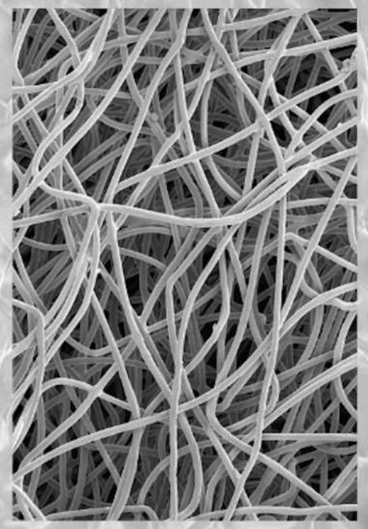
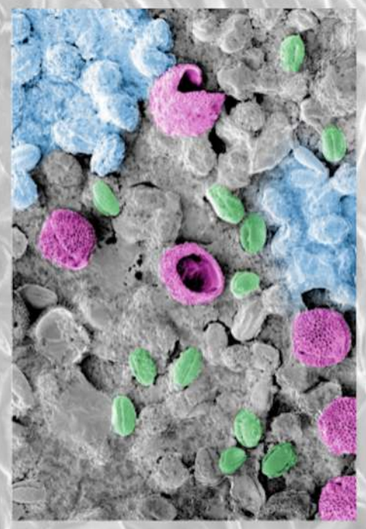
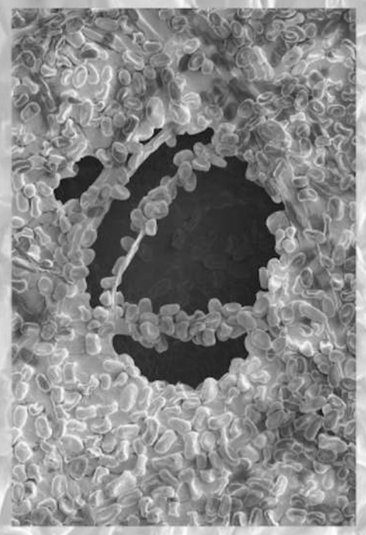
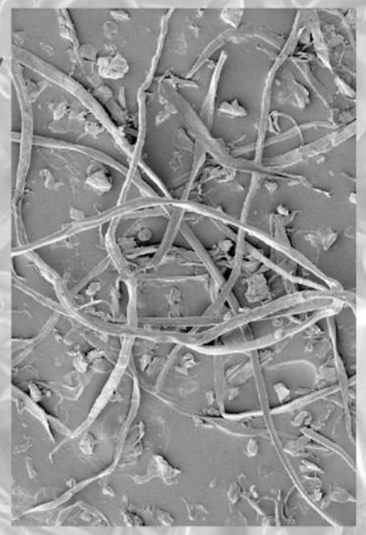


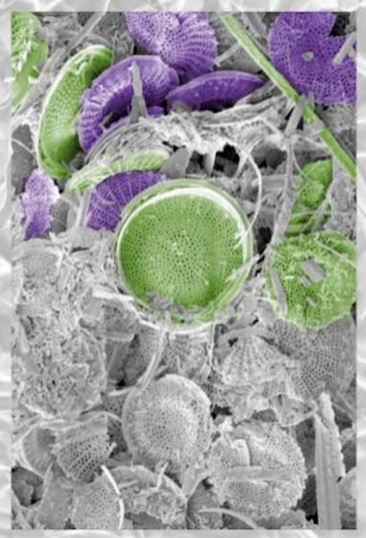


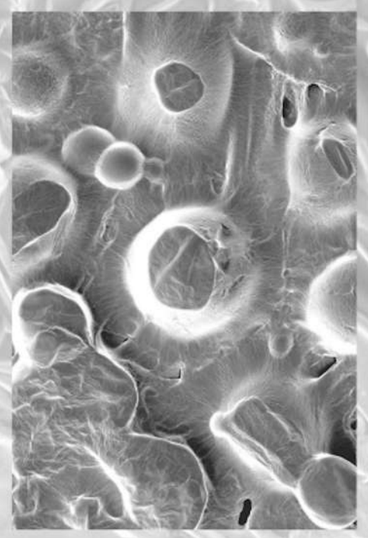


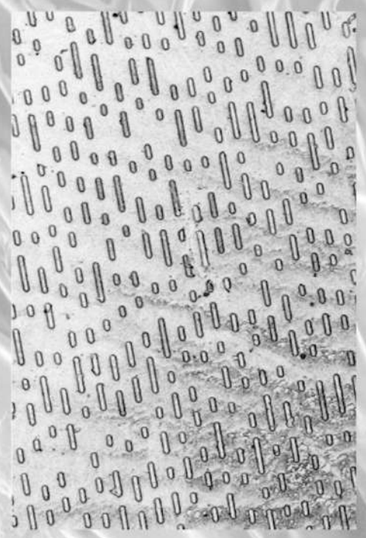
70 greyscale micrographs to color

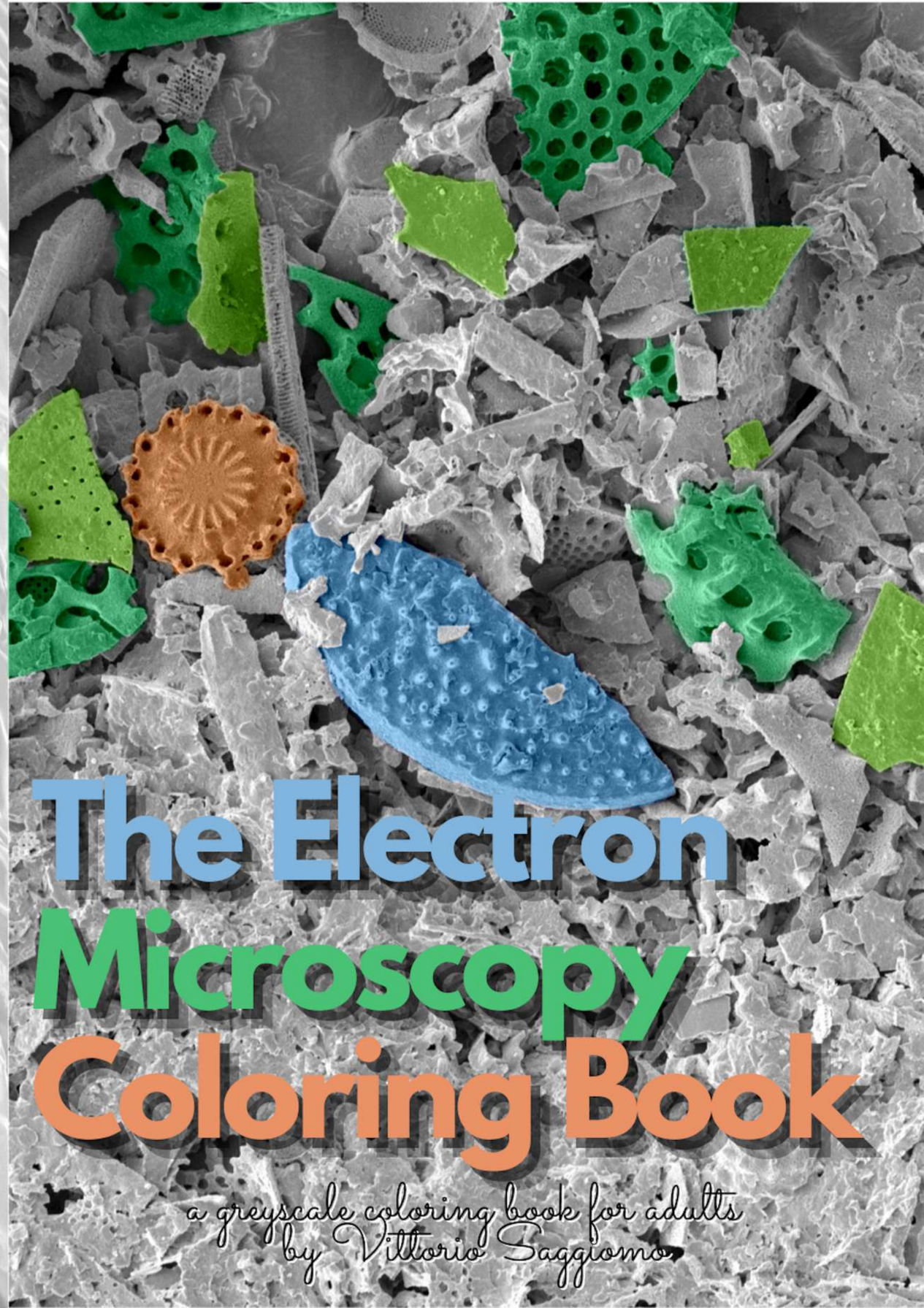


Vittorio Saggiomo









The Electron Microscopy Coloring Book

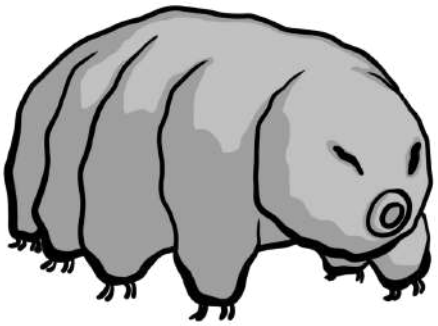
a greyscale coloring book for adults
by Vittorio Saggiomo

Vittorio Saggiomo
The Electron Microscopy Coloring Book
©2022
Self-published

Micrographs recorded by Vittorio Saggiomo

Drawings by Bleeptrack

Introduction



Once, I was digitally coloring some SEM micrographs I recorded the day before, and I found the process extremely relaxing. “This is nice”, I thought while coloring some fungal spores. Obviously, I had to share the final, colored pictures on Twitter. A few seconds later Andrew Boa (@anboa4) asked me if I was receiving a coloring set for Christmas… Not new to coloring books, I wondered if there were any electron microscopy coloring books available online. A fast search didn’t show up anything…

And here we are… You hold in your hands what is possibly the first electron microscopy coloring book. :)

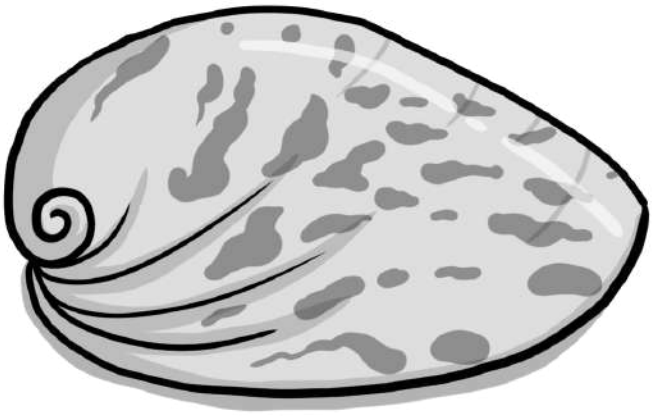
But let’s start at the beginning. What is SEM? SEM stands for Scanning Electron Microscopy. In a few words, you shoot a beam of electrons at a sample you want to image. And I really mean “shooting”, we do this with an electron gun. When the electron beam is focused on the sample, some electrons from the sample are scattered and collected in a detector, which will then form the image of the sample.
Yes, yes, I know - this is a very basic description, but for the sake of brevity let’s leave it at that.

SEM pictures are beautiful and detailed surfaces reconstructions of the sample in greyscale. They are perfect for being colored in post-processing. This is usually done digitally by scientists: to highlight some parts of the image, to enhance contrast, or, in general, to make a pleasant picture.
Now, you also have the possibility of doing the coloring by hand, using pencils, or watercolor pencils if you feel fancy (but use as little water as possible).
I have chosen ten objects and recorded multiple SEM pictures for each of them, for a total of 70 pictures to be colored. The images have been recorded to be aesthetically pleasing and modified for being easily colored using pencils.

Last but not least: 1 micron (µm) is 1/1000 of a millimeter (mm), just as reference think that a human hair is usually between 60 and 90 µm.

Have fun, relax, and enjoy many many many hours of coloring. :)

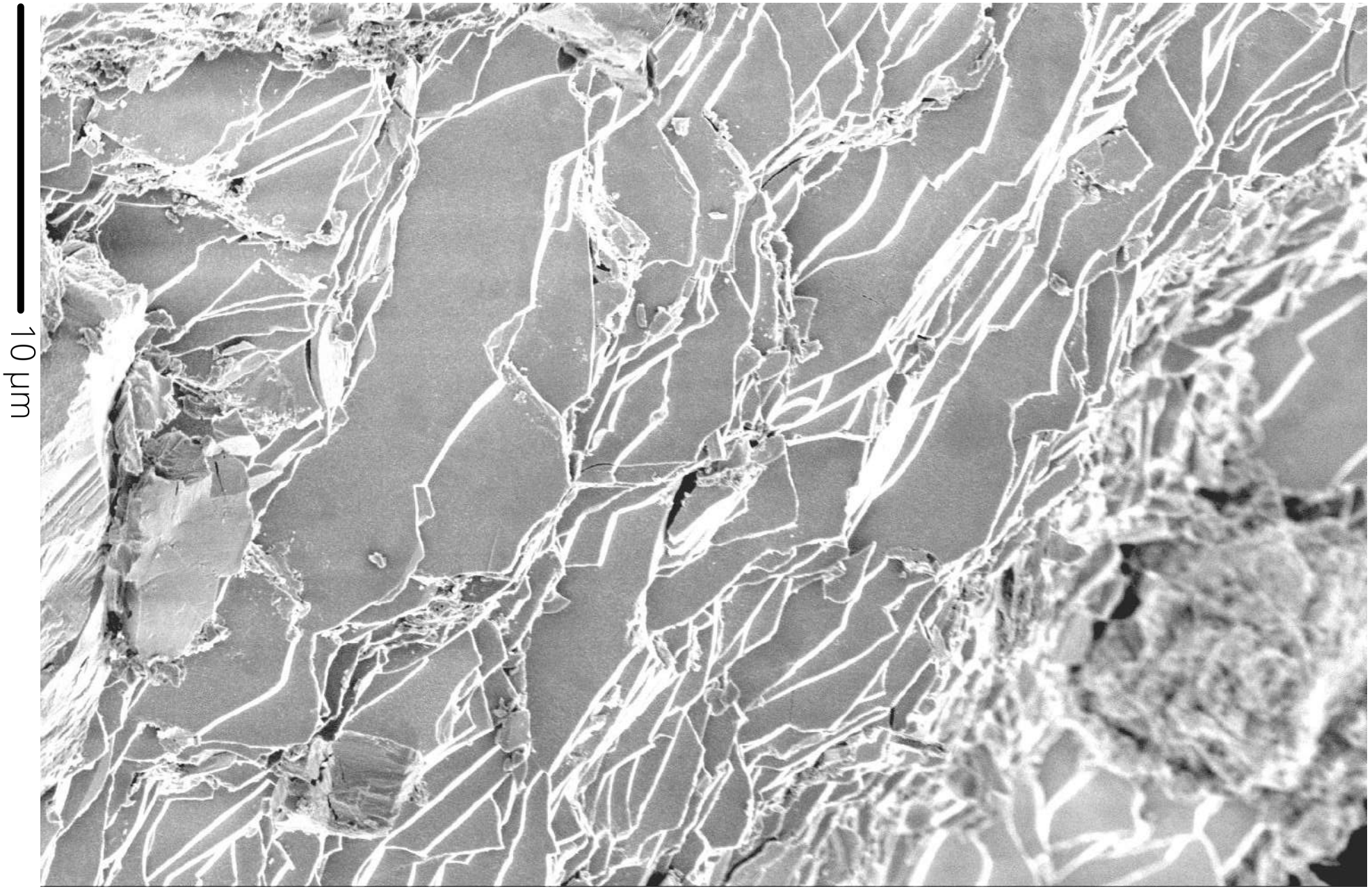
1 - Abalone Shell



If you have ever been in a beach touristic place, you've for sure seen some Abalone Shells for sale as souvenir.
Their inner shell color is beautifully iridescent, and they make an amazing natural showpiece in your living room; also a dust magnet, but we will see this later. From an engineering point of view, the shell is unbelievably strong, and for decades, and counting, scientists are trying to achieve the same strength using synthetic materials.

Both color and strength come from the special laminar structure of the shell. Microscopic tiles of calcium carbonate (aragonite) are stacked in layers like bricks and are held together by organic materials. This structure is known as nacre.

