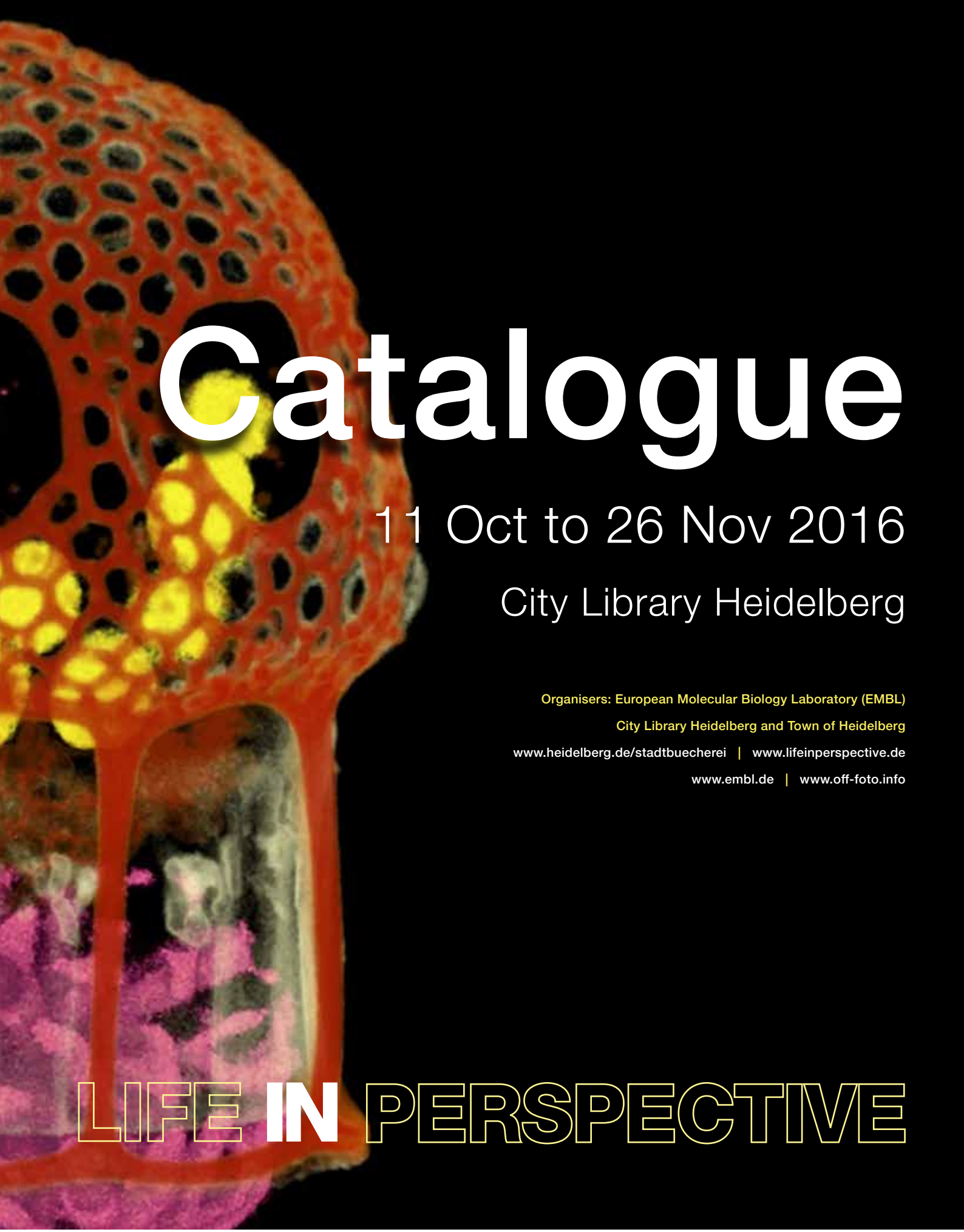

Catalogue

11 Oct to 26 Nov 2016

City Library Heidelberg

Organisers: European Molecular Biology Laboratory (EMBL)

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LIFE IN PERSPECTIVE

Heidelberg

Stadtbücherei Heidelberg

OFF// FOTO 2016

EMBL

Introduction

Curiosity is the most powerful driving force of scientific discoveries. Since the very early ages, the importance of our sight for evaluating and observing nature has led to the creation of de–vices improving our vision. From the first known single Nimrud lenses dating back to 750 BC to the Hubble space telescope, philosophy and science have sought to see the unseen. In life sciences, modern microscopy techniques al–low us to observe biological specimens with unprecedented spatial and temporal resoluti–on: for the first time in history the recording of living natural phenomena in three–dimensions has become a scientific standard. Nonetheless, these 3D images are often shown with the help of 2D projection maps, and with the loss of one dimension come distortion artifacts. This prob–lem is not new: for many centuries cartography has been dealing with these aberrations while trying to show our three–dimensional earth on a two–dimensional page of an Atlas. However, the complexity and beauty of nature can only be truly experienced when observing it in its entire dimensionality.

