for all living organisms that use photosynthesis, excluding land plants. They primarily thrive in water and moist environments, and they come in many di erent forms, sizes, and characteristics, such as seaweed, freshwater algae, and single-celled algae. Some are microscopic, while others can grow to several meters in size. For example, familiar types of algae include wakame seaweed and kombu. Algae have been around long before humans appeared, playing a fundamental role in establishing the Earth's natural cycles. It's no exaggeration to say that algae built the foundation of the world as we know it.

— Could you explain in more detail what you mean by "algae built the foundation of the world as we know it"?

Fujita When Earth's oceans rst formed, over 90% of the atmosphere consisted of carbon dioxide. Algae emerged in the oceans and, through photosynthesis over a long period of time, increased the amount of oxygen in the atmosphere. Today, our air is made up mostly of nitrogen and oxygen, with only a small amount of carbon dioxide. It's thanks to algae that we now have an environment where humans can survive.



Fujita During this process, carbon dioxide accumulated underground, eventually transforming into oil, coal, and natural gas—resources that humans later began using for energy. If we trace it back to the source, our ability to breathe and use energy today is largely due to algae.

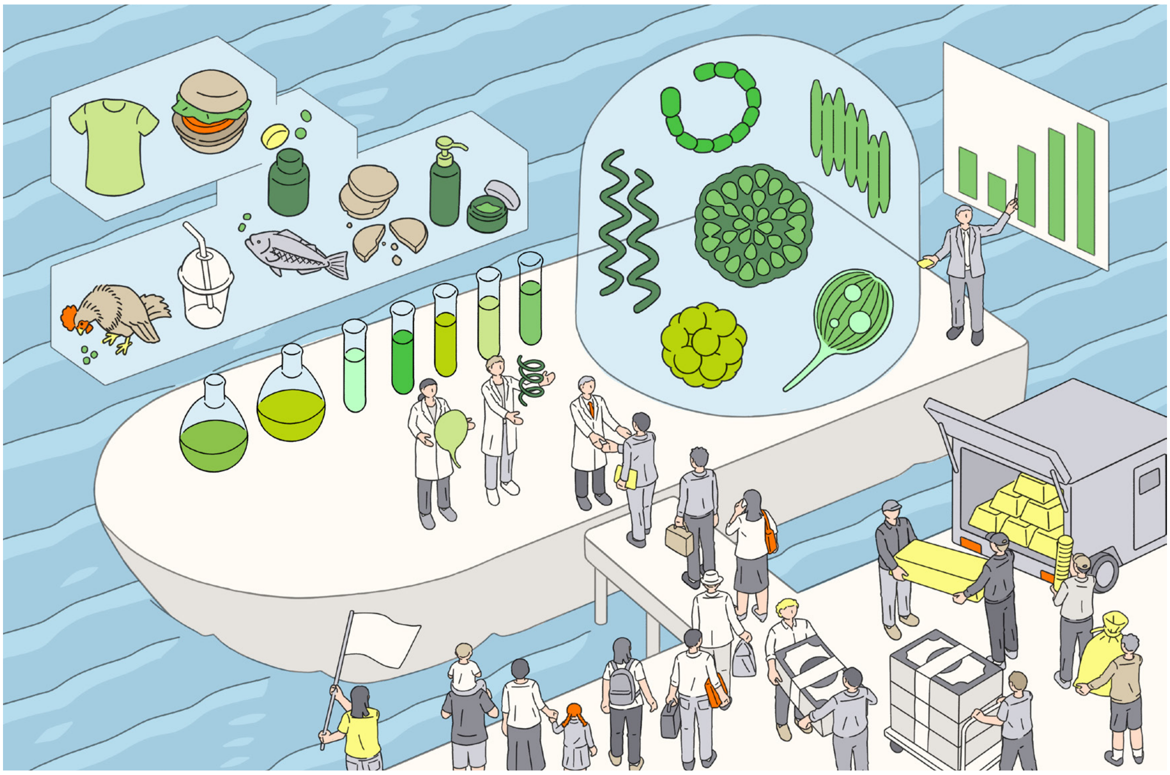
— Algae played a crucial role in shaping Earth's environment. What role do you think algae will play in Earth's future?