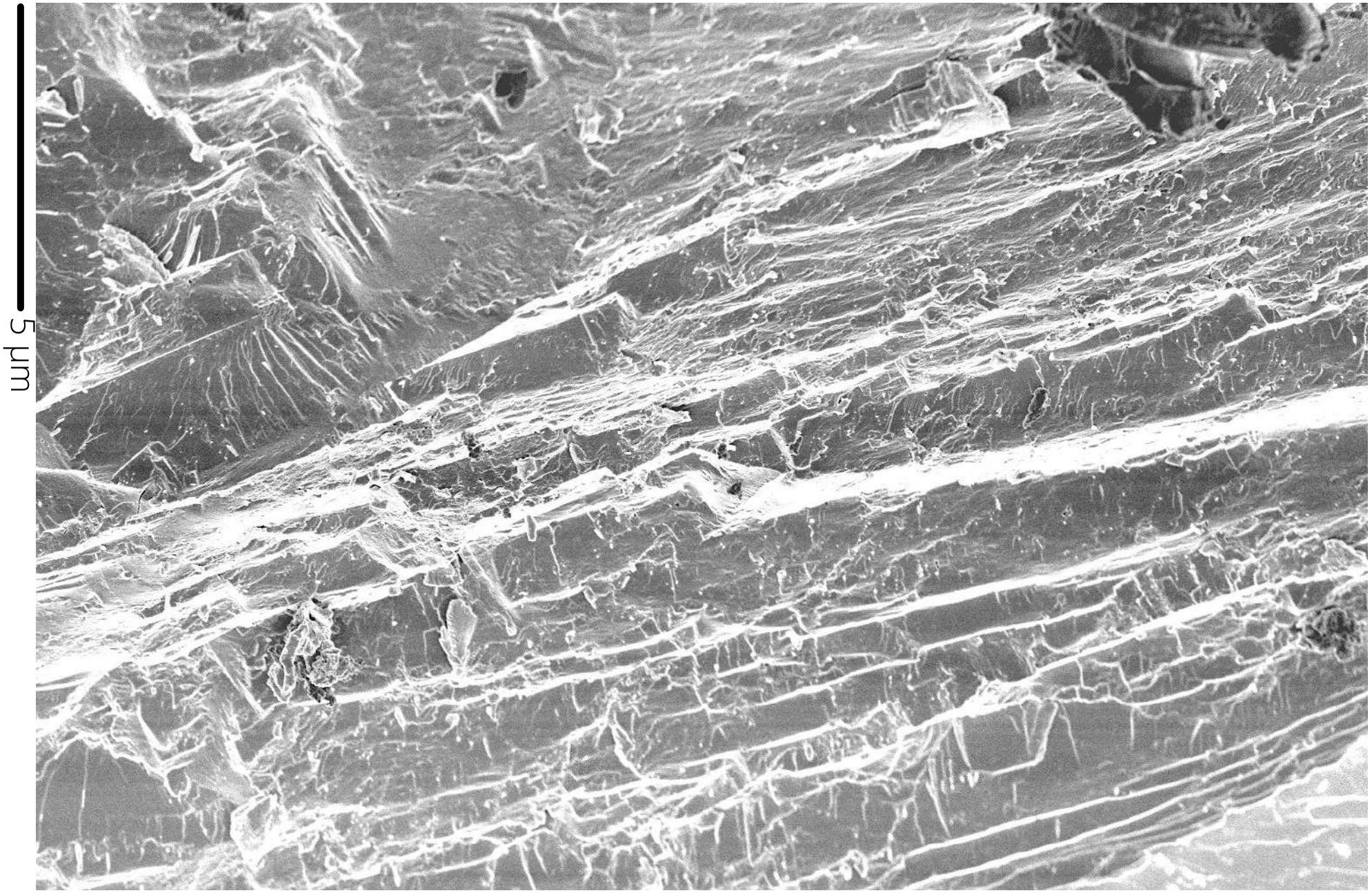
In the next three pictures, you will find both the nacre structure as well as the calcium carbonate not in the aragonite (brick) form.



1 - Abalone Shell

5 µm

1 - Abalone Shell



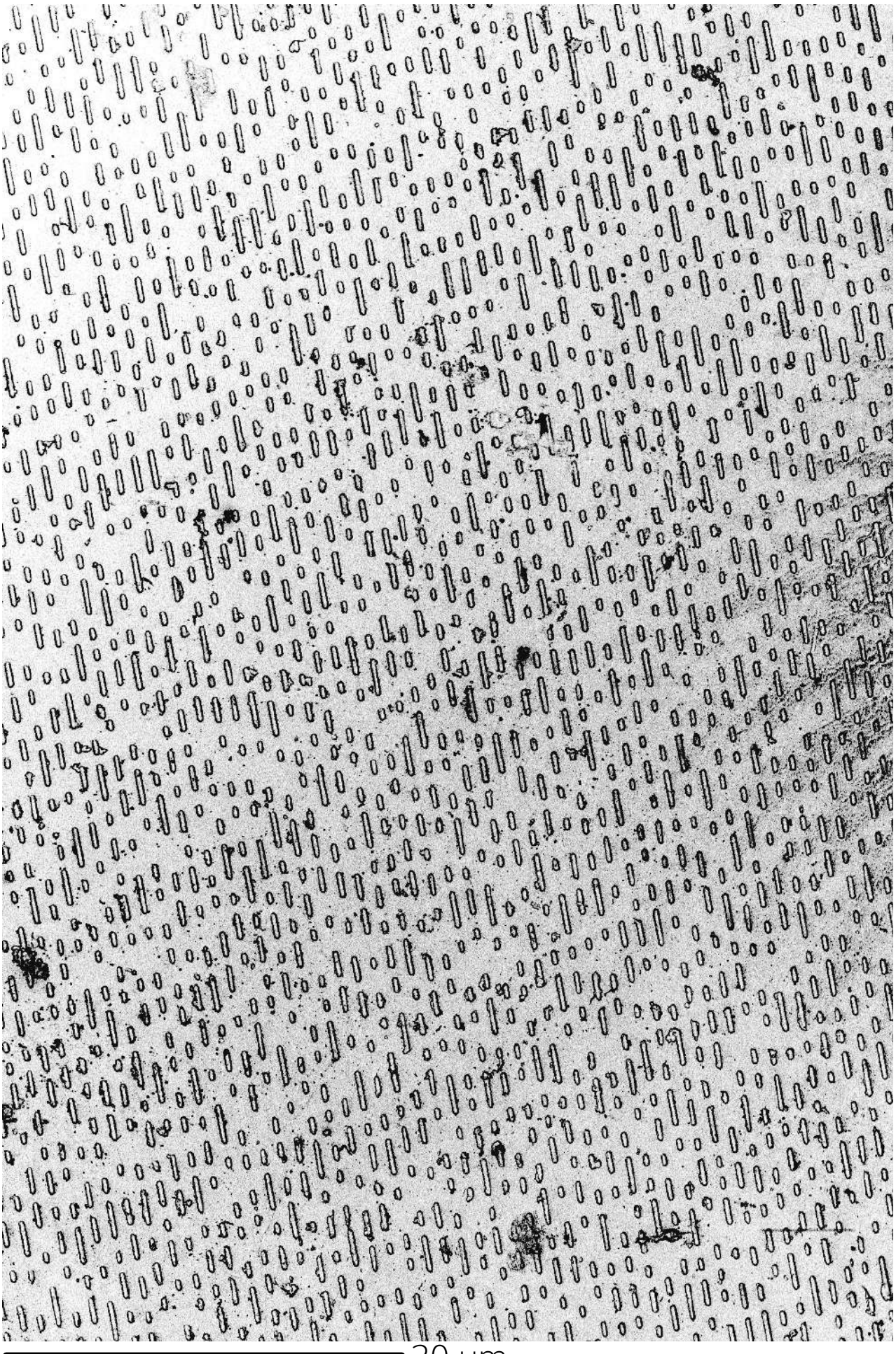
1 - Abalone Shell

2 - Compact Disk

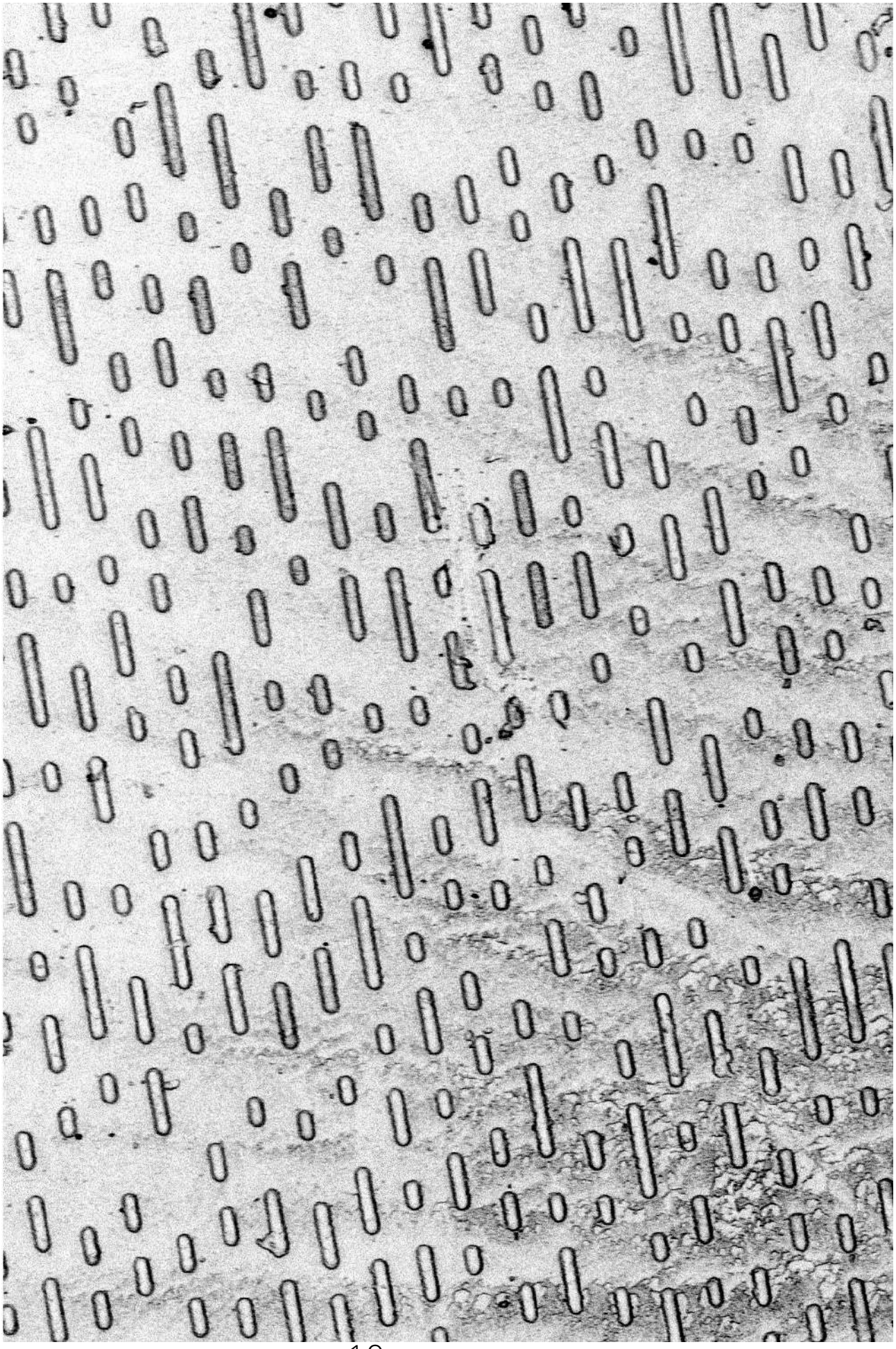
I know, I know, I'm old and the CD is an obsolete media.... That may be true, but do you know how the CD works? No?

A CD has small indentations on its surface; these bumps reflect a laser light to a detector while the CD is rotating inside the reader. Being a digital media, each reflection corresponds to 1 while no reflection corresponds to 0. This is the same for DVD and Blu-ray, though the laser used differs. Smaller lasers can read smaller and closer bumps, resulting in high data efficiency.

In the next three pictures you can see the bumps, and in one of them also the carbon tape I used to fix the CD layer to the sample holder, just because I find it nice. The CD tracks in the pictures are from a Celine Dion CD, just because as such I can record CD-CD pictures.

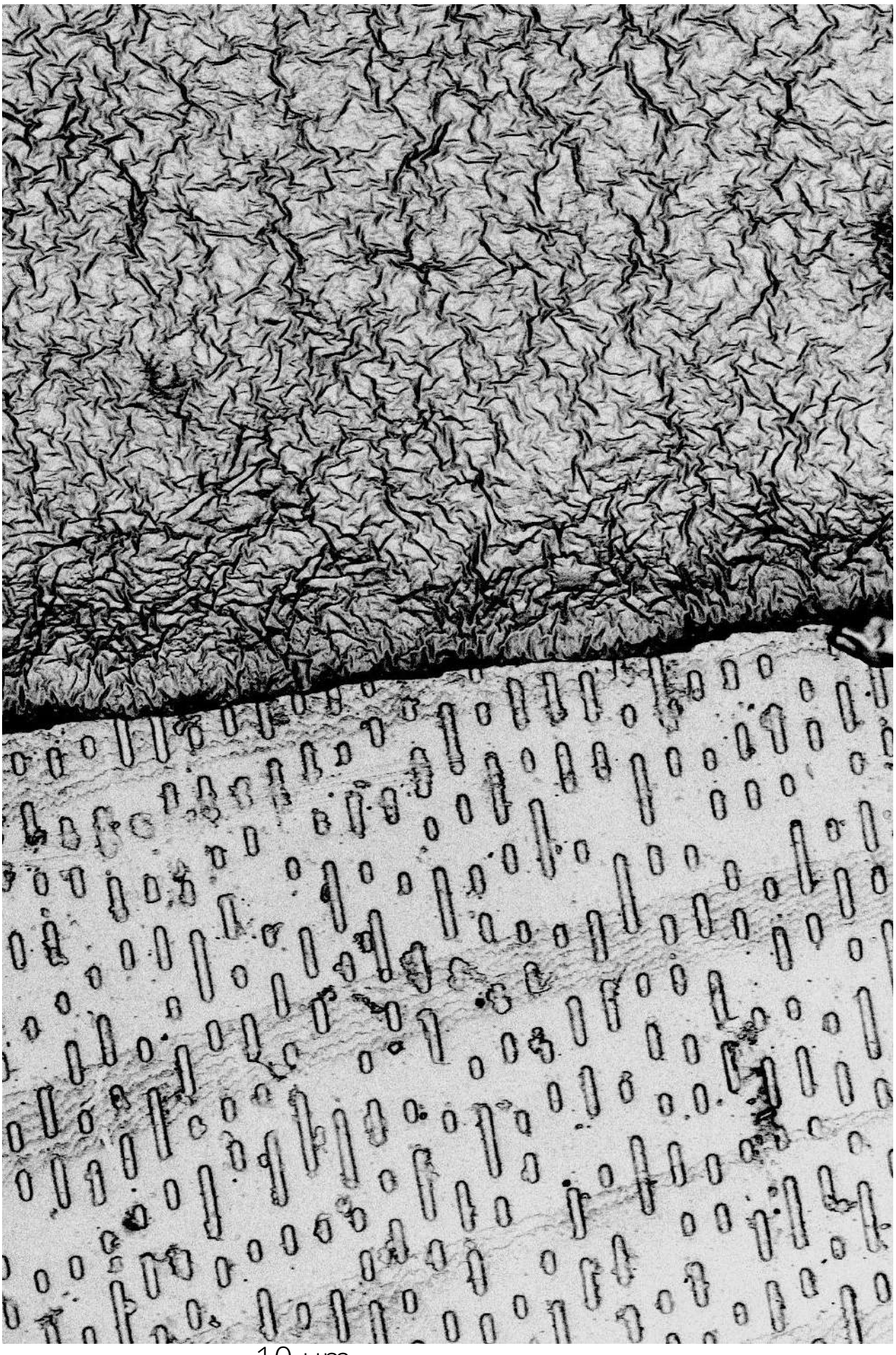


2 - Compact Disk



10 µm

2 - Compact Disk



2 - Compact Disk

3 - Post-it

Do you remember a long time ago, when you were studying (or maybe you still are?), there was something important to remember and you put a magic piece of sticky paper on that page, and then never opened the book ever again in your life?
Well, that was a post-it. I mean the sticky stuff, not the book.

This sticky reusable stuff has two tricks on its sleeve: strength and structure. The adhesive itself is not the strongest adhesive in the world, as its inventor (Dr. Spencer Silver) hoped to achieve. It contains some polymeric microspheres on its surface, and these spheres decrease the contact points between the surface of the adhesive and, let's say, your book, making the attachment/detachment easier. This is a fast explanation in two sentences, but the history of the Post-it is quite entertaining, so google it and give it a read if you have the time.

In the following pictures, you can see the spheres both in the positive (the sphere itself) and in the negative (the hole left from the detachment of the spheres); a few fibers from the paper are also peeking here and there.