"Life in Perspective" explores creative ways of representing 3D microscopy images. It is an initiative which aims at showing nature as it is, three–dimensional and without distortions. And by doing so, previously hidden aspects all of the sudden come into view: forms are rea–dily recognizable, with spectacular symmetries and unique beauty, revealing nature's facets in true depth. As a result, 3D scientific microscopy images become a valuable outreach source and can be perceived as truly artistic.

In order to see nature in all three dimensions, different visualization technologies are used in combination with microscopy images. In this exhibition, we focus on lenticular printing as a visualization technique. This method uses a clever combination of interlaced prints with micro–lenses plates in order to provide each of our eyes with a view of the same 3D object in a different perspective. Our brain then does the rest, by combining the two inputs into one 3D image, very much in the same way that we ex–perience the world around us every day.

Besides lenticular posters, this exhibition also encompasses the use of other types of me–dia, some of which you will be able to access with your own phone: ***feel welcome to explore and interact!***

This exhibition marks the very beginning of an innovative collaborative work which is one of the foundations behind the ***"Life in Perspective"*** initiative. As such, we are always in search of new enthusiastic partners and collaborators. If you would like to know more, or join us, please check our website or simply send us a message.

We are happy to invite you to experience as–pects of life with depth and color, and share our enthusiasm for arts, science, and nature.

3D@lifeinperspective.de
www.lifeinperspective.de

Life in Perspective – Team

GUSTAVO DE MEDEIROS

So far my work has focused on in toto live fluorescen–ce microscopy and laser–tissue interactions: from de–veloping fluorescence microscopes to acquiring and processing large 3D image datasets. Through the “Life in Perspective” initiative, Stefan and me were inspired find novel ways to look at 3D biology data as it is.
gustavo@lifeinperspective.de

STEFAN GÜNTHER

My scientific experience is theoretical physics, 3D bio–microscopy and data science. 3D image and data visualization is one of my essential tool to enable peo–ple to grasp fundamental principles in biology and to admire the aesthetics of life.
stefan@lifeinperspective.de | www.sguenther.eu

JORAN DESCHAMPS

I work as a Ph.D. student on novel 3D methods in superresolved light microscopy and automation of microscopes. Along the years, I have also grown a strong interest in visual arts, in particular spray pain–ting with stencils. I have joined the team as a desi–gner and explore new media for data visualization.
joran@lifeinperspective.de

MANUELA BECK

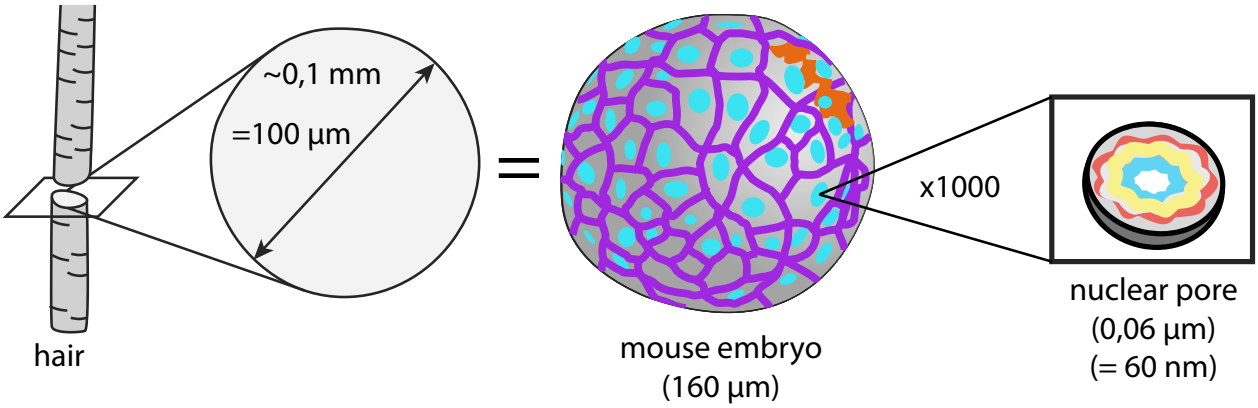
I work as chair of the ARTS@EMBL group, designer and project manager. It is a pleasure to bring the project “Life in Perspective” to live. I really do enjoy working across the disciplines science, communication and art. It is a pleasure when working with fascinating images to make science accessible to the general public.
manuela@lifeinperspective.de