Fujita First, it's important to understand that the Earth is currently facing a serious energy crisis. For a long time, we've relied on large-scale, cheap, and uniform energy, mainly from oil and coal. However, if we continue on this path, it will be impossible to maintain a stable global environment. Right now, humans consume about 0.6 zetajoules of energy annually (a joule is a unit of energy, work, heat, or power—1 joule equals the e ort needed to lift a 102-gram object one meter. Zeta represents 10 to the power of 21). It's estimated that only 10 zetajoules of oil remain in the ground, meaning we could run out in just a few decades.

That's why at CHITOSE Group, we're promoting the idea of recycling resources with the help of algae, which absorb carbon dioxide and produce organic matter.

— Do you think the shift from fossil fuels to algae will accelerate in the future?

Fujita In 2022, a presidential order in the United States declared that "in the future, the bioeconomy, led by algae-based photosynthesis, will become a 4500 trillion yen industry." This sparked attention toward a future without petroleum.

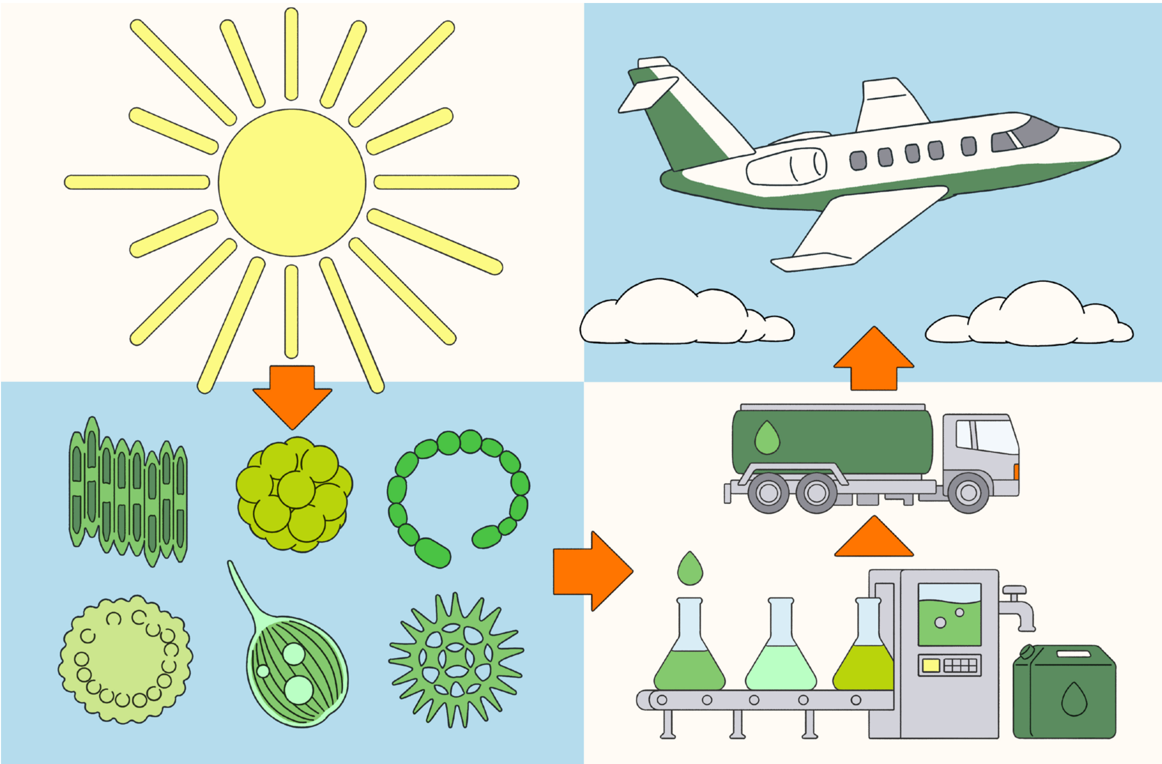


Fujita In capitalist societies, elds that draw this kind of attention tend to attract signi cant economic investment. As investors focus on these areas, rapid development often follows.

We believe the bioeconomy o ers a path for humanity to grow while also protecting the global environment. It shows how the mechanisms of capitalism can align with the movement to solve environmental challenges. Algae, as it turns out, is not only environmentally bene cial but also economically pro table.