3 - Post-it

3 - Post-it

3 - Post-it

3 - Post-it

3 - Post-it

20 µm

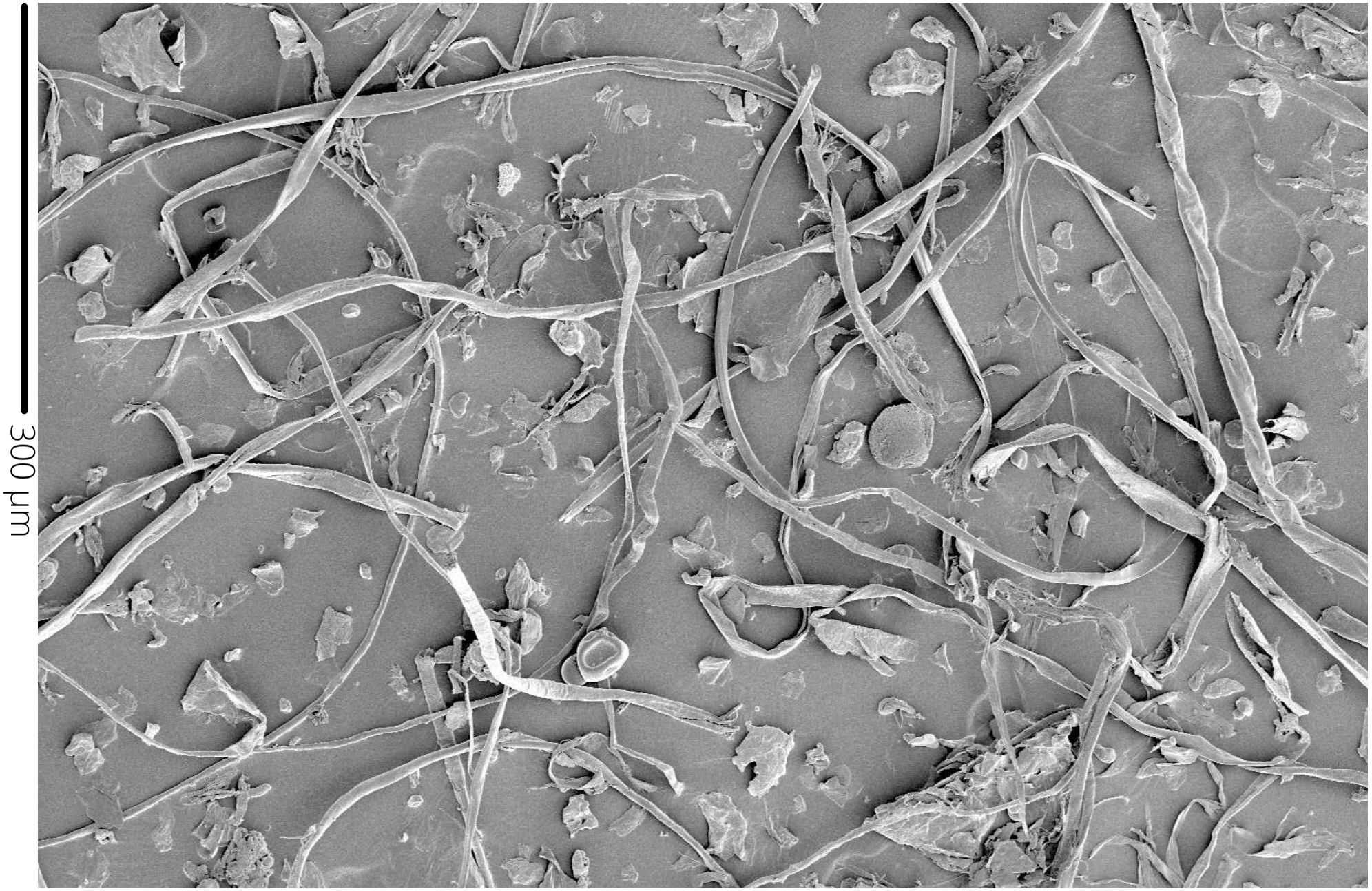
3 - Post-it

4 - Dust

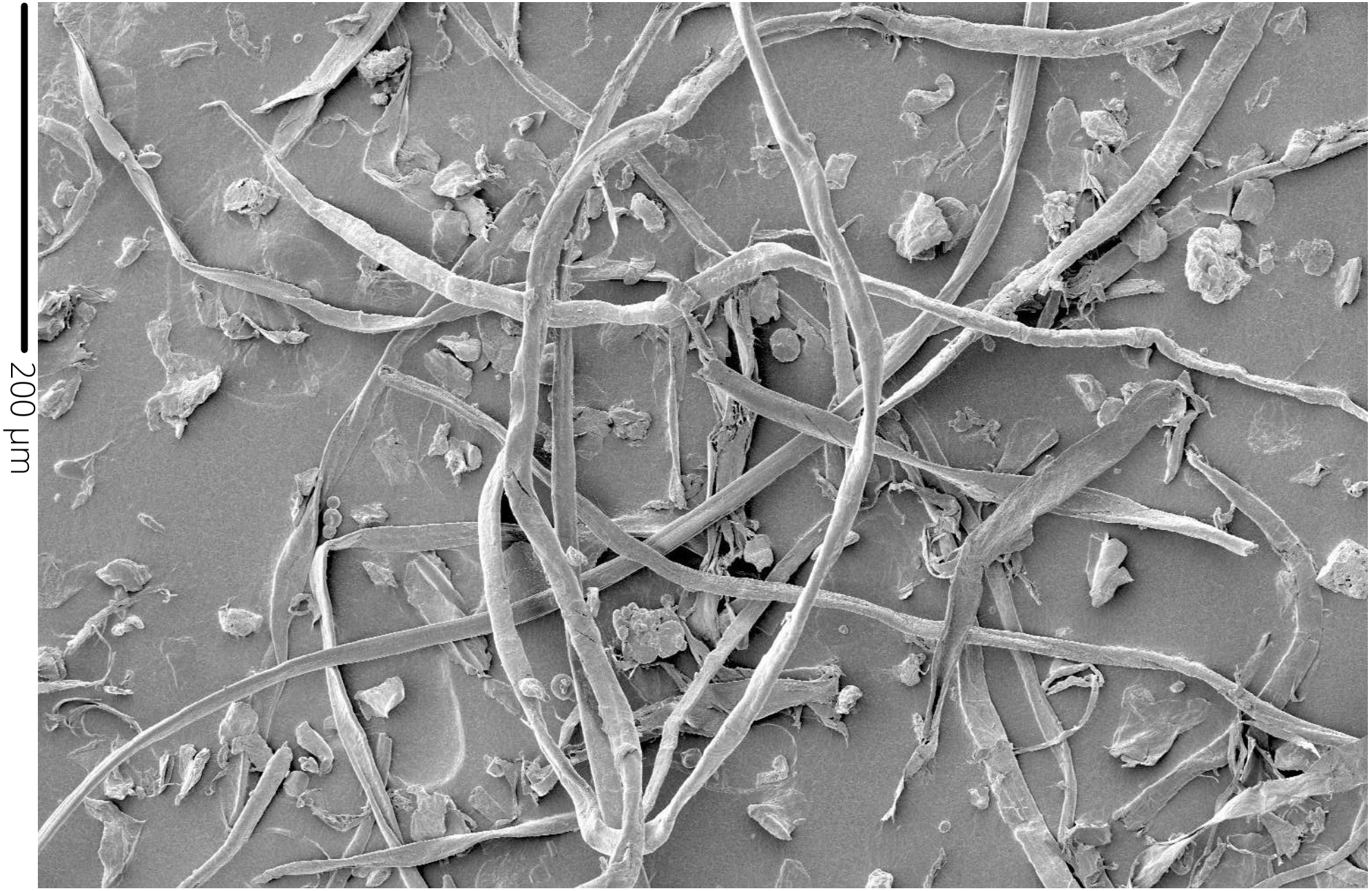
“Ash to ash, dust to dust, fade to black”. In 1997, Metallica were the first to use the sentence “dust to dust”… Ok, maybe they were not the first… Don’t quote me on this.

Dust is omnipresent, from that surface you just cleaned five seconds ago, to your collection of plush Pokemon in the attic. Dust is an unappealing mix of dead cells, fibres from different sources, microplastics, pollen, spores, and so on.
If you are lucky, and outside, you may also find some micrometeorites, literally stardust.
At home, unless you have proper filtration, you will find dust settling down on any surface. It is also the perfect environment for dust mites. And don’t get me started with allergies…

Anyway, once magnified 400 times, it looks pretty nice. In the following pictures you can find many fibres, dead skin, and few pollen grains here and there.
If you think that there are not enough pollen grains, the next chapter has you covered.



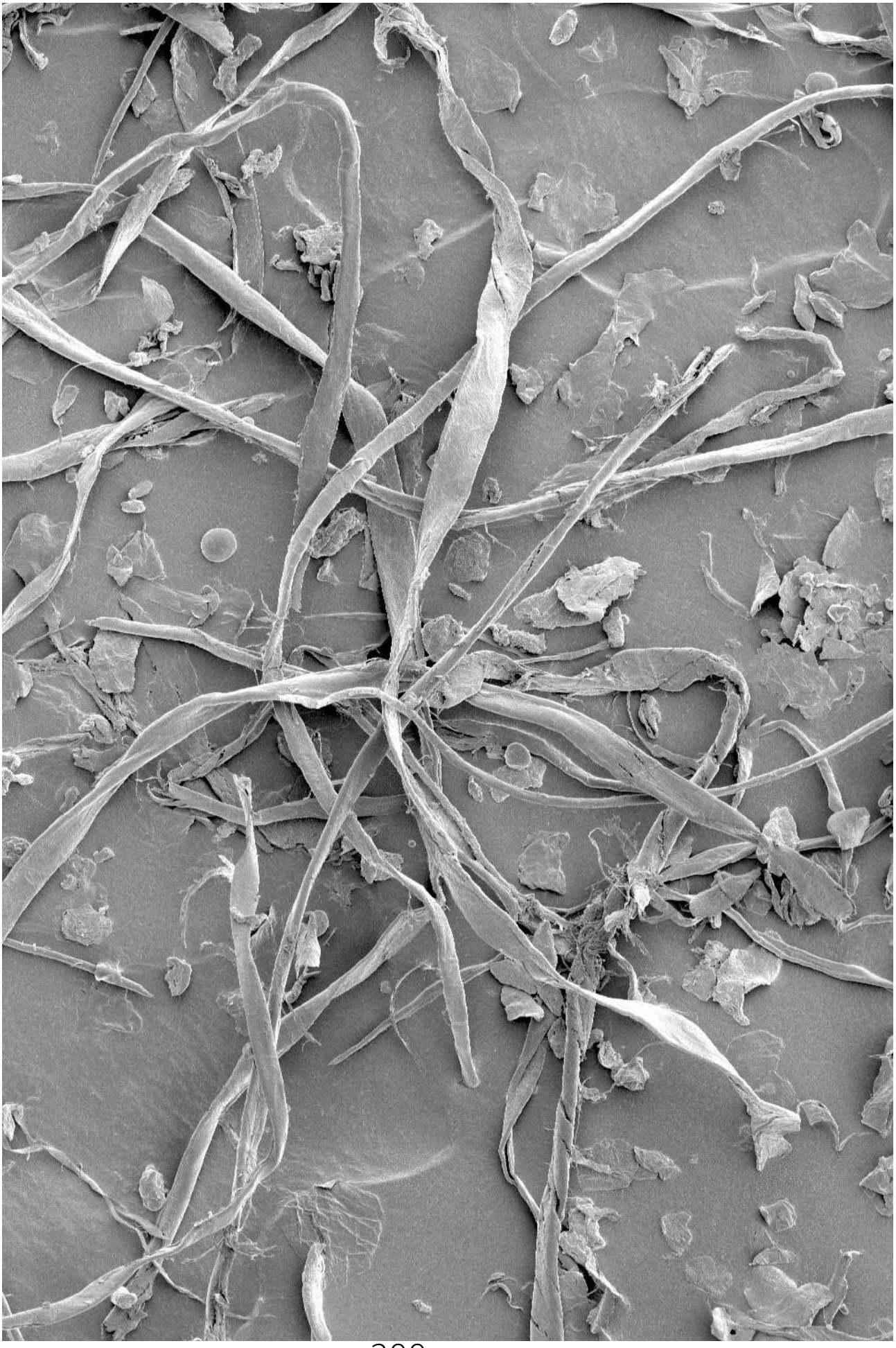
4 - Dust



4 - Dust

200 µm

4 - Dust



200 µm

4 - Dust

200 µm

4 - Dust

200 µm

4 - Dust

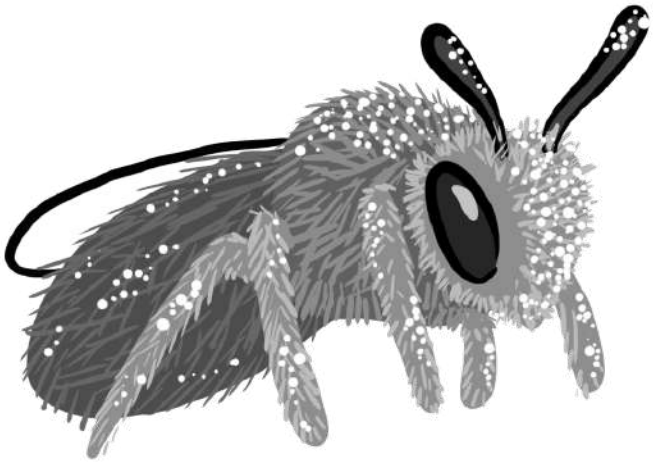
100 µm

4 - Dust

100 µm

4 - Dust

5 - Pollen

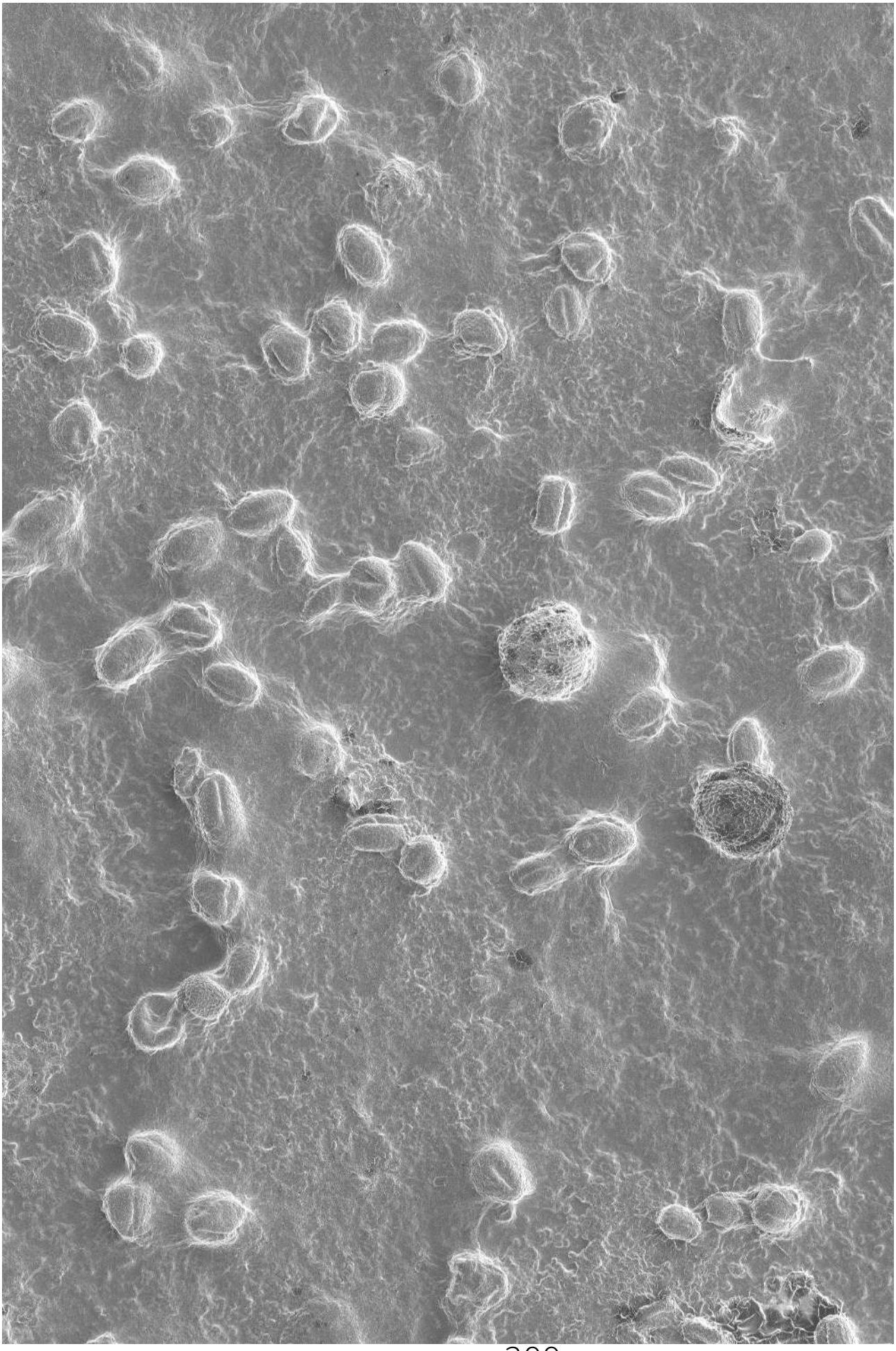


Sneezing uncontrollably in public during a pandemic is not something you wish to do. Unfortunately for some of us, it's not something we can control, especially in spring time. Apart from irritating your eyes, nose, and throat, pollen is used by plants to transfer genetic material from one plant to another, or even within the same plant for self-pollination. Now, if you're not allergic to it, pollen can be used as food supplement, and it's easily found in raw honey.