Facts and Figures

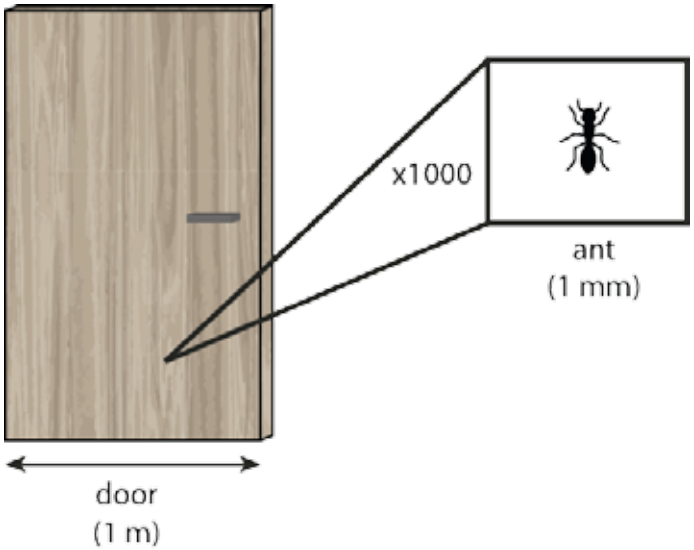
Life in the sea

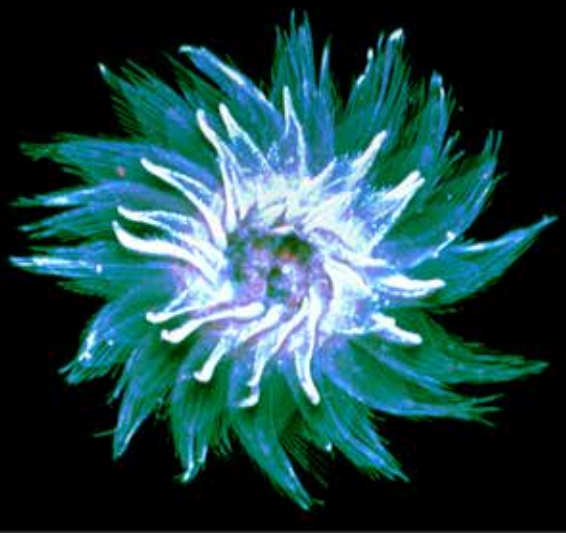
All the marine life presented here has been collected in distinct places of the globe, as part of the TARA Oceans expedition.

Tiny Nature



What does tiny mean?
All the exhibits shown in this exposition have been recorded with various microscopy techniques. Most of the samples are about the diameter of human hair while other are the finest details of life. The difference in sizes throughout the exhi–bition is equivalent to the difference between a door and an ant.





Number: 1 – Ciliate

Size: 80 x 100 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: 100 µm diameter

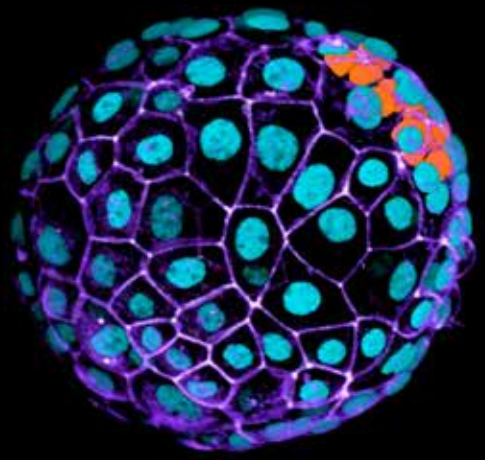
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Fleur de mer

Tendrils of membranes propel prey to entrance of tiny planktonic species

The first *tintinnid ciliate* was described more than two centuries ago. Hundreds of species have been discovered since, but you are looking at one that scientists have not yet identified. The filamentous rays coming from the apex of this tintinnid are rows of membranelles, which help steer food toward the cell. Up close, they look like solar flares. At the center of this ciliate sun is a predatory apparatus – it is not a mouth, since the ciliates are unicellular. Hidden from view is its lorica, a vase shape shell, which hosts the cell body. When feeding, the cell pushes out of the lorica and consumes its food with this mouth–like pore.

Ciliates are grazers at the base of the food chain – they chiefly eat minute plankton and other microalgae. Ciliates do not actively seek out prey. Rather, they haphazardly dance and twirl as water flows through their membranelles. They create local currents to propel prey to the 'oral' region, where it is trapped and then phagocytosed. This view of the ciliate sun demonstrates the complexity of the predatory behaviour of protists, the kingdom of microbes that comprises ciliates. Studies of protist diversity allow us to better understand the planktonic ecosystems that affect other life in our seas and oceans.



Number: 2 – Mouse embryo

Size: 120 x 140 cm (width x height)
Imaging: L. Panavaite, EMBL

Sample size: 160 µm diameter

Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

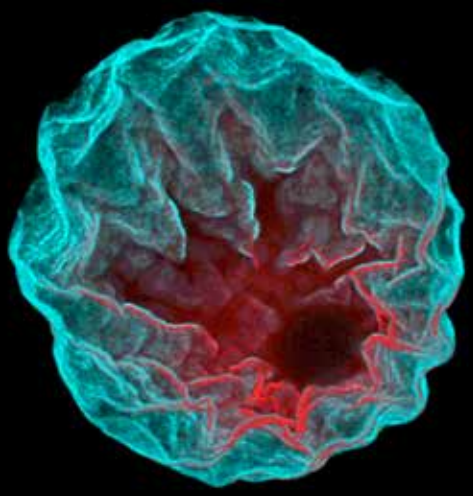
Room to expand

Specialised cells of a mouse embryo stem from a single cell

Much like us, mice begin life as a single cell. During the first few days of development, this cell divides into dozens. They collectively assemble into a spherical, fluid–filled structure called a blastocyst. Then, the blastocyst embeds itself in the wall of the mother's uterus during a process called implantation. The mouse embryo you see here is four days old, and this blastocyst is on the brink of progressing through this stage of development.