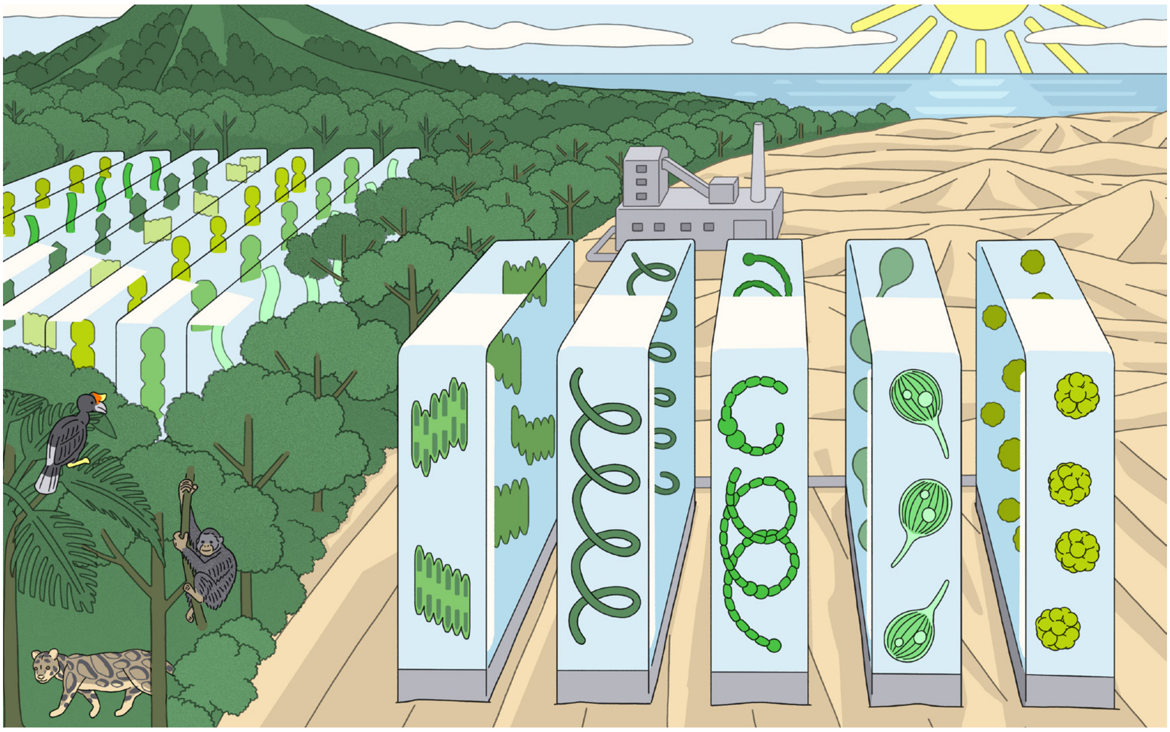
— What makes algae unique as a source of energy?

Fujita There are many ways to generate energy, such as solar power, wind power, and nuclear fusion, but most of these methods only produce electricity. Algae, on the other hand, can do much more through photosynthesis. It can gen-erate organic matter like proteins, lipids, carbohydrates, and even fuel. For example, airplanes can't run on electricity alone—they will always need fuel. The ability to supply that fuel using algae is a major advantage. While corn can also produce organic matter, algae is far more productive per hectare. I wouldn't go so far as to call algae an all-purpose solution, but it is certainly more e cient than many other methods.



— Can you tell us about the environmental benefits of algae production?

Fujita Cultivating algae has a much lower environmental impact compared to other forms of energy production. One major advantage is that it uses very little water. For example, producing 1 kilogram of protein from a cow requires 105 tons of water during the breeding process. With algae, water is recirculated during cultivation, so only a small amount is needed. Additionally, since algae don't require soil, they can be grown in diverse environments, from dry deserts to humid jungles. While it may not be immediately apparent in Japan, fresh-water supplies are dwindling globally, and topsoil is being lost at an alarming rate. Algae o er a way to make e cient use of land that otherwise couldn't be farmed.



— Does algae grow through photosynthesis, like plants?