In the next few pictures, you can see pollen grains from different plants.

200 µm

5 - Pollen



200 µm

5 - Pollen

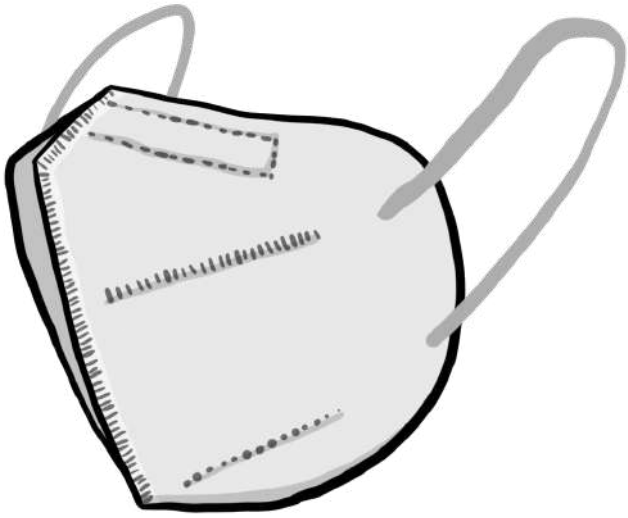
100 µm

5 - Pollen

100 µm

5 - Pollen

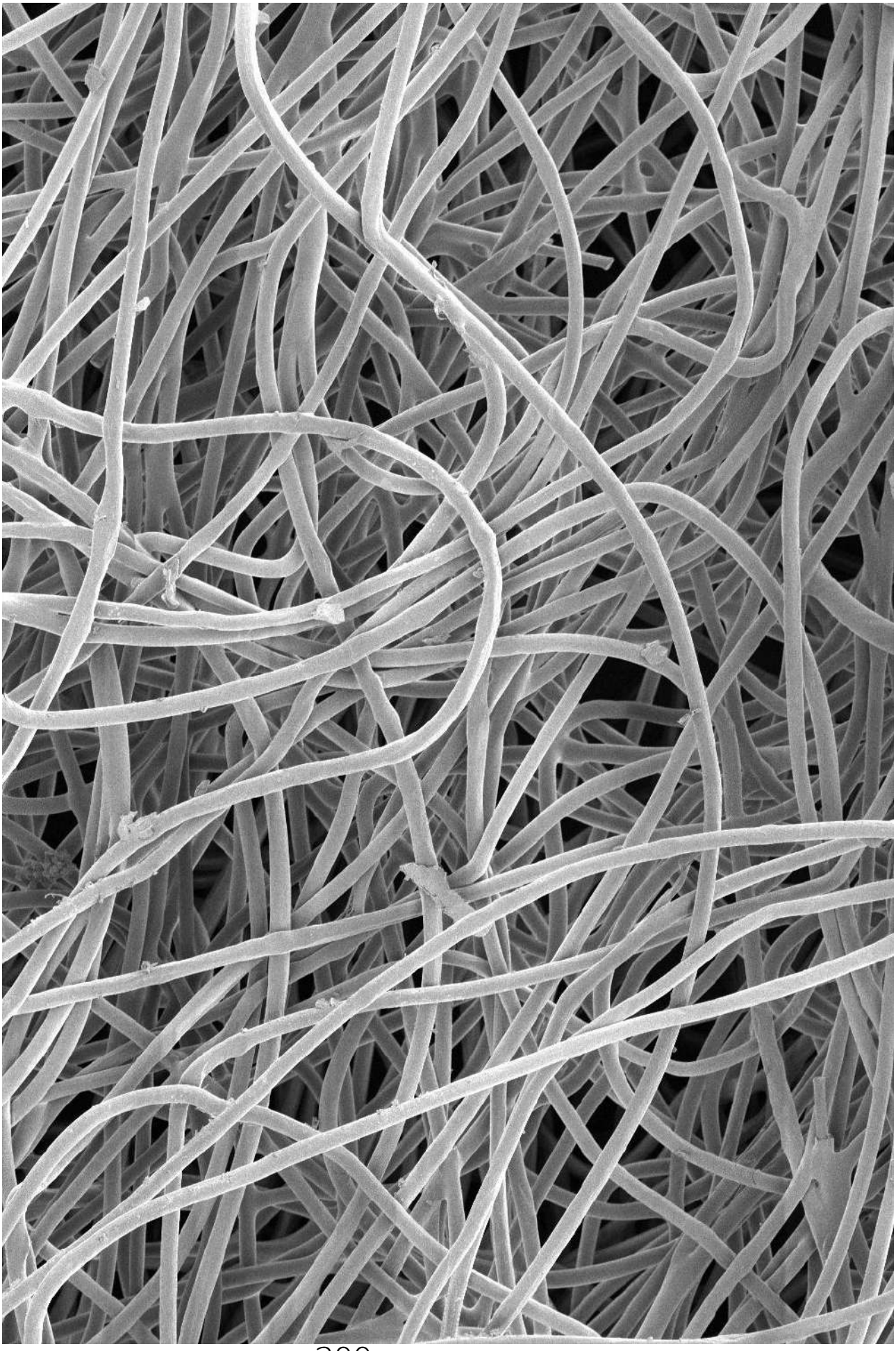
6 - Mask



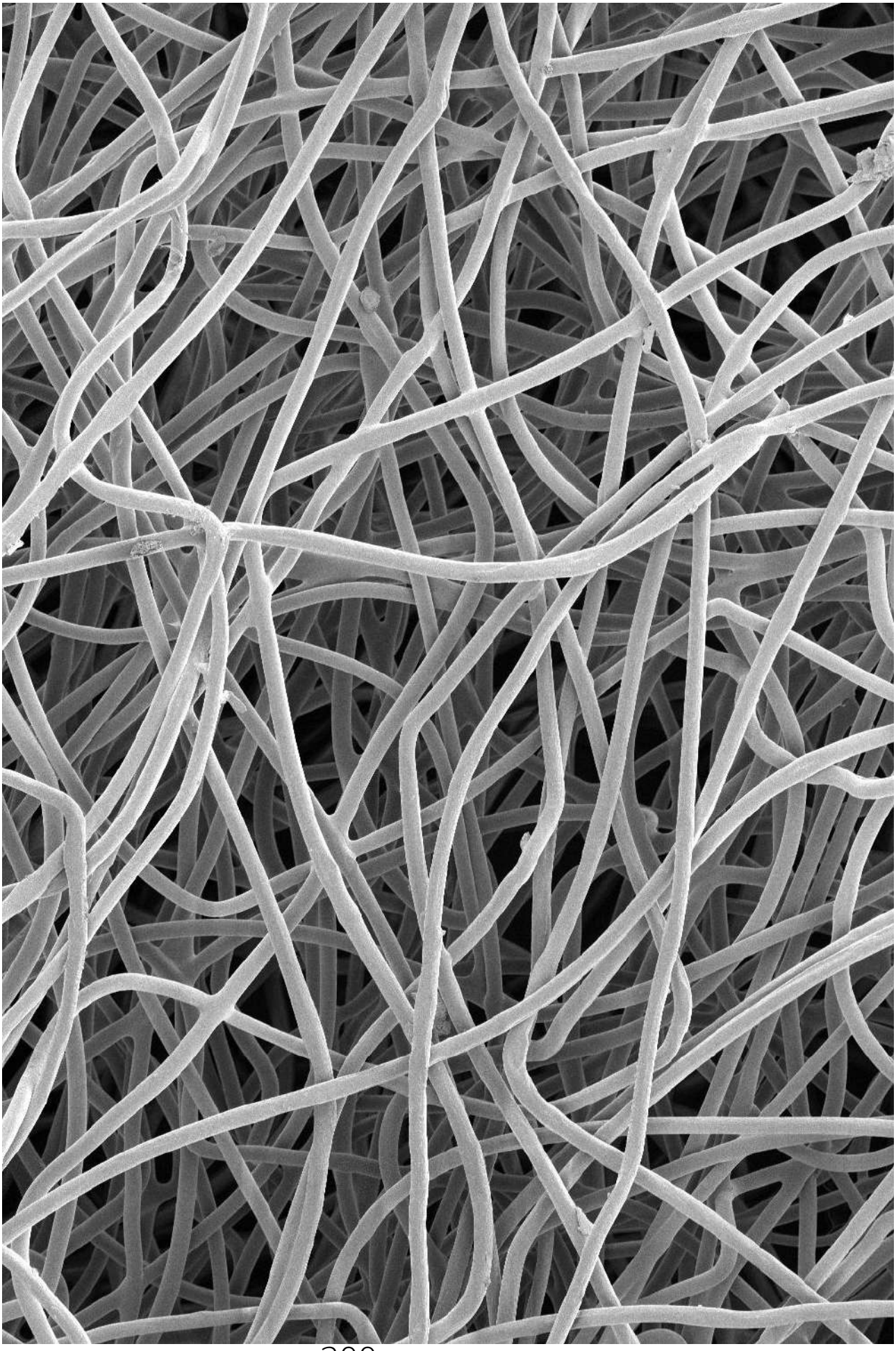
One moment you are watching Netflix on your sofa, and a few moments later there is a shortage of toilet paper in supermarkets. Welcome folks to the COVID-19 pandemic...

While the virus is still roaming around the world (2022), one physical barrier we have at our disposal are masks. FFP2 masks are composed of multiple layers of materials to filter 94% of airborne particles. The internal layer, the one which does the heavy job, is a mesh of small electrostatic fibers which capture small particles present in the aerosol.

The next few pictures show this intricate mesh of fibers, and even if never used, some particles are attached to them. Can you find and highlight them?



6 - Mask



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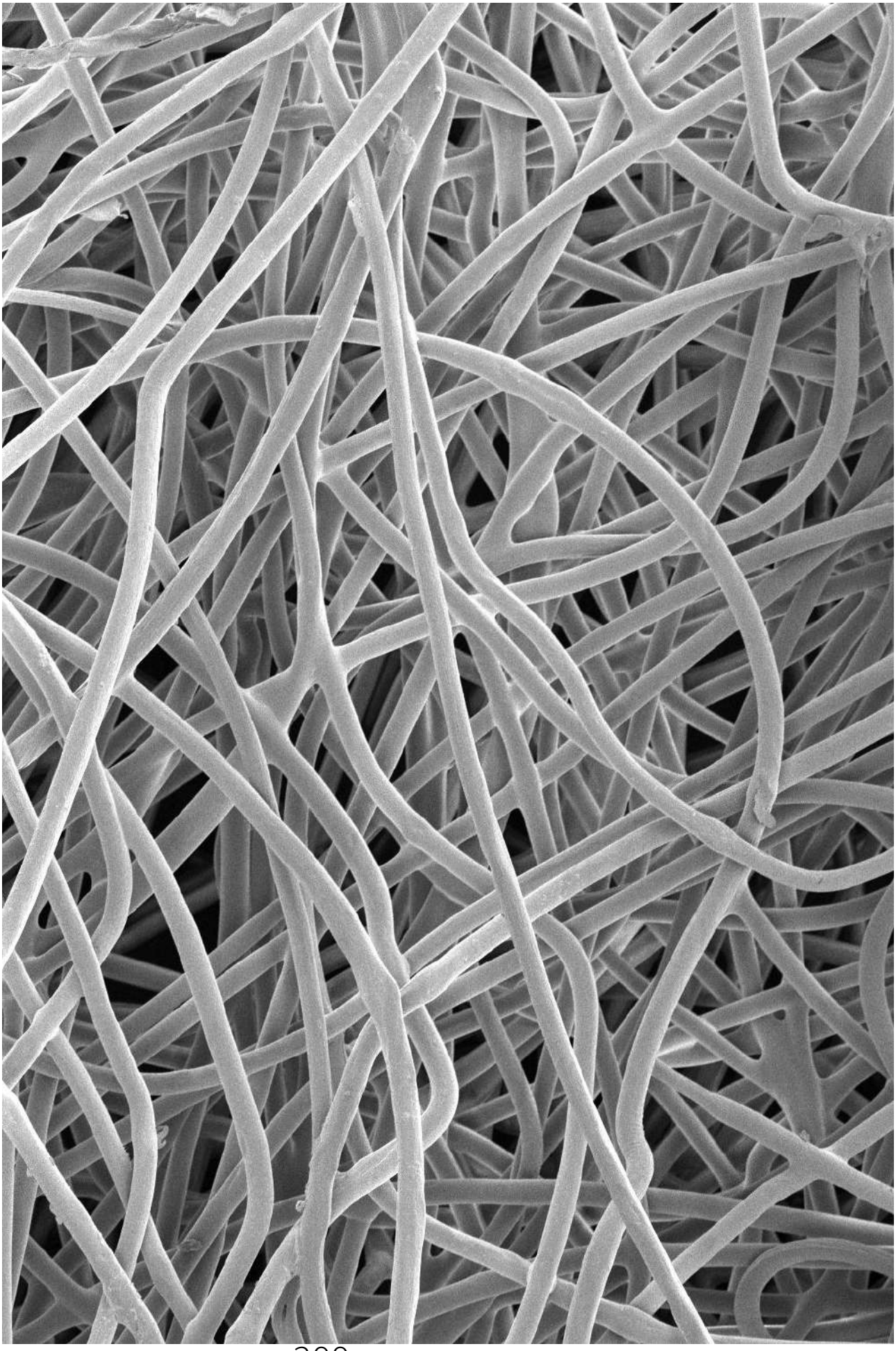