As this tiny ball of cells embeds itself in the womb, the trophectoderm cells on the outside layer (seen in blue) create vital connections to the mother and contribute to the placenta. This process is essential to maintain and nourish the foetus throughout pregnancy. The spidery network of purple lines are the membranes of these embryonic cells.

The orange–coloured patch in the inner layer of the ball is a cluster of epiblast cells, which will make up the body of the developing mouse. The specimen was labelled with antibody staining and imaged with a confocal laser scanning microscope. By studying how embryonic development works in mice, we can better understand how other animals, including humans, develop.



Nummer: 3 – Starfish nucleus

Size: 120 x 140 cm (width x height)
Imaging: N. Wesolowska, EMBL

Sample size: 65 µm diameter

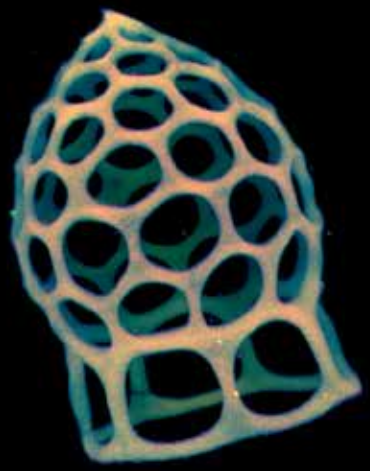
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Stellar explosion

Starfish nuclei burst open prior to cell division

You are looking through the surface of the nucleus of a starfish egg cell, or oocyte, as it prepares to fuse with a sperm cell. During cell division, chromosomes contained in the nucleus are distributed to daughter cells. In order to distribute the correct number of chromosomes, the nucleus of the parent cell needs to be broken down. When prompted with a hormonal signal, the surface of the nucleus – or nuclear envelope (seen in red) – loses structural integrity. It becomes leaky, allowing a protein called actin (seen in blue) to enter and form its fibrous assemblies inside the nucleus. Actin, which normally acts as a scaffold to the cell, can also reshape or even break down cellular compartments. It floods into the nucleus, lines the underside of the nuclear envelope and forms a thick but transient shell. This shell seems to push outwards, apparently triggering the nuclear envelope to fragment. This breakdown frees the cell's genetic material to be transferred to the daughter cell. If you look closely, you can see shards of the crumpled nuclear envelope thinly lined with actin. This process of nuclear envelope breakdown is critical for the generation of a mature egg.

This starfish oocyte was imaged with a confocal microscope, which enabled researchers to acquire images of the cell layer by layer. The view also makes visible the nucleolus, a specialised compartment of the nucleus, which appears as a dark circle towards the bottom right of the image. Starfish oocytes are particularly useful to scientists because they are transparent and nearly one thousand times bigger than the average cell in the human body. This enables us to gain unprecedented insights into crucial mechanisms of reproduction.



Number: 4 – Dictyocysta mitra

Size: 80 x 100 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: 65 µm x 45 µm (height x diameter)

Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Oceanic Tiara

Some ciliates are sheathed inside a natural coat of armour

Tintinnid ciliates are single–celled sea creatures. They are outfitted with a shell called a lorica, which refers to armour worn by Roman soldiers – except here, it fits over a single cell. Loricae serve as protection against predators, as well as contribute to cell asymmetry. Each Tintinnid is a unicellular builder of these microscopic works of art. They can be found in a staggering variety of shapes. Some are tubular, others are bowl–like. Some are chalices, others have ridges and pores and in many cases, the shape is species dependent. This particular lorica belongs to a kind of ciliate known as *Dictyocysta mitra*. This one is empty. A Tintinnid may abandon its lorica in a number of circumstances, including death or cell division. When the Tintinnid divides, daughter cells will keep their mother's shell, while the mother progressively builds a new one for itself.

The shape and texture of the ciliate's loricae is influenced by its environment. In this particular image of *D. mitra*, the lorica has been stained with hydrophobic dyes, indicating organic materials in the shell. While the chemical composition of loricae is still barely known, scientists believe that their construction is influenced by factors such as water temperature and salt levels. Some species even amass mineral debris from their microalgae prey in order to construct their loricae.

Number: 5 – Dictyocysta lepida

Size: 120 x 140 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: 140 µm x 88 µm (height x diameter)

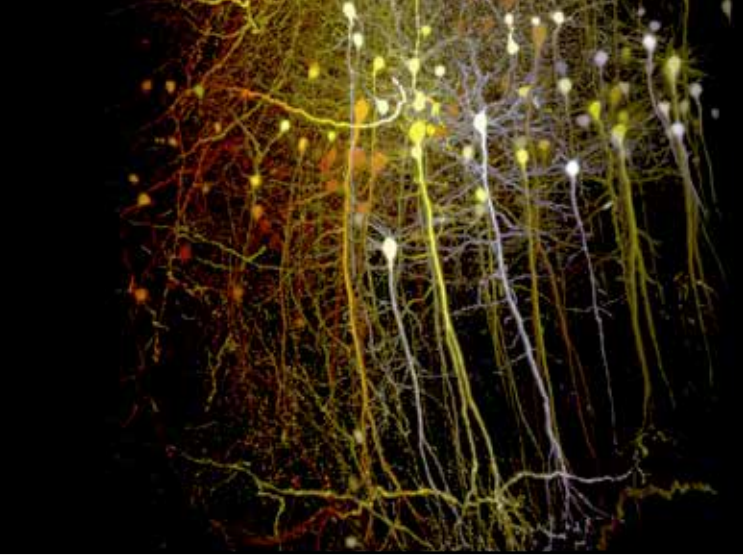
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Single-celled predator