Fujita Yes. While it's possible to grow algae by supplying sugar, the process of import-ing sugarcane and extracting sugar consumes a lot of energy and releases signi cant carbon dioxide. This would actually worsen the environment. That's why at CHITOSE Group, we focus on photosynthesis to cultivate algae in an eco-friendly way.

If we could create algae elds covering the same area as the world's corn - elds, and cultivate them through photosynthesis, we could produce 40 times the protein, 2.2 times the calories, and 0.5 times the oil needed by humans. Combined with alternative energy sources, algae could help build a more sustainable future.

— Algae sound like a beacon of hope for the Earth's future, but are there any challenges in using algae as a future energy source?

Fujita The latest calculations show that for algae plants to make a signi cant pos-itive impact on the global environment and economy, they need to cover at least 2,000 hectares. The bene ts of algae cultivation increase with scale, so larger operations are far more e ective than smaller ones. Additionally, as mentioned earlier, energy costs can be high if algae aren't grown through photosynthesis.

Currently, we cultivate algae by stacking at cases, each 5 centimeter wide, vertically. After experimenting with various methods, we found this to be the most cost-e ective way to produce algae at scale. CHITOSE Group's goal is to expand algae farms to 10 million hectares by 2050.

Building algae plants, however, requires an enormous nancial investment. The main challenge isn't technology—it's scale. There's a limit to what we can achieve on our own, so we're collaborating with governments and companies worldwide to move towards a future where algae plays a central role in energy development.

CHITOSE Group

CHITOSE Group is a collective of bio-venture companies primarily operating in Japan and Southeast Asia. Their mission is to preserve an environment where humans can thrive for the next thousand years. With expertise in material production using microorganisms, algae, and animal cells, they are working in partnership with gov- ernments and companies to advance the bioeconomy and build a sustainable society.

Illustration: Yutaka Kato

Hello! Choose Your Favorite "Algae × Hello Kitty Encyclopedia"

Index

Long before humanity existed, “algae” have been thriving on Earth. Although often overlooked, algae are gaining attention as a potential solution to global challenges. Not only do they convert carbon dioxide and water into oxygen and sugar through photosynthesis, but they also provide high-nutrient food, alternative fuels to petroleum, and raw materials for cosmetics. New technological developments are underway to unlock their latent power.

At the Japan Pavilion of Expo 2025 Osaka, Kansai, an exhibit will showcase Japan’s innovations in algae technology. Among these is the beloved character Hello Kitty, reimagined in the form of various algae. Over 300,000 species of algae are known to exist in nature, ranging from microscopic sizes to over 50 meters in length. Out of these, 32 species have been selected to become “Algae × Hello Kitty” and will be displayed as life-sized sculptures in the Japan Pavilion.

Explore Shapes that Catch Your Eye

In anticipation of the Expo in April 2025, this article introduces the “Algae × Hello Kitty Encyclopedia.” Algae possess diverse and unique characteristics, each with its own distinct shape. While learning about their capabilities and potential, why not find your favorite among these unexpected encounters with 32 types of algae?

*The “Algae × Hello Kitty” designs are inspired by real algae species. To effectively convey the appeal of algae, each character emphasizes the outer shape characteristics of the species. As a result, the designs may differ from actual algae in terms of size, color, and shape.

*The website showcased 32 Hello Kitty silhouettes, each dressed up as a different type of algae. Clicking an individual silhouette displayed a card. In addition, flipping a card over revealed a photo of the algae that was the model for that specific Hello Kitty design. These two effects have been omitted in the PDF archive due to technical limitations.

Macroalgae Supervision: Taiju Kitayama

Chief Researcher, Fungi and Algae Research Group, Department of Botany, National Museum of Nature and Science. Ph.D. in Science. Specializes in the taxonomy, algal flora, and history of phycology, with recent research on freshwater algae growing in rivers. Currently studying algae in the vicinity of the Imperial Palace. Oversees the “Phylogeny Square” exhibit in the permanent collection of the museum’s Global Gallery and has developed the educational museum product “Kahaku Cards” to accompany the exhibit.