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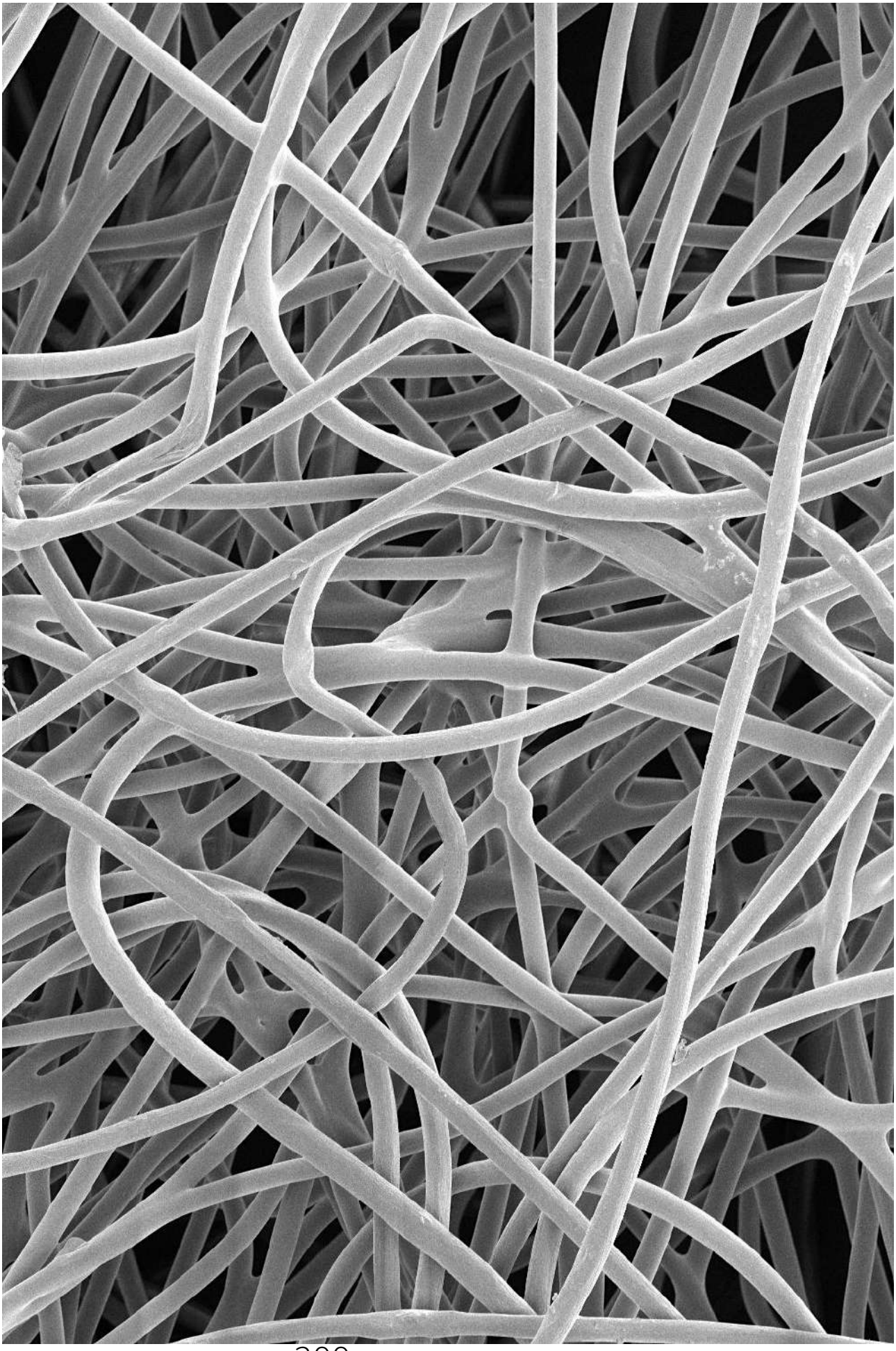
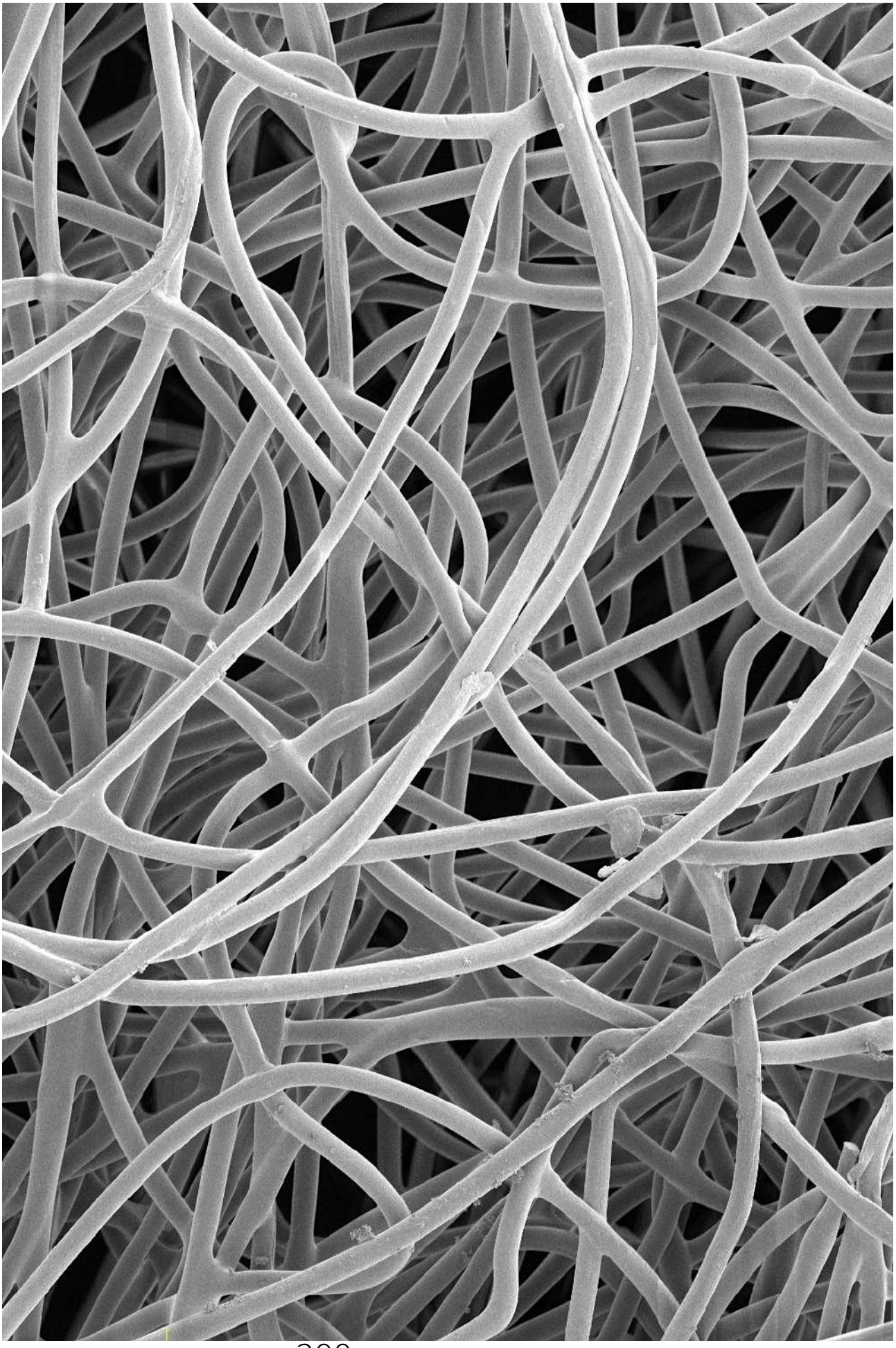
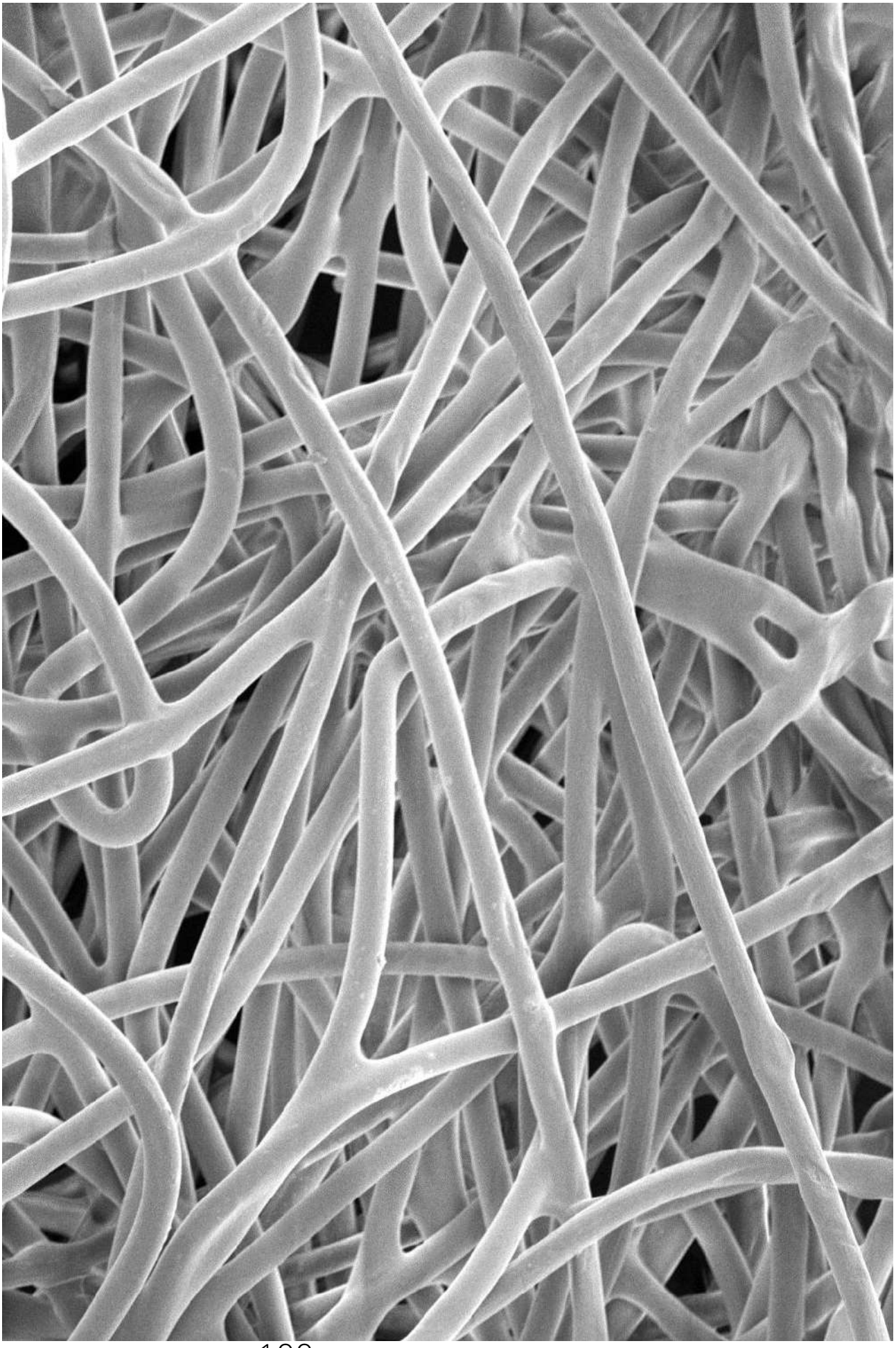


6 - Mask

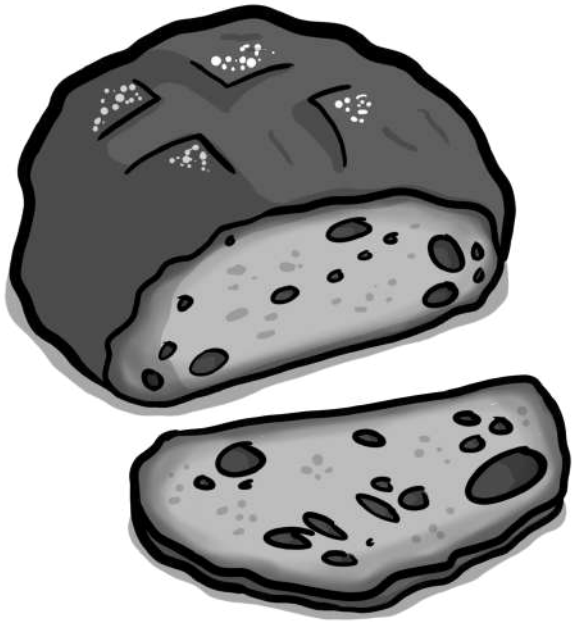


6 - Mask



6 - Mask

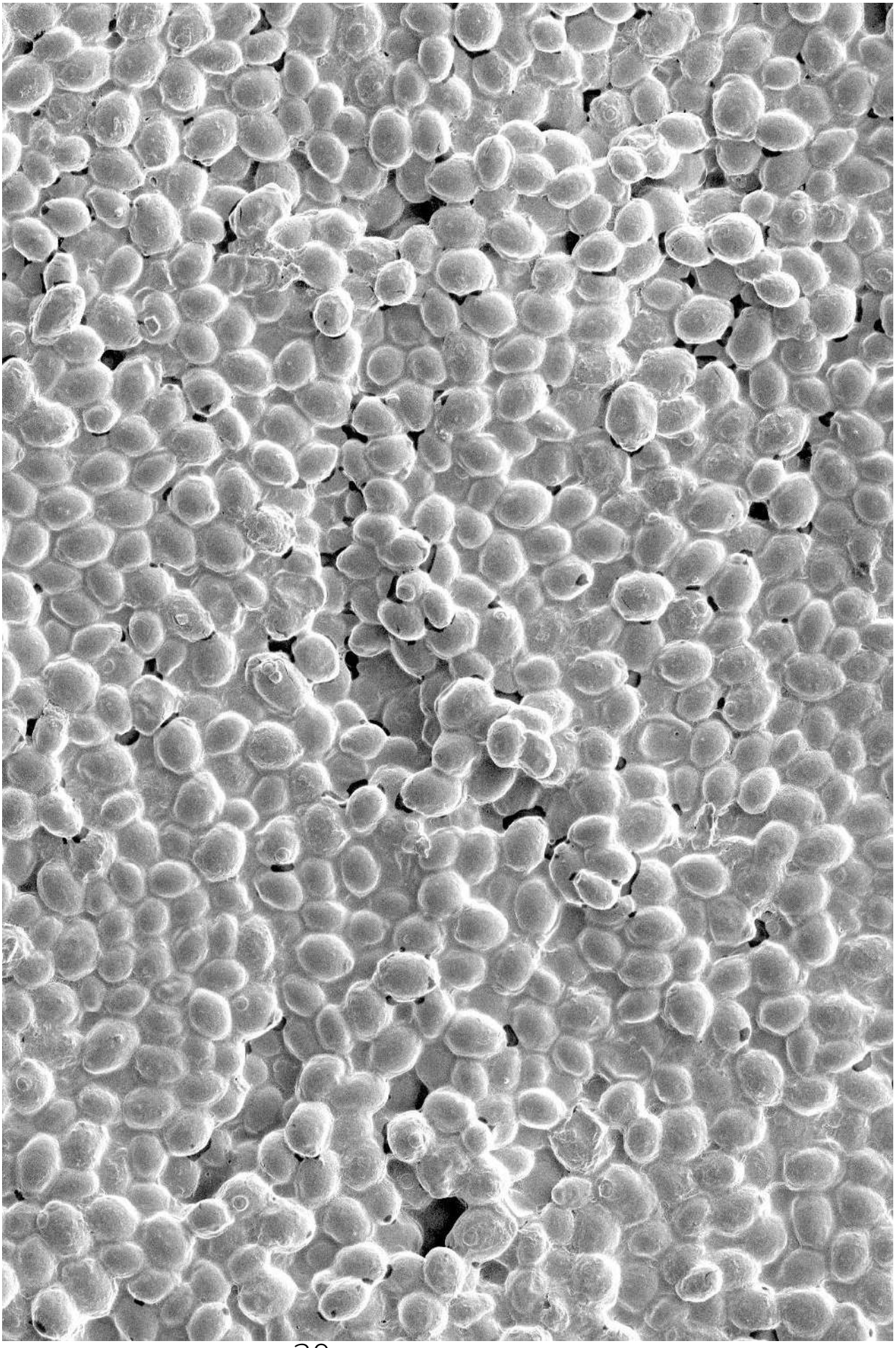
7 - Yeast



Running for the last roll of toilet paper in the supermarket was not the only shortage rush of the COVID-19 times. Together with the microchip shortage, another, probably more important shortage was roaming the world: the great 2020 flour shortage. While in lockdown, many people started home bakeries, from the classical sourdough, to pizzas, to the fancier profiteroles.

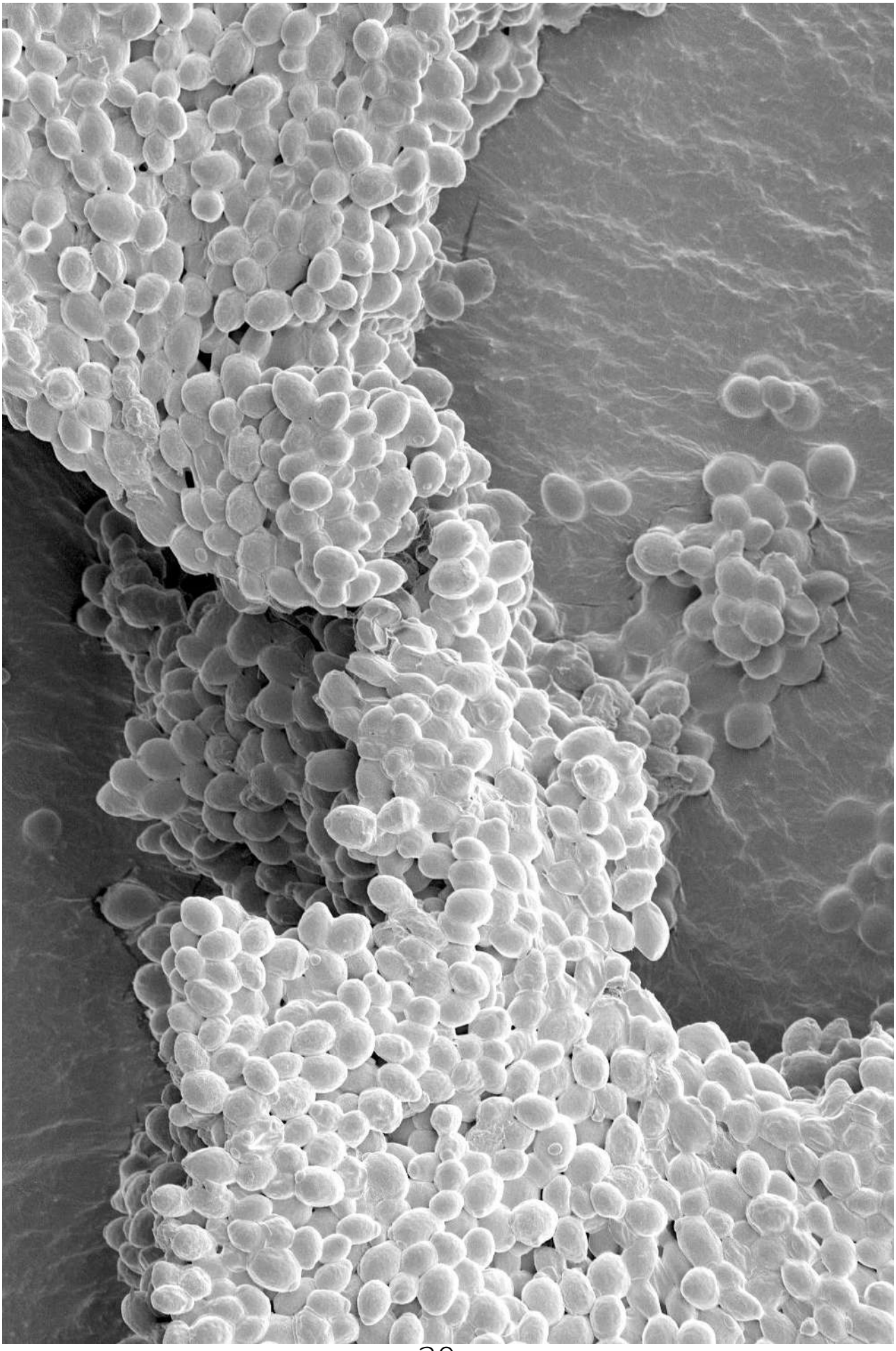
Besides flour and water, you need something else: a single cell organism capable of fermenting the dough. The hero of the day is *Saccharomyces cerevisiae*.