Microbe caged in a shell engulfs its prey

At first glance *Dictyocysta lepida* seems rather unassuming. It is a unicellular creature one thousand times smaller than the head of a pin. Yet despite its diminutive size it is a natural predator, protected by a cage–like shell called a lorica (seen in orange). Here we see it engul–fing a micro–alga prey (in magenta). *D. lepida* is a tintinnid ciliate, which is a kind of plankton. This particular specimen was scooped out of the South Indian Ocean during the Tara Oceans ex–pedition. Between 2009 and 2013, researchers sailed the world's oceans aboard the schoo–ner Tara collecting samples so that EMBL and partner institutions could learn more about the billions of organisms that populate every drop of seawater.

Most of these organisms – like *D. lepida* – are heterotrophic and must catch prey for energy. You can also see some striking characteristics in its prey: chlorophyll that emit light naturally (in magenta) and even its chloroplasts (in light pink). Imaged with a confocal laser–scanning microscope, you can see *D. lepida*'s DNA (in bright yellow). By analysing the morphologi–cal and genetic biodiversity of planktonic spe–cies, researchers are now starting to unravel the crucial role they play in Earth's underwater ecosystems and how changes in our climate might affect these systems.



Number: 6 – Nerve cells

Size: 120 x 150 cm (width x height)
Imaging: A. Ciccarelli, EMBL

Sample size: 15 µm neuronal body; 500 µm axon length

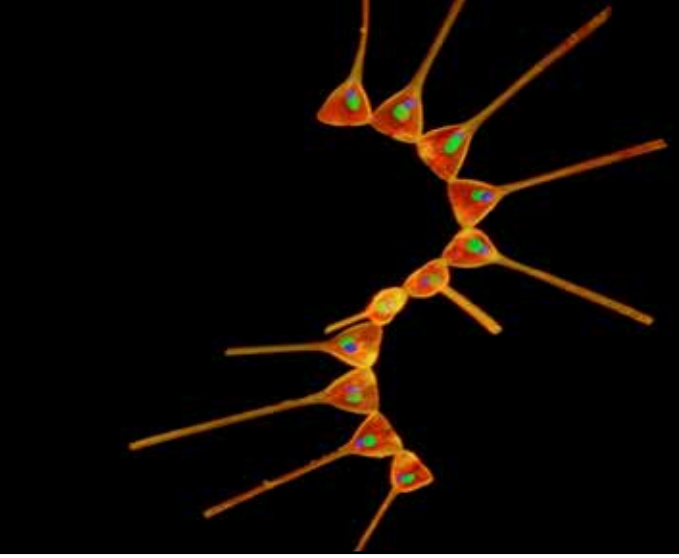
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Dendritic flickers

Nerve cell shape sheds light on brain connectivity and function

The brain is a forest full of nerve cells called neurons. Like shining a flashlight into the inky darkness of a thicket, just a fraction of the 'trees' are visible in this snapshot of a mouse brain. If all cells were visible, then the image would look like a tangled mass of wiring. So researchers have selectively shone light on just 10 percent of the neurons. The various shades of yellow, orange, and white reveal their proximity to you. Some outlines of trees are brighter: these are closer to you. Duller trees are farther away. Branching off of these nerve fibres are dendrites, an intricate network of tissue shaped like branches. In fact, dendrite comes from the Greek word for tree. Dendrites receive, integrate, and store information in the form of electrical signals coming from other neurons.

These cortical excitatory neurons were isolated from a region of the brain that enables perception and voluntary movement. Neurons were dyed with fluorescent markers, and their colours indicate their 3D position within the brain forest. This image was obtained using light sheet microscopy, allowing illumination of slices up to a hundred times smaller than the diameter of a hair. Collectively, the images show a high–resolution 3D projection of a thick brain slice. Visualising neurons through thick slices of brain tissue can be difficult due to intense light scattering in the tissue. To overcome this issue, the slices were run through a clarification process: lipids, which are the main cause of light scattering, were removed. This combination of light–sheet microscopy and specimen clarification is a powerful tool to study the elegant morphology of neurons on a short timescale and at a high resolution. Understanding how the branches are shaped and how they connect with each other is essential to understand how the brain works.



Number: 7 – Asterionellopsis sp.