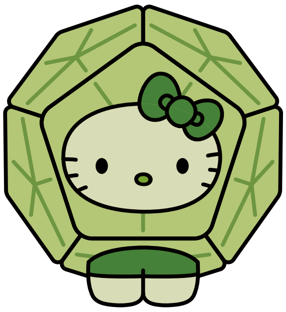
Microalgae Supervision: Takashi Nakada

Lecturer, Hokkaido University. Graduated from the Faculty of Science and completed the Ph.D. program at the Graduate School of Science, University of Tokyo. Previously served as a Specially Appointed Lecturer at Keio University’s Graduate School of Media and Governance. Specializes in the taxonomy of micro-green algae and has a keen interest in scientific and Japanese names of organisms, proudly expanding his collection of reference books daily

Haptophyte

Braarudosphaera bigelowii

Braarudosphaera



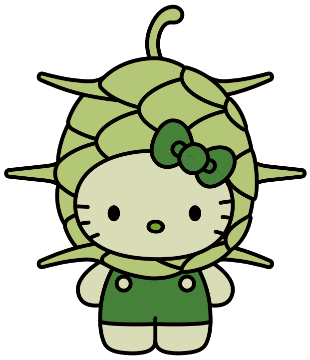
Size: 0.01–0.02 mm (cell diameter)
Habitat: saltwater

This organism, with pentagonal calcium carbonate scales forming a dodecahedron, has remained unchanged since the Late Cretaceous, when dinosaurs roamed the Earth.

Chrysophytes

Phacus helikoides

Mallomonas



Size: 0.01–0.06 mm (cell length)
Habitat: freshwater

Covered in spiky scales, this organism has a yellowishbrown appearance and appears in winter ponds. It aids water purification but smells fishy if it overgrows.

Ulvophytes

Ulva intestinalis

Gut weed

Size: ~1 m
Habitat: saltwater

Long and rod-shaped, this organism grows like grass on coastal rocks and can exceed 1 metre in length. It is edible, and is commonly used in miso soup.

Euglenophytes

Mallomonas

Phacus helikoides

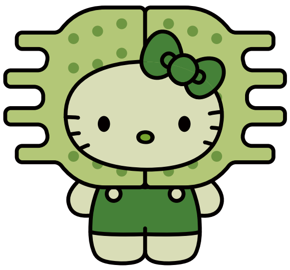
Size: 0.07–0.12 mm (cell length)
Habitat: freshwater

Twisted like a chocolate cornet, this Helicoides species differs from its flat, fan-shaped relatives. It inhabits ponds, swimming with a drill-like spinning motion.

Diatom

Stephanopyxis

Stephanopyxis



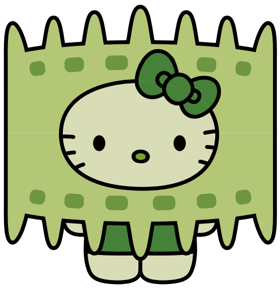
Size: 0.03–0.15 mm (cell diameter)
Habitat: saltwater

It has a capsule-like shell, connecting with other individuals through protrusions to form a linear filament, resembling skewered dumplings. It inhabits warm seas.

Diatom

Neofragilaria

Neofragilaria



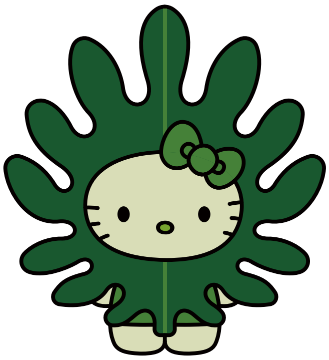
Size: 0.02–0.04 mm (cell diameter)
Habitat: saltwater

It has protrusions at both ends, releasing sticky mucus to connect with other individuals in a zigzag pattern or attach to rocks and large aquatic plants.

Phaeophyceae

Undaria pinnatifida

Wakame



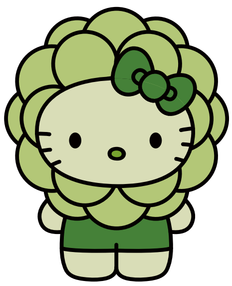
Size: 1–2 m
Habitat: saltwater

It grows 1-2 metres long. Brown underwater, it turns green when boiled. The reproductive part, 'mekabu', is highly nutritious and has been eaten since ancient times.