In the next few pictures, you can see the yeast as well as a few “budding yeast”, where the cell is forming “buds” for dividing into daughter cells.



30 µm

7 - Yeast

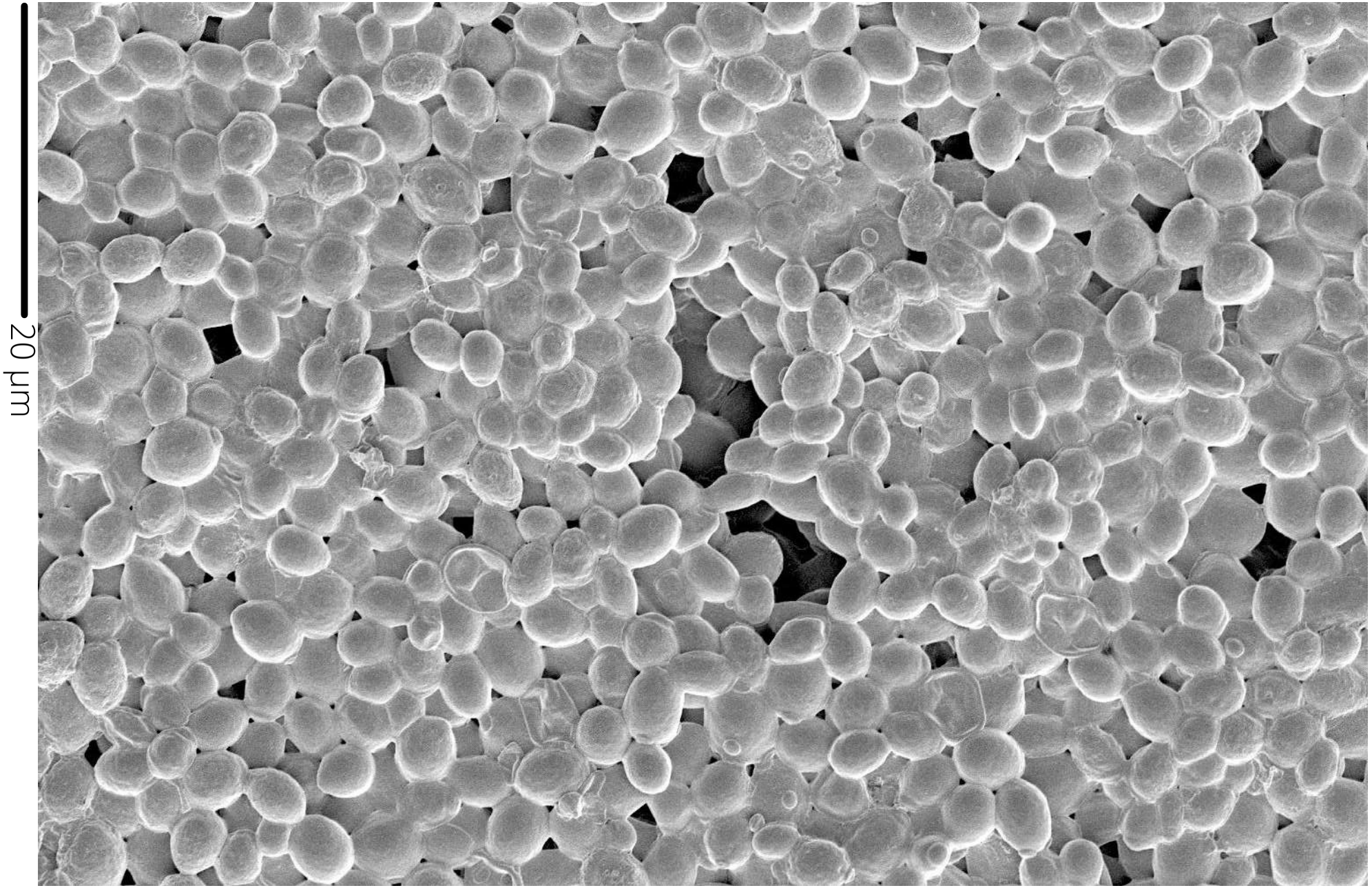


30 µm

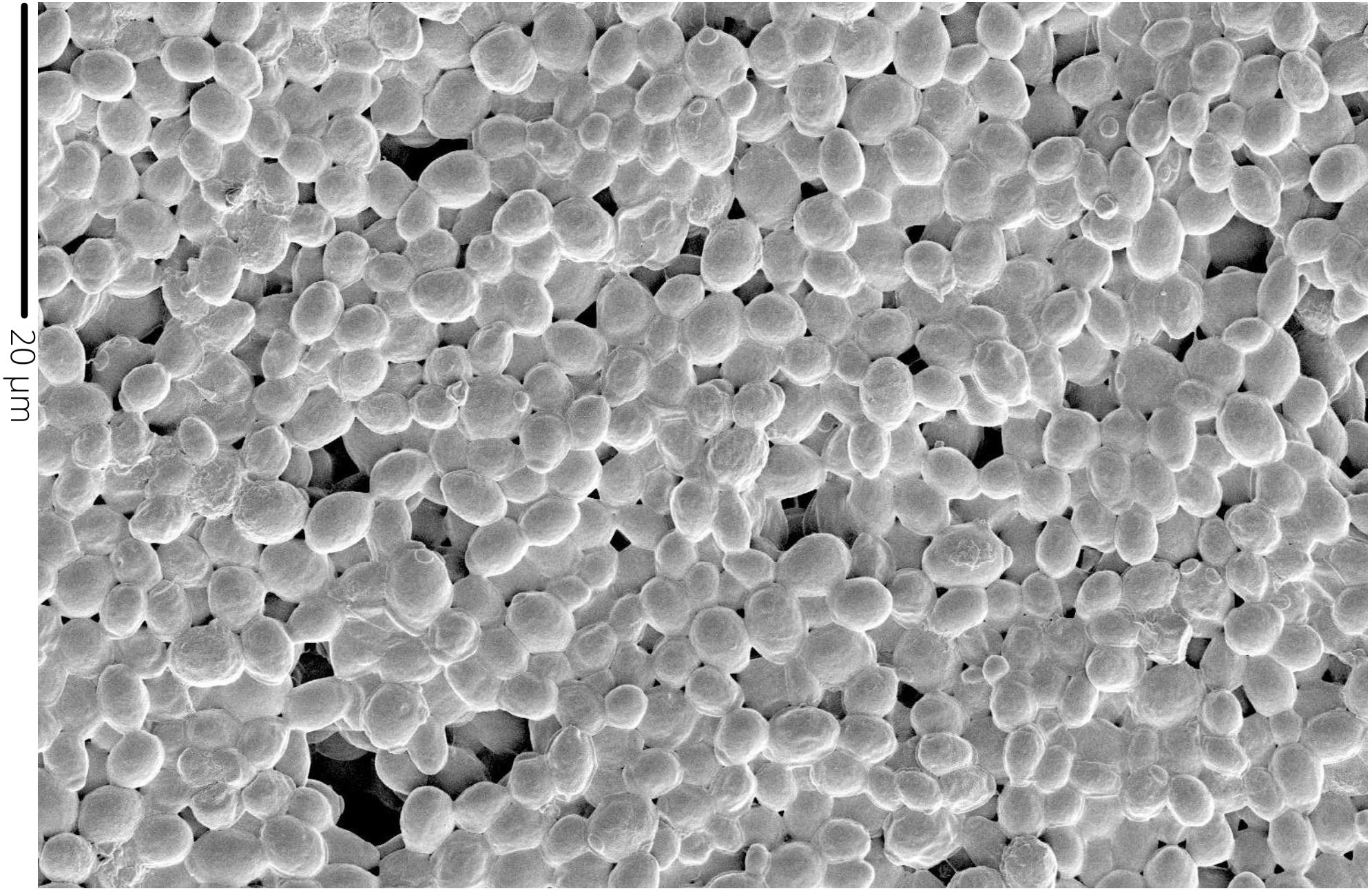
7 - Yeast

20 µm

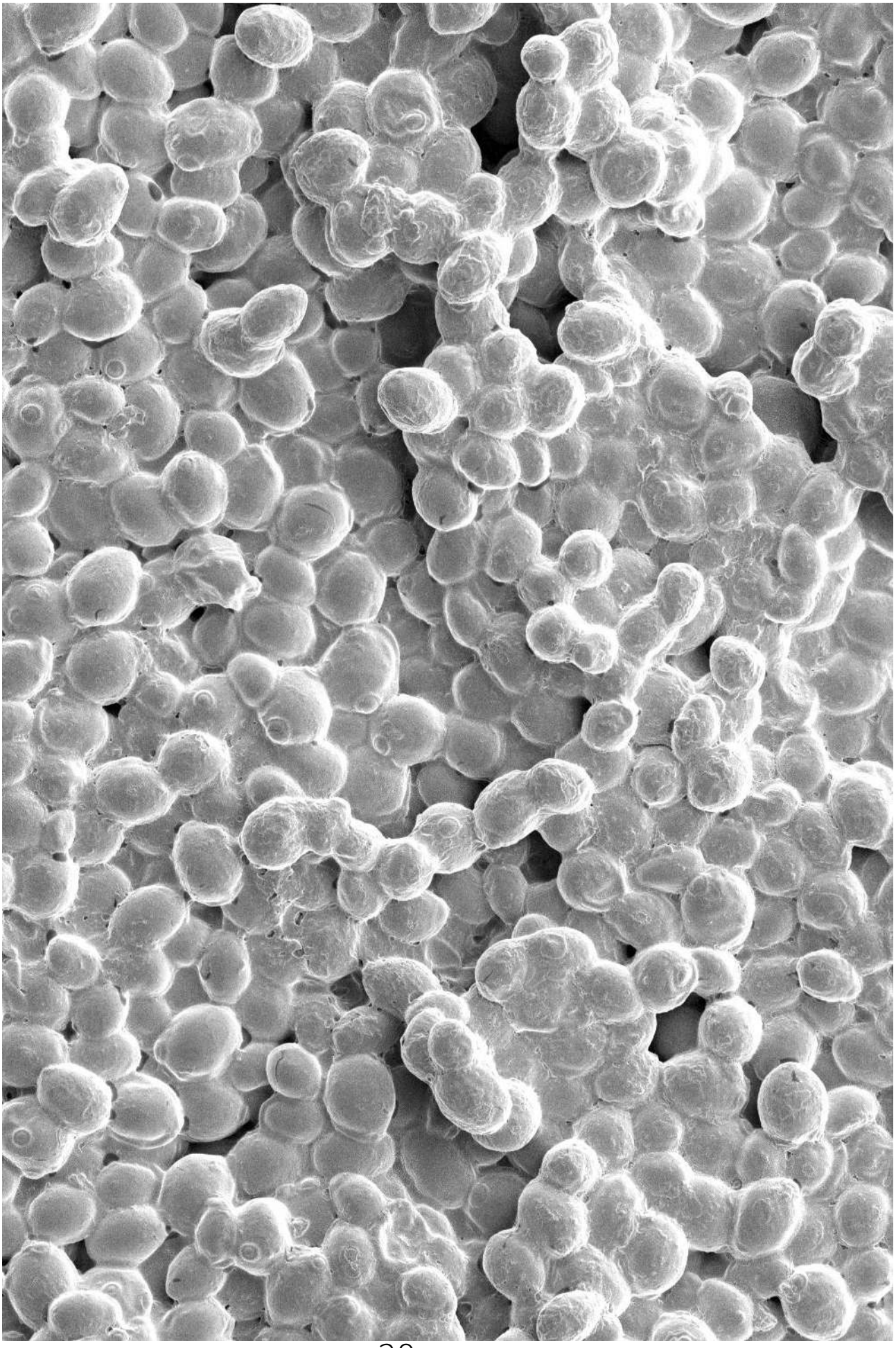
7 - Yeast



7 - Yeast



7 - Yeast

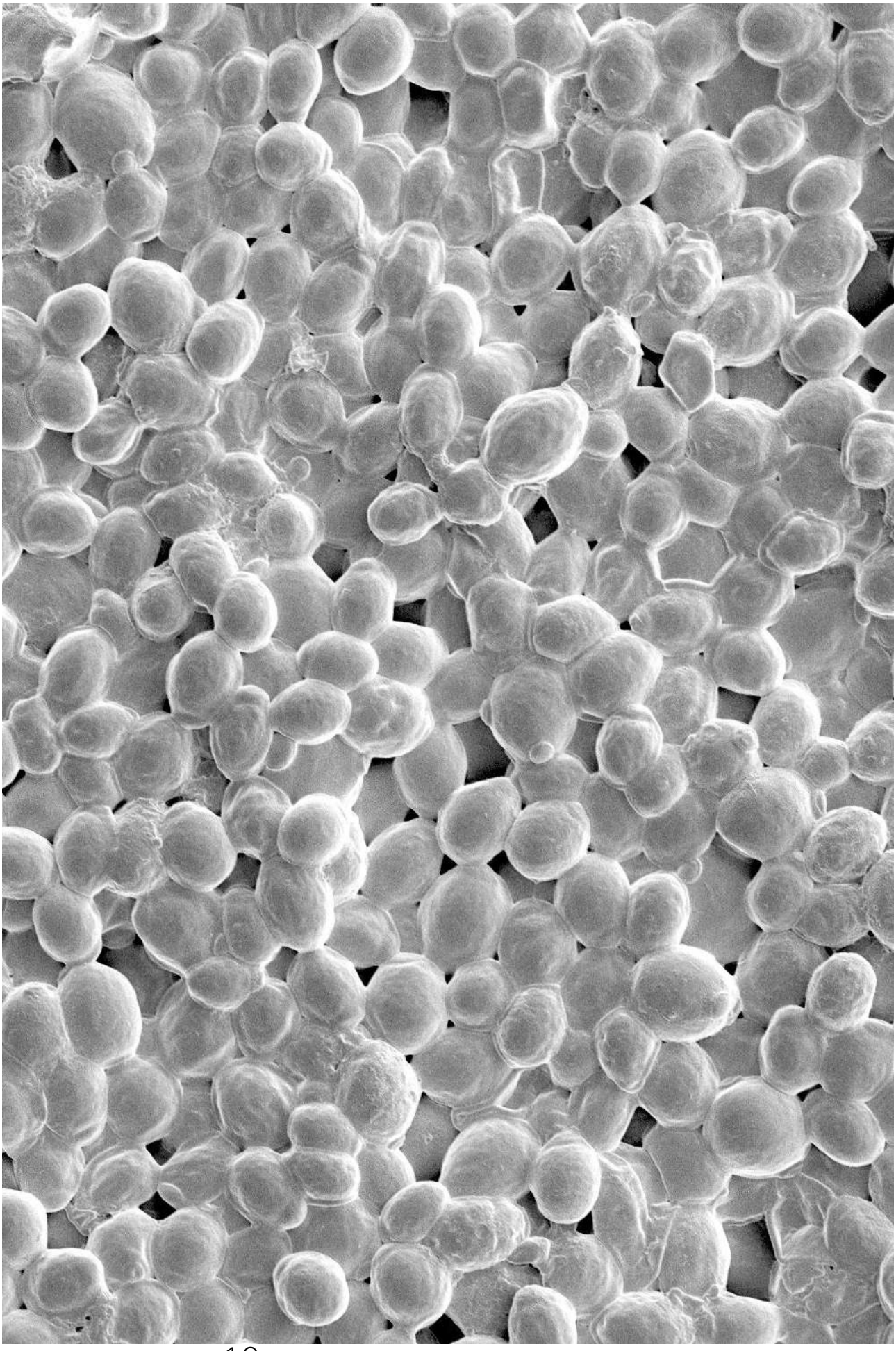


20 µm

7 - Yeast

20 µm

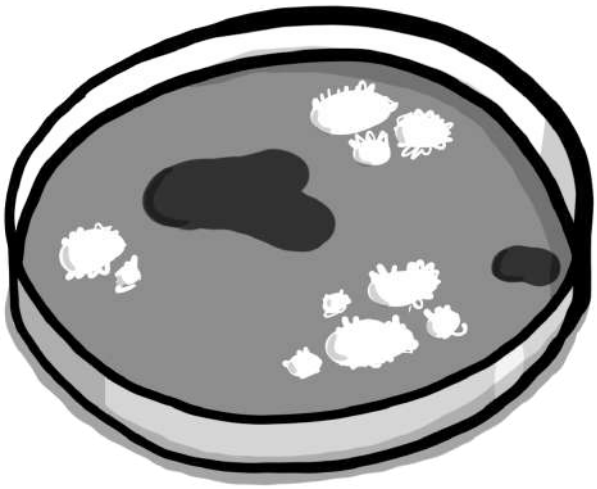
7 - Yeast



10 µm

7 - Yeast

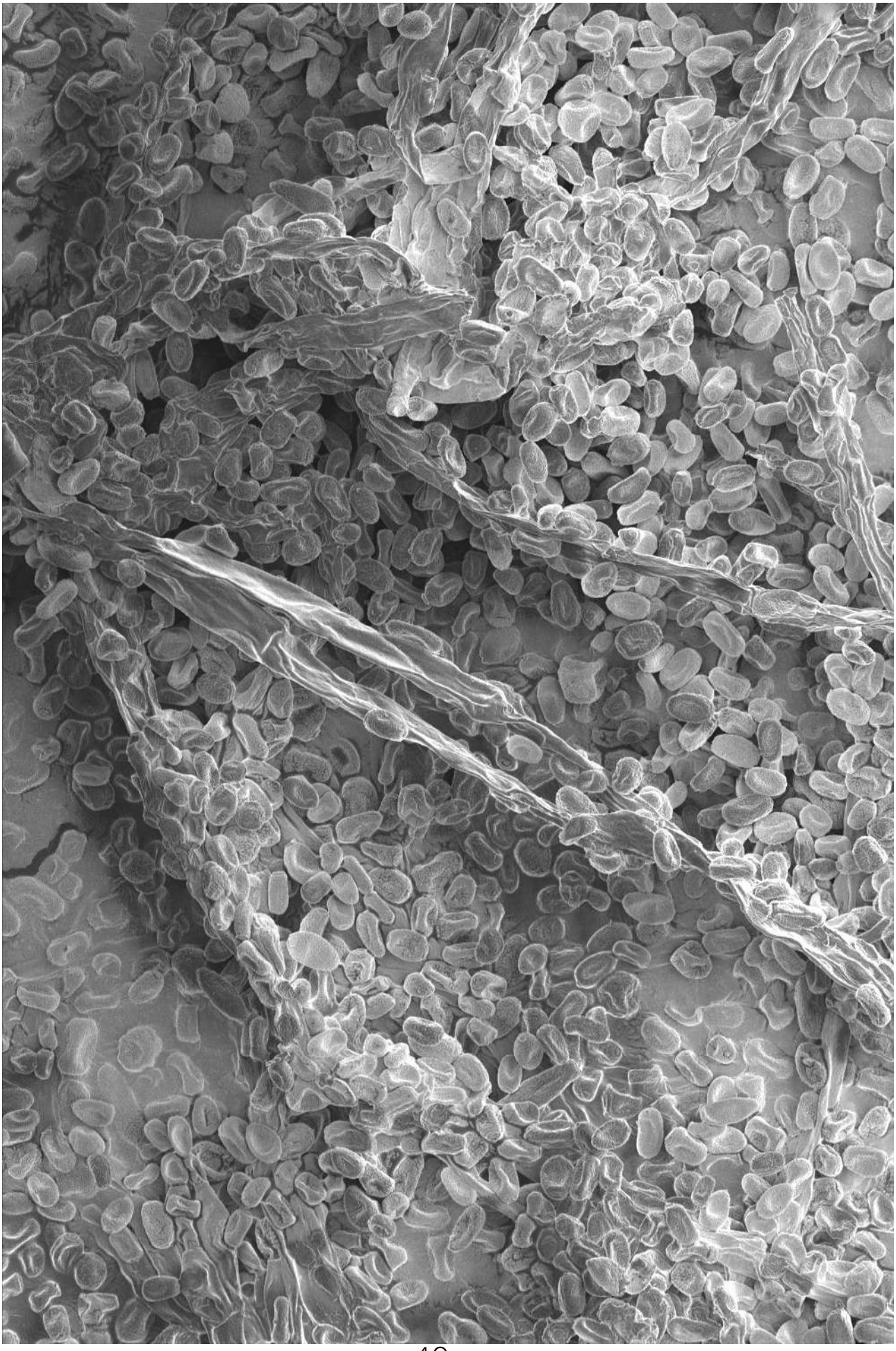
8 - Spores



With a size similar to the yeast cells, this is something you don't want in your food, or at least most of the time...

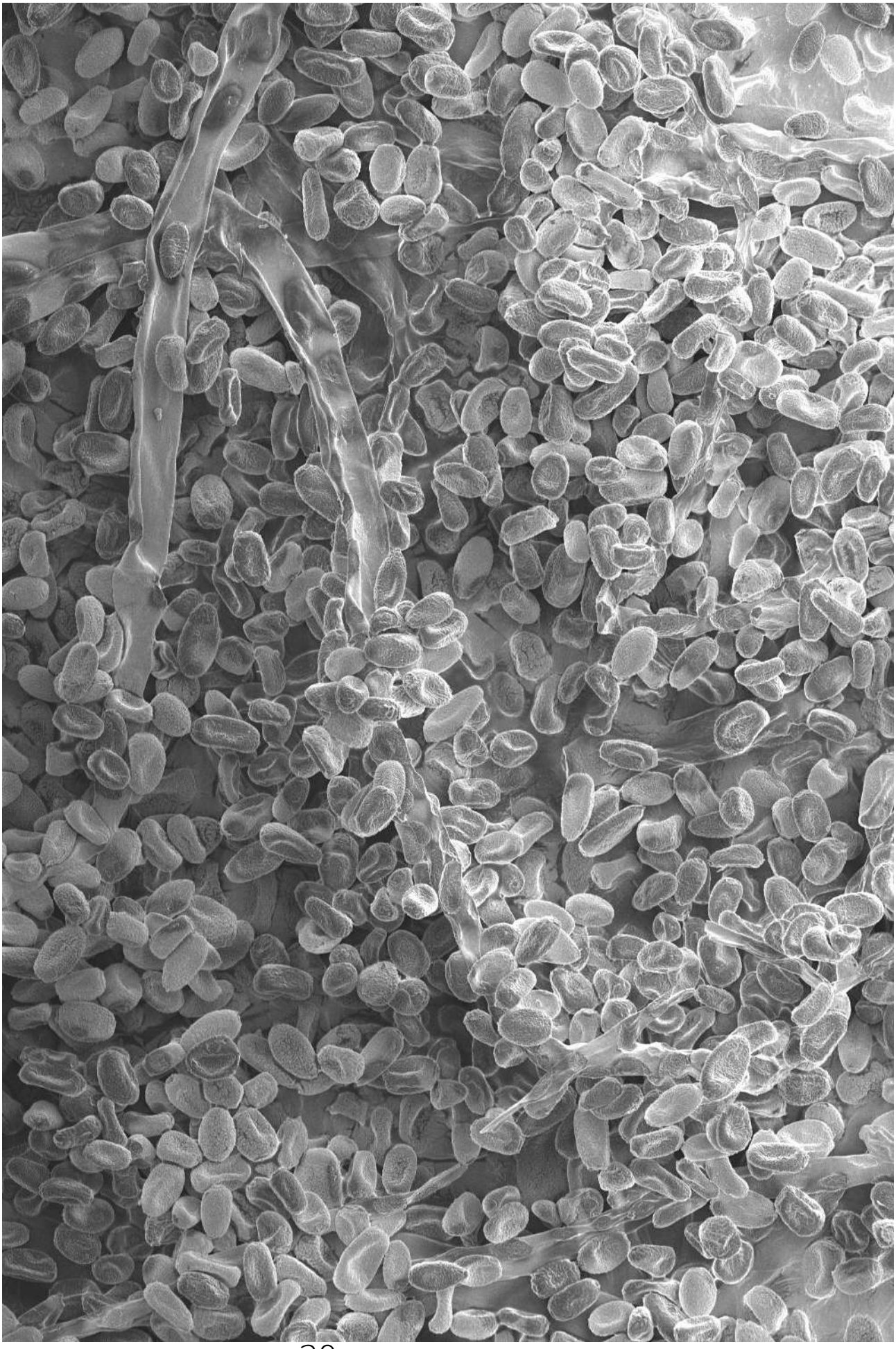
Mould is a type of fungi which, in the right conditions of temperature and humidity, develops on your food. You know, that green/black stuff you can find on that piece of cheese left in the fridge forever. For reproducing, these moulds form spores, which can "fly" away and start colonizing your entire fridge. But not all of them are bad: if you love blue cheese, well, it's done with a specific fungus: the *Penicillium roqueforti*.

In the next pictures you can find plenty of these spores (from the Penicillium genus) directly from a batch of fresh gnocchi I forgot to store properly.