Size: 86 x 100 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: 10 µm one cell diameter x 65 µm length

Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Plankton necklace

Single cells of Asterionellopsis form spiral chain after cell division

This delicate spiral of spines is not just one cell, but a colony of individual cells. They belong to a genus of diatoms called *Asterionellopsis sp.* Diatoms comprise a group of single–cel–led algae that display an exquisite diversity of habitats, shapes and sizes. Each cell contains chloroplasts, which allows the diatom to get energy from photosynthesis. The most striking characteristic of diatoms, though, is their cell wall: It is made of transparent silica, which is similar to glass.

After division, the *Asterionellopsis* cells remain bound to one another and form a helix–shaped chain. Staining techniques reveal two essential intracellular components within the triangular base of each cell – DNA (in blue), and chlo–rophyll (in green). The silica cell walls (in red) form a micro–patterned greenhouse, scatte–ring the light beautifully.

Number: 8 – Fruit fly embryo

Size: 170 x 120 cm (width x height)
Imaging: S. Günther, EMBL

Sample size: 500 µm x 200 µm (height x diameter)

Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

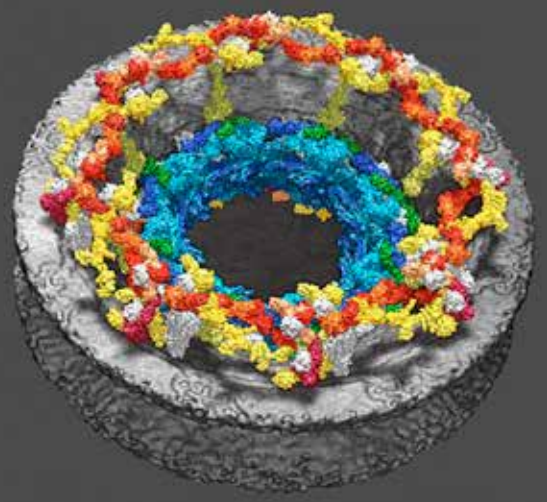
Travel by Folds

Fruit fly tissue folds like curtains to give rise to complex anatomy

What you see before you happens in your kitchen all the time. From left to right, these images show a single fruit fly, *Drosophila melanogaster*, developing as an embryo. The upper row shows the future fly's back, while the lower row shows its belly: a yolk–filled egg wrapped within a single sheet of cells. When you see a fruit fly hovering above your trash bin, it is because one of these eggs developed into a larva and hatched as a fly. Their embryonic development is very rapid, yet very intricate. The fly embryo is just three hours old. At this stage of development, the cell precursors – which play a role in organ formation – are located on the surface of the embryo. But in order to build structures inside the body, the cells need to be brought inside. So they start to fold. Imagine you are standing in front of a curtain hanging across a room. Now imagine someone is standing behind the curtain opposite you and pinches the fabric. From your point of view, the fabric would pucker and fold inward. This is similar to how a fly embryo brings its cells inside.

One notable fold can be seen in the last three frames, toward the bottom of the specimen. Germline cells, like sperm or egg cells, are formed in the tip of this pocket. They move inside to be fully protected and surrounded.

Cell nuclei were labeled with a fluorescent molecule called mCherry, which glows when illuminated with laser light. Then, using multiple–view light–sheet microscopy, scientists can observe biological processes – such as embryonic development – over the course of many days and without harming the organism. These screenshots are from just a 20 minute segment of a 24 hour–long movie. Light sheet microscopy generates lots of data: in total the movie was two terabytes. Tracking the positional history of each of the thousands of cells within a growing fly embryo sheds more light on events crucial in the development of *D. melanogaster* and can even help us understand more about ourselves.



Number: 9 – Nuclear pore

Size: 120 x 140 cm (width x height)
Imaging: J. Kosinski, EMBL

Sample size: 60 nm diameter

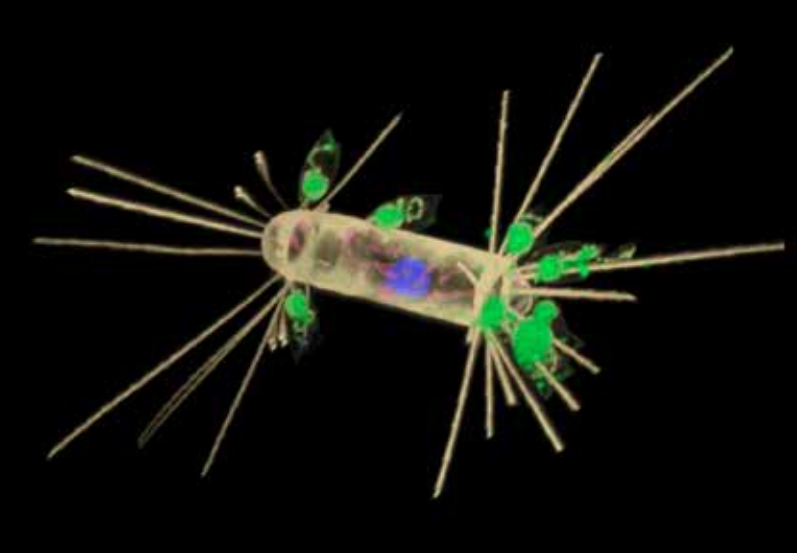
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Gate to the nucleus