Chlorophyta

Coelastrum

Coelastrum



Size: 0.02–0.10 mm (colony diameter)
Habitat: freshwater

Spherical cells adhere to form a larger sphere, with 4, 8, 16, 32, or 64 cells arranged uniformly. It excels at storing oil and floats on pond water.

Diatom

Trigonium

Trigonium

Size: 0.05–0.30 mm (cell diameter)
Habitat: saltwater

Two equal-sized triangular shells fit together like a bento box. This genus includes square- and star-shaped species. It can absorb heavy metals, aiding environmental purification.

Chlorophyta

Chlamydomonas reinhardtii

Chlamydomonas

Size: 0.006–0.011 mm (cell length)
Habitat: freshwater

Ellipsoidal with two antenna-like flagella, easy to crossbreed and widely used in genetic research. It evolved into 4-celled Tetrabaena and multicellular Volvox.

Phaeophyceae

Sargassum fusiforme

Hijiki

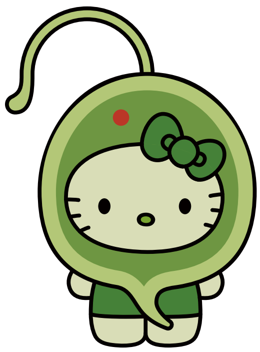
Size: 50 cm–1 m
Habitat: saltwater

Cylindrical stems with rod-like leaves grow densely in intertidal zones. Yellow underwater, it turns black when dried due to high iron content.

Euglenophytes

Phacus gigas

Phacus gigas



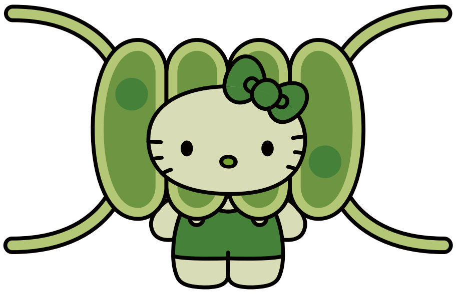
Size: 0.10–0.12 mm (cell length)
Habitat: freshwater

Flat like a fan, it extends a long flagellum forward. A red eyespot helps it detect light direction. It swims in a spinning motion in rice paddies and ponds.

Chlorophyta

Desmodesmus

Desmodesmus



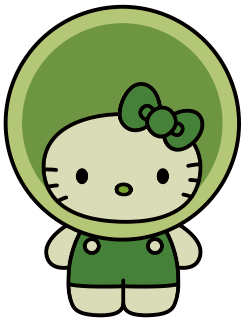
Size: 0.010–0.035 mm (cell length)
Habitat: freshwater

Four ellipsoidal cells form a chain, with spines at both ends. It drifts in paddies and ponds, tough enough to resist breaking under a coverslip.

Chlorophyta

Chlorella

Chlorella



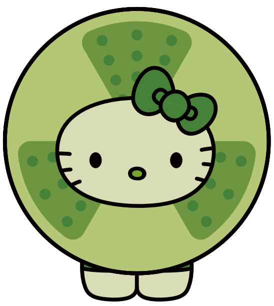
Size: 0.002–0.010 mm (cell diameter)
Habitat: freshwater

Tiny and round, it lives in soil or ponds, excelling at photosynthesis. Half protein, it is valued as a nutrient-rich food. Many similar-looking species exist.

Diatom

Actinoptychus senarius

Actinoptychus



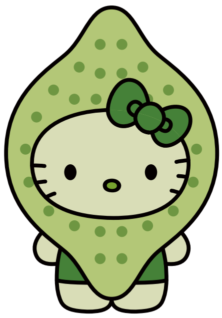
Size: 0.03–0.20 mm (cell diameter)
Habitat: saltwater

Shaped like a windmill, its disk-like shell has six fan sections with alternating ridges and grooves. It lives in shallow seas, sometimes linking with neighbours.

Diatom

Rhaphoneis

Rhaphoneis



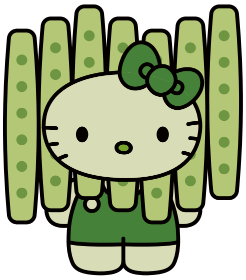
Size: 0.03–0.10 mm (cell diameter)
Habitat: saltwater

A diatom with a lemon-shaped, glassy shell. It attaches densely to sand in shallow seas and is considered a strong, durable material for industrial use.