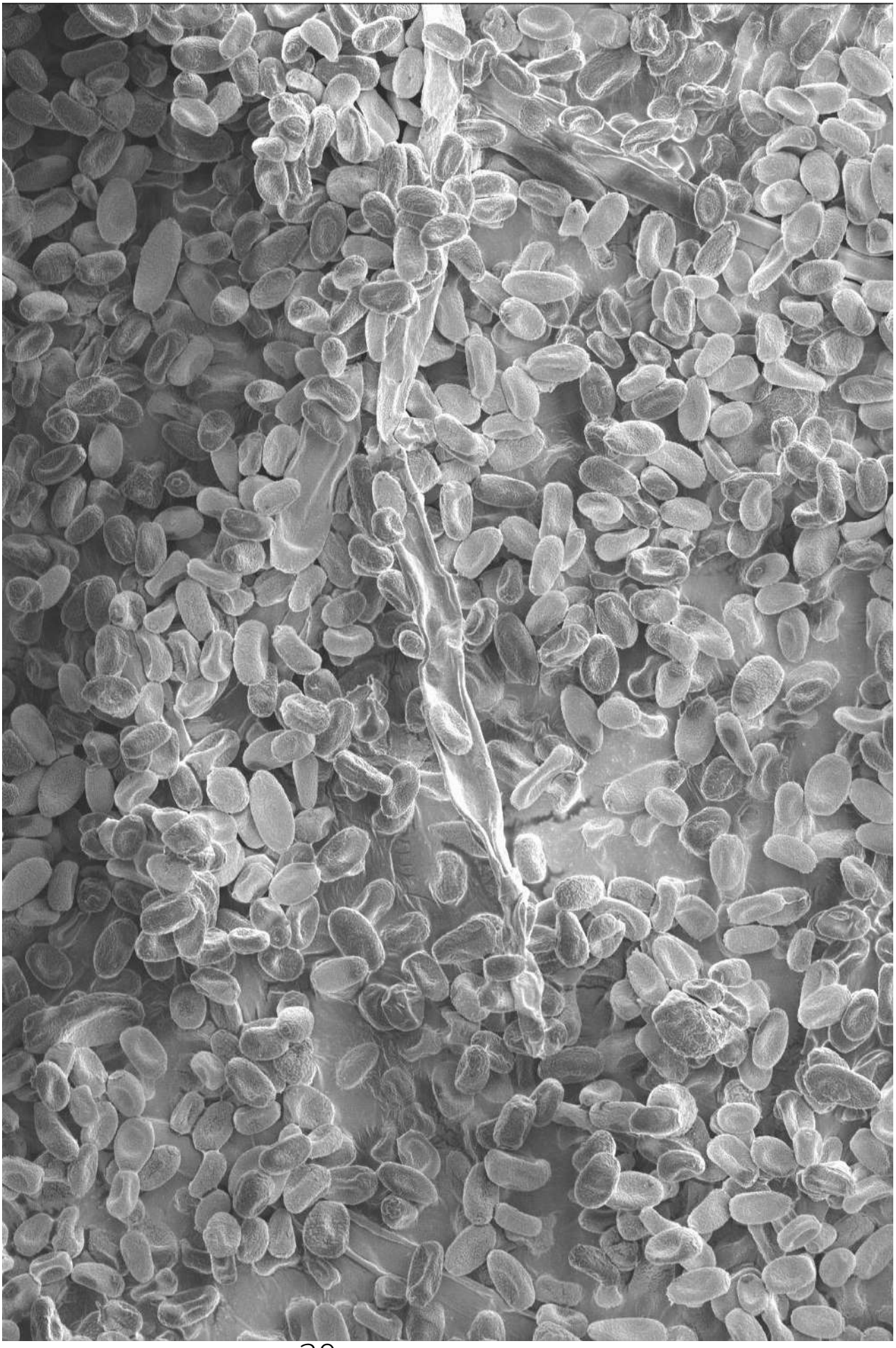
40 µm

8 - Spores



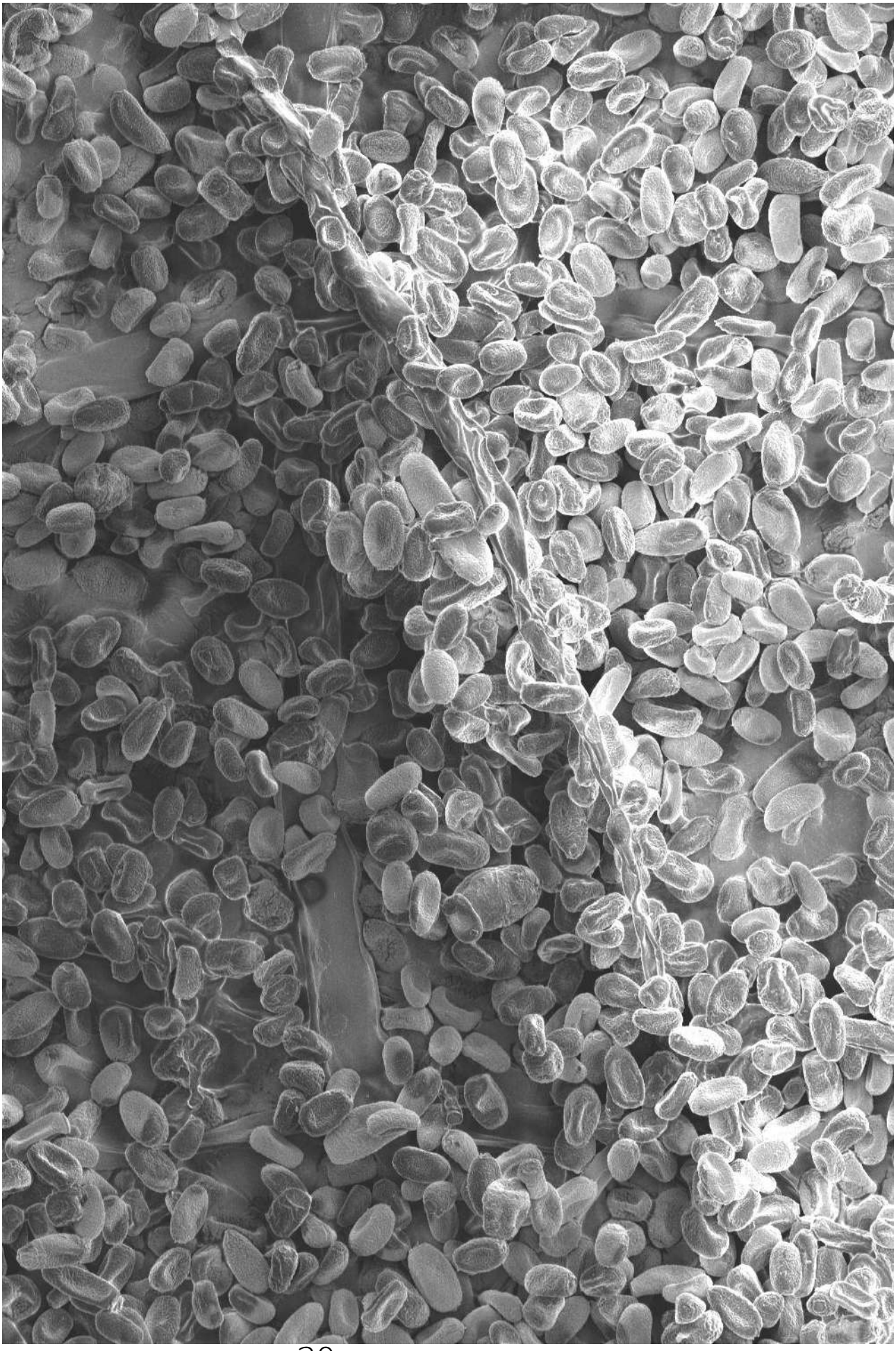
30 µm

8 - Spores



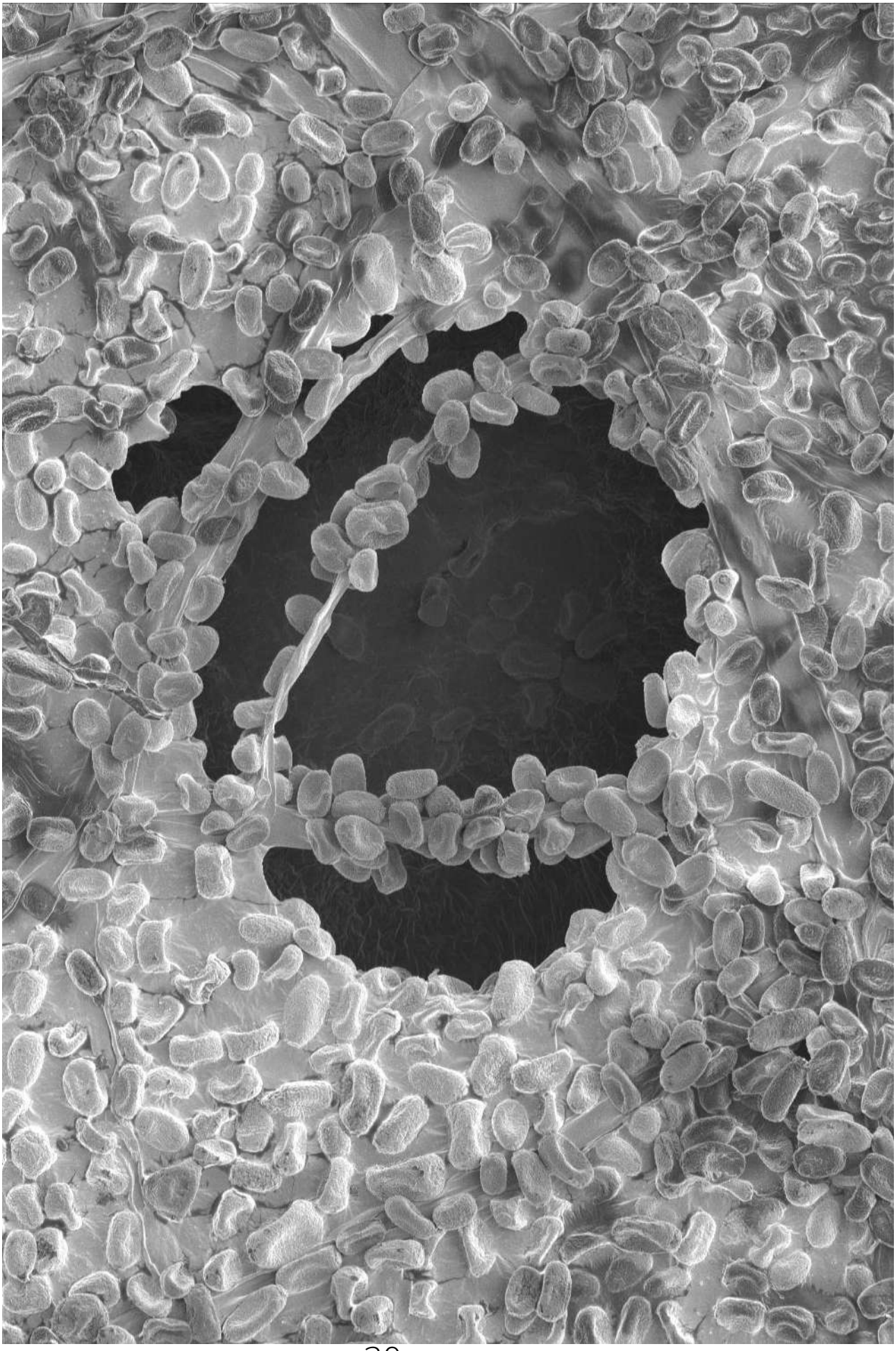
30 µm

8 - Spores



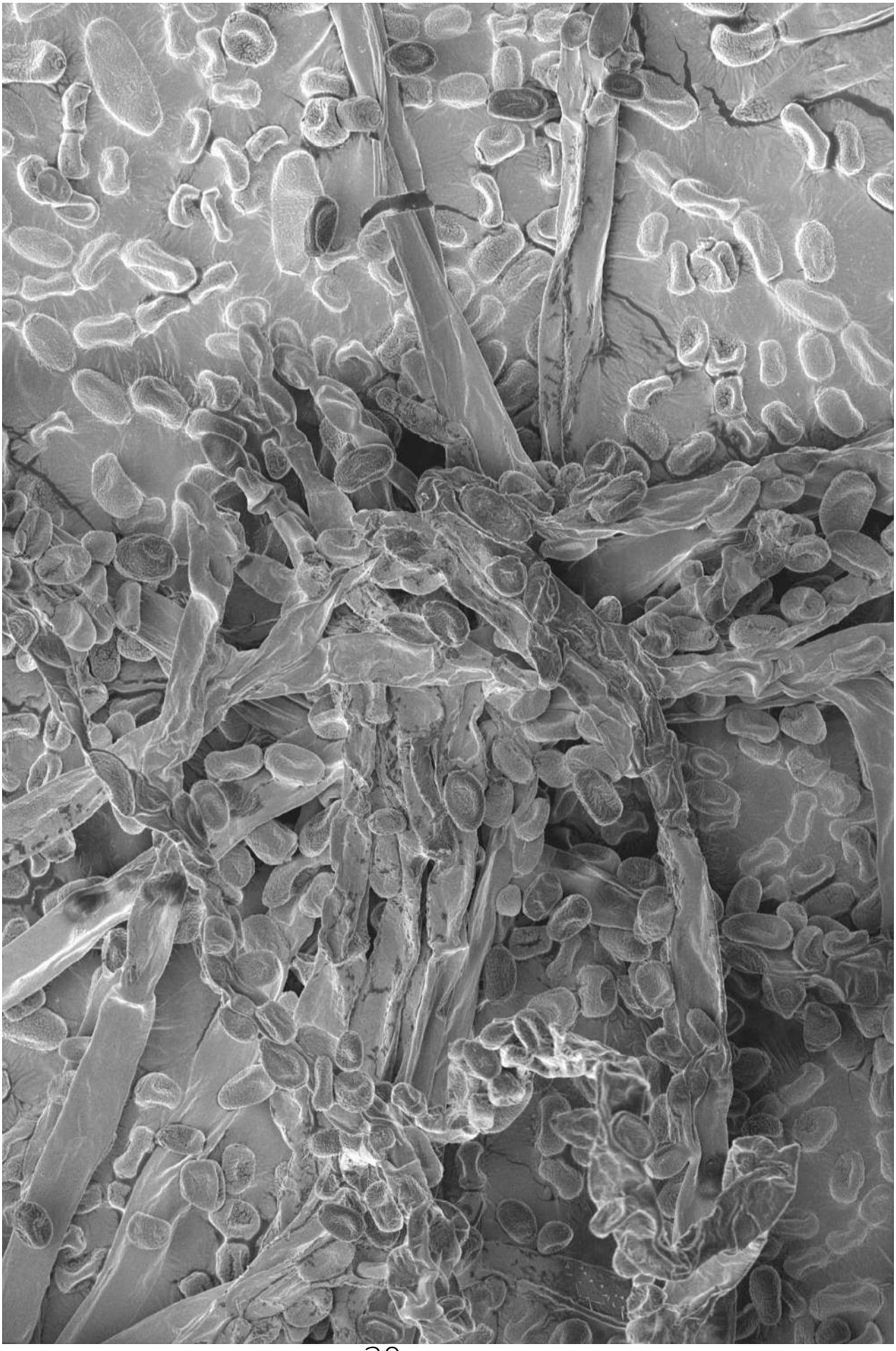
30 µm

8 - Spores



30 µm

8 - Spores

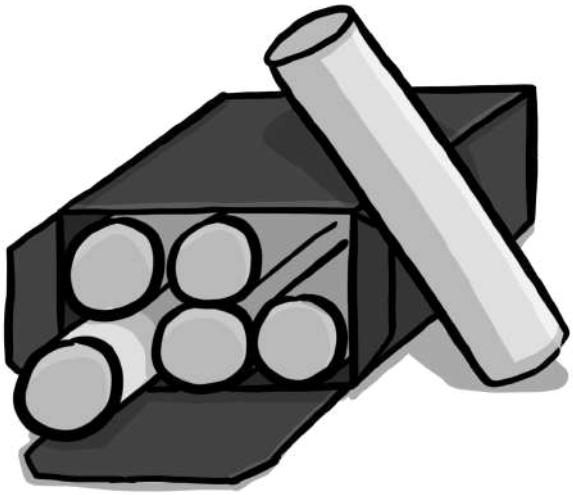


8 - Spores

20 µm

8 - Spores

9 - Chalk



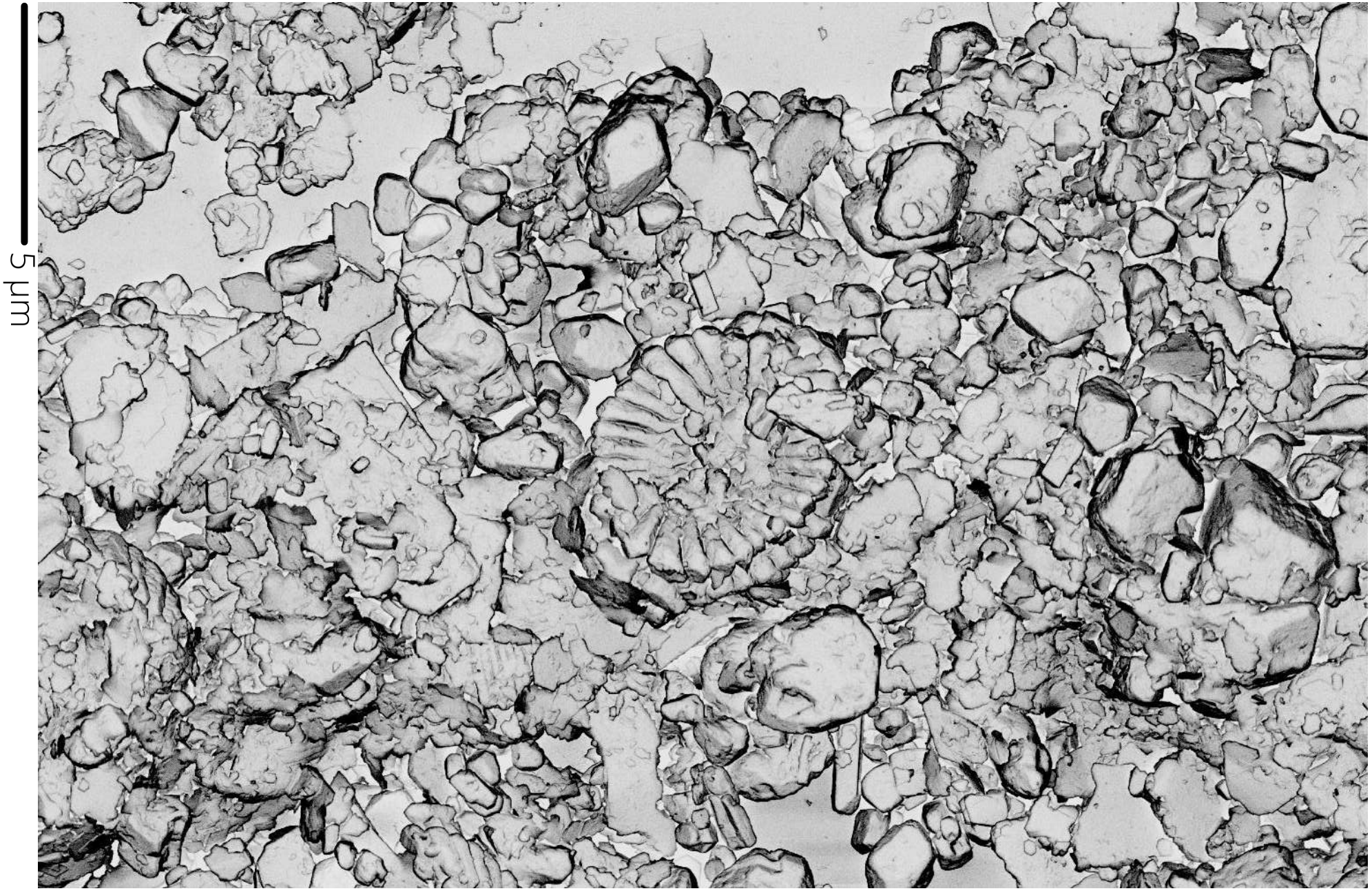
With all the digital whiteboards, chalk is going to disappear from the lecture rooms, at least in the form of cylindrical sticks.