Nuclear pore complexes regulate molecular traffic in and out of the nucleus

Every cell inside of us has a nucleus, the surface of which is studded with thousands of pores. If the nucleus is a castle, nuclear pore complexes are its protective gates – they let certain proteins in, and they keep certain others out. They not only regulate what enters the nucleus, but also what exits this microscopic stronghold. In this striking image you can see a single nuclear pore ringed with a bastion of a thousand proteins. Collectively, the pore and proteins form a structure known as the nuclear pore complex. The nuclear pore complex is tiny – 1000 times less than the width of a human hair. Yet it is a behemoth in the scientific world – it is one of the biggest and most complex molecular structures ever analysed. Some viruses have developed ways that exploit this defensive wall. HIV and influenza viruses, for example, can use the nuclear pore complex to inject their genetic material into the nucleus.

In this image, the way into the nucleus is downward – the proteins surrounding the pore have been coloured to illustrate the depth of the nuclear pore complex. Blue is deeper in the channel, while red is closer to the outside of the nucleus. These nuclei were isolated from human cells. Researchers used cryo–electron tomography, an application of electron microscopy, to take images of the sample from many angles. They could then identify the rough shape of the nuclear pore, which is like a puzzle template. Using automated, custom–made software, the researchers then fit proteins that are known from online databases together into the shape identified – like solving a 3D puzzle. By understanding the structure of the nuclear pore, we can better understand how proteins and viruses interact with it.



Number: 10 – Corethron criophilum

Size: 80 x 60 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: 10 µm x 35 µm diameter x length cell body

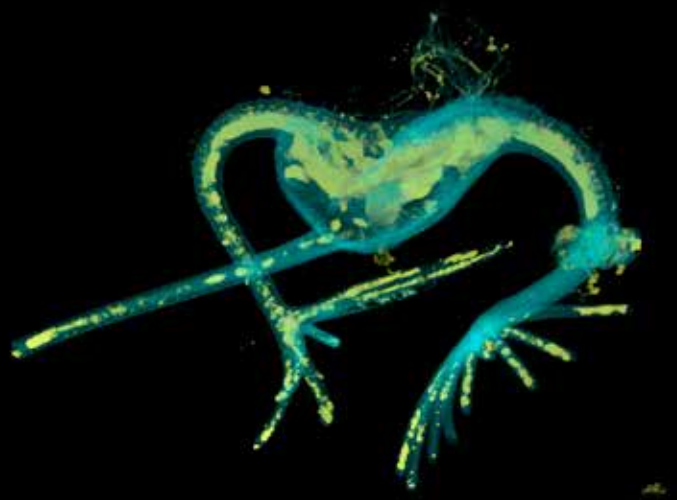
Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Crown of spines

Two different species of cells form a microscopic hanging garden

Some plants grow upon others without harming each other. Similar relationships occur at the microscopic scale, like in this image of two marine species. The orange pill–shaped organism with needle–like spikes is *Corethron criophilum* – a diatom (a single–celled alga). Its name translates to crown of spines, which are seen at both ends of its body. The spines grow atop valves, or ring–like bands encircling each end of the alga. The microbes in green are nanoflagellates. They are not punctured by the spines – rather, these tiny cells are living on top of them. Their symbiosis is harmless. In a sample of water taken from the Indian Ocean, scientists from EMBL and partner institutions in the Tara Oceans expedition noticed a multitude of interactions between species of microbes.

This image was taken using confocal microscopy. Look closely and you make out flattened red structures, which are chloroplasts. The wall encapsulating the cell is made of the same material as the spines: glass–like bio–silica. DNA of *C. criophilum* (seen in blue) is housed inside of a nucleus. This nucleus is roughly the same size as each of the nanoflagellate cells – just one micron in diameter or the equivalent of just one–hundredth the width of a human hair. Learning how some organisms live together in a symbiosis can help researchers to understand more about evolution.



Number: 11 – Ceratium ranipes

Size: 80 x 60 cm (width x height)
Imaging: S. Colin, Tara Oceans

Sample size: around 50 µm length of each finger

Concept and visualisation:
S. Günther, G. de Medeiros, J. Deschamps, M. Beck

Catching light

Finger–like extensions of Ceratium ranipes open or close depending on time of day

When the sun rises, it's feeding time. The eerie, hand–like shapes you see belong to *Ceratium ranipes*. This dinoflagellate – a type of sing–le–celled algae – displays an elegant behavi–our. During the daytime, it delicately unfurls its finger–like extensions. Inside its 'fingers' are chloroplasts that help it to convert light energy into sugars. As it reaches out towards the sun, these chloroplasts are bathed in light, enab–ling photosynthesis and providing the energy it needs to survive and thrive. When night falls, these fingers retract back inside.

This incredible image shows their intricate na–ture in striking detail. You can clearly see the cell wall (in blue), which is made of cellulose. The yellow spots dotting the fingers and arms are chlorophyll. Roughly half of dinoflagellates – including *C. ranipes* – are photosynthetic, whi–le the rest need to catch their own prey. Some dinoflagellates, however, can take part in en–dosymbiosis. That is, they can host other spe–cies within themselves, or be hosted by other species. Far from 'survival of the fittest', such interactions help organisms to prosper, such as those between dinoflagellates and corals.