Diatom

Bacillaria paxillifer

Bacillaria



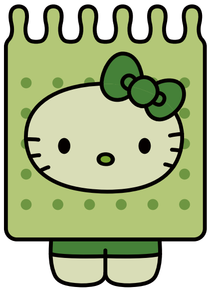
Size: 0.06–0.15 mm (cell diameter)
Habitat: saltwater

A diatom with elongated, glassy shells arranged flat. They slide against each other, extending and contracting like rafts, moving dynamically. It inhabits the sea.

Diatom

Aulacoseira

Aulacoseira



Size: 0.03–0.30 mm (cell diameter)
Habitat: freshwater

A diatom with barrel-shaped cells forms filaments, sometimes coiling. It thrives in murky ponds and lakes, absorbing nitrogen compounds and phosphate for water quality.

Haptophyte

Calcidiscus leptoporus

Calcidiscus

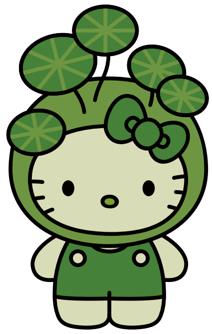
Size: 0.02–0.03 mm (cell diameter)
Habitat: saltwater

Covered in round calcium carbonate scales (also used in chalk), made of two overlapping discs. Tiny and buoyant, it is found in oceans worldwide.

Ulvophytes

Acetabularia ryukyuensis

Mermaid's wineglass



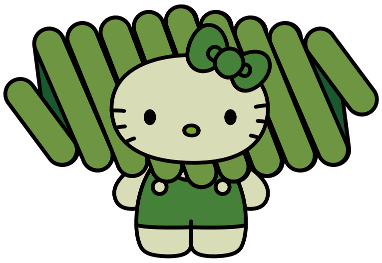
Size: 10 cm
Habitat: saltwater

A 10-centimetre stalk with a 1-centimetre disc cap. Unicellular seaweed, chalky and inedible, native to East Asia and Japan's southwest islands. Caps enlarge in winter.

Cyanobacteria

Spirulina

Spirulina



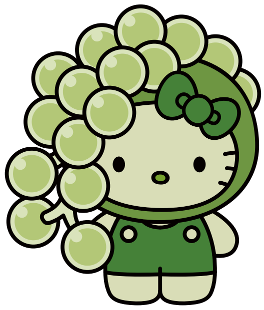
Size: 0.001–0.003 mm (cell diameter)
Habitat: freshwater

Spiral-shaped ('spirulina' means 'spiral' in Latin), it twirls on pond bottoms. The health food known as 'spirulina' is actually another cyanobacterium, Arthrospira.

Ulvophytes

Caulerpa lentillifera

Sea grapes



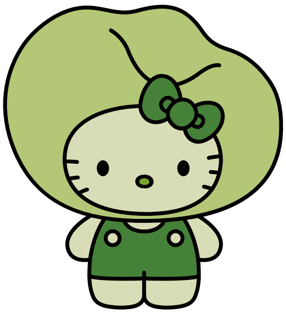
Size: 10–20 cm
Habitat: saltwater

Covered in spherical branches, this seaweed is known as 'sea grapes' but is officially called 'Kubirezuta'. It grows in Okinawa, Japan's southwest islands, and Southeast Asia.

Phaeophyceae

Colpomenia sinuosa

Sinuous ballweed



Size: 20 cm
Habitat: saltwater

Brown and amorphous like a cream puff, this seaweed is hollow and collapses when dry. Found along Japan's shores, it is studied for biofuel and plastic production.

Chlorophyta

Volvox

Volvox

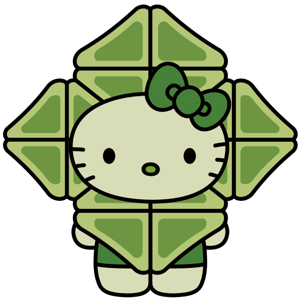
Size: 0.03–1mm (colony diameter)
Habitat: freshwater

Hundreds to thousands of green cells form a single body with transparent gelatin, moving by rolling. Large green balls inside are offspring.