Chalk is mainly composed of limestone, a calcite (calcium carbonate) sedimentary rock. Up to now: nothing special about it. Well, besides non permanently writing on blackboards or on the roads.

The special thing about chalk is that it can contain small fossils from quite some time ago...
Can you spot the fossils in the next pictures and make them pop with colors?

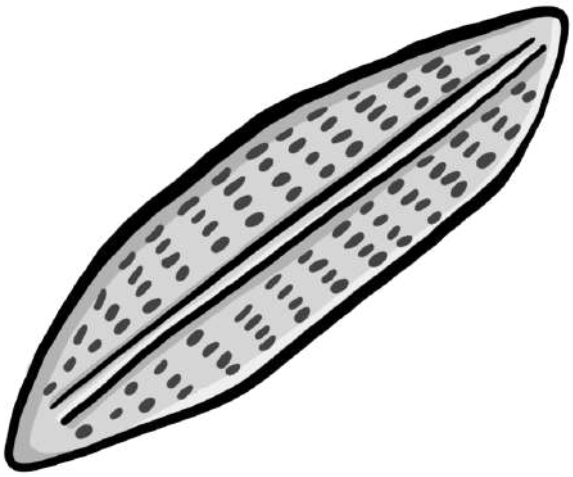
And if you are thinking “not enough fossils” in these pictures, do not worry, the next chapter has plenty of them to entertain you.

9 - Chalk



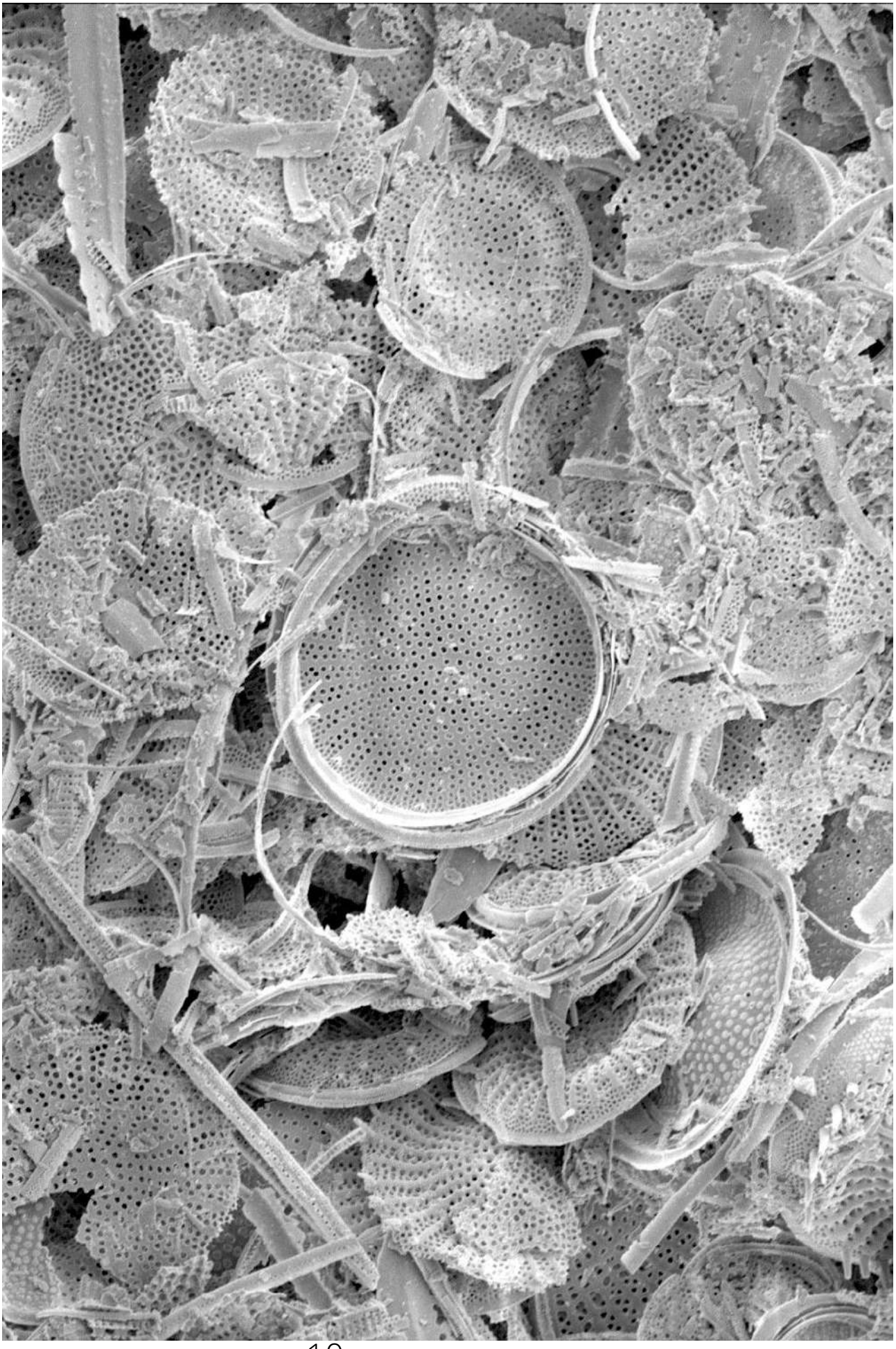
9 - Chalk

10 - Diatoms