Experience the exhibition on video

Stereoscopic 3D videos

Watch a 3D video about the exhibited pieces on your smartphone! Stereoscopic videos require the use of special glasses, which are available in the public library.

1. Get a smartphone head mount from the library reception
2. Follow the YouTube link on your smartphone
3. Mount your smartphone in the holder
4. Enjoy the 3D movies!

www.bit.ly/lip–stereo

Anaglyph 3D videos

Watch a 3D video at home about the exhibited pieces. Anaglyph videos allow you to see a scene in 3D with the help of red–cyan glasses.

1. Get red–cyan anaglyph glasses
2. Follow the YouTube link
3. Enjoy the 3D movies!

www.bit.ly/lip–anaglyph

Perspective videos

Watch perspective videos of the exhibited pieces and share them with your friends and family.

1. Follow the YouTube link
2. Enjoy the movies!

www.bit.ly/lip–perspective

Credits

"Life in Perspective" is an initiative, which searches for novel visualization methods combined with 3D scientific data, so that scientists have better ways to understand their own images. Created by the scientists Dr. **Stefan Günther** and Dr. **Gustavo de Medeiros**, the search soon stumbled upon an unexpected artistic aspect: when combined with the right visualization technique, scientific data can display spectacular symmetries and shapes. The artistic aspect motivated designer **Manuela Beck** in joining the team, providing artistic design, communication and curator support; ideas of trying out new visualization techniques and combining new approaches are also interesting aspects which brought scientist **Joran Deschamps** into the group.

Most importantly, the initiative has continuously received support from many others, which helped providing scientific data, implementation support, scientific writing and more. Together, this joint undertaking has made ***"Life in Perspective"*** an interesting center which attracts people from different expertise, allowing multidisciplinary work to make biological data combined with visual communication techniques an one of a kind experience for the public.

In particular, we would like to thank Professor Dr. **Matthias Hentze** and his office from European Molecular Biology Laboratory (EMBL) for his full support of our project, the implementation of our first ideas and his advise on the exhibition environment. We appreciate the entire **EMBL** as an institution open to permitting new artistic ideas to be developed within a scientific environment and for its funding. At EMBL we received support from the **Strategy and Communication** department in particular from Dr. **Margaux Phares** for writing the scientific texts and **Angela Michel** for translations and press work. And we would like to thank **Sonja Noss** from the **Grants Services** for her support.

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If you wish to support the ini–tiative or if you are interested in lenticulars for your own use, feel free to drop us a message!

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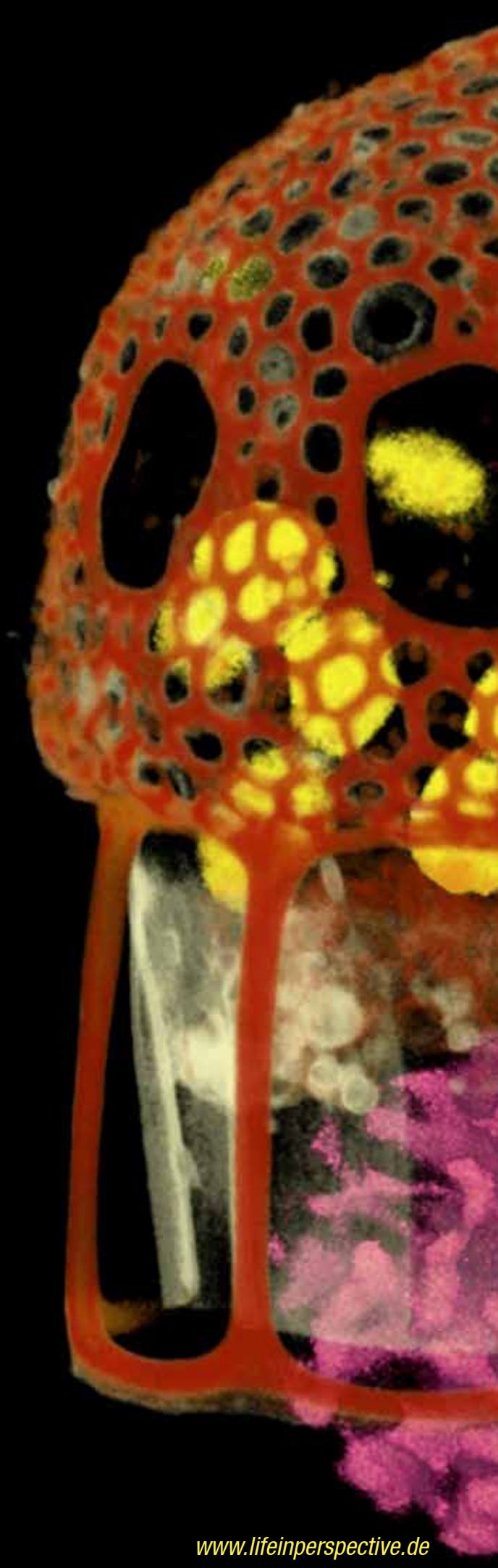

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