Chlorophyta

Lemmermannia tetrapedia

Lemmermannia



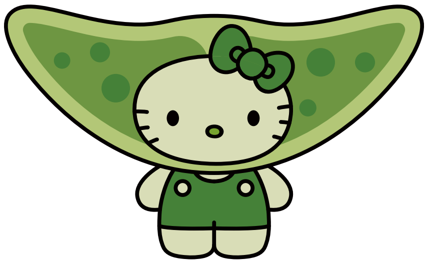
Size: 0.010–0.015 mm (colony diameter)
Habitat: freshwater

Four triangular cells form a square, joining to create larger squares. It is related to Pediastrum and Coelastrum, floating in ponds and marshes.

Zygnematophyceae

Closterium

Closterium



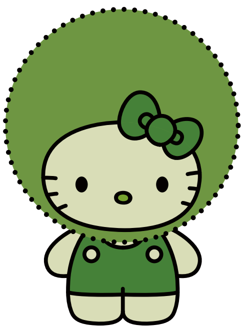
Size: 0.03–1.00 mm (cell length)
Habitat: freshwater

Crescent-shaped, it divides at the centre to reproduce, with each half regrowing. Two can merge to form offspring. It lives at the bottom of rice paddies and marshes.

Ulvophytes

Aegagropila brownii

Marimo



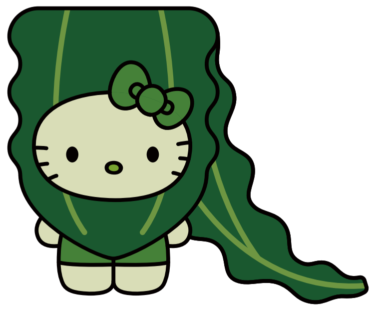
Size: 2–30 cm
Habitat: freshwater

Originally filamentous and attached to rocks, it becomes spherical as its filaments roll along lake beds. In Lake Akan, its primary habitat, wind causes it to roll.

Phaeophyceae

Saccharina japonica

Kombu



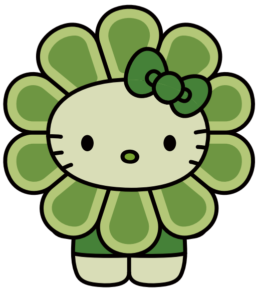
Size: 1.5–7 m
Habitat: saltwater

Brown and ribbon-like, it can grow up to 7 metres long. Among its 20 relatives, it is prized as a delicacy. Edible but too thick to eat raw, it is ideal for making flavourful broth.

Chlorophyta

Botryococcus braunii

Botryococcus



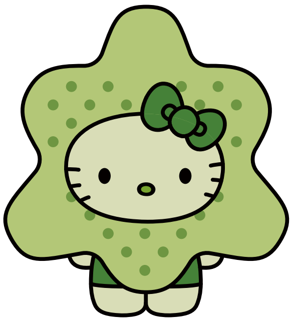
Size: 0.005–0.010 mm (cell length)
Habitat: freshwater

Composed of dense, ovoid cells, it produces diesel-like hydrocarbons, making it a promising biofuel for addressing environmental issues. It floats in pond water.

Diatom

Hydrosera

Hydrosera



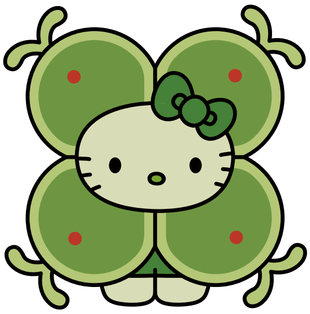
Size: 0.08–0.12 mm (cell diameter)
Habitat: saltwater/freshwater

This diatom has two overlapping triangles. It lives in seas and rivers, sensitive to water quality changes, used for monitoring.

Chlorophyta

Tetrabaena socialis

Tetrabaena



Size: 0.02–0.05 mm (colony diameter)
Habitat: freshwater

Shaped like a four-leaf clover, it is found worldwide. Once debated whether it is four linked individuals or one with four cells; Japanese studies confirmed the latter.

Phaeophyceae

Nemacystus decipiens

Mozuku

Size: 30–40 cm
Habitat: saltwater

Slender cylindrical stems branch irregularly. It attaches to seaweed, optimising light for photosynthesis. The fibres are slimy, giving it a smooth texture when eaten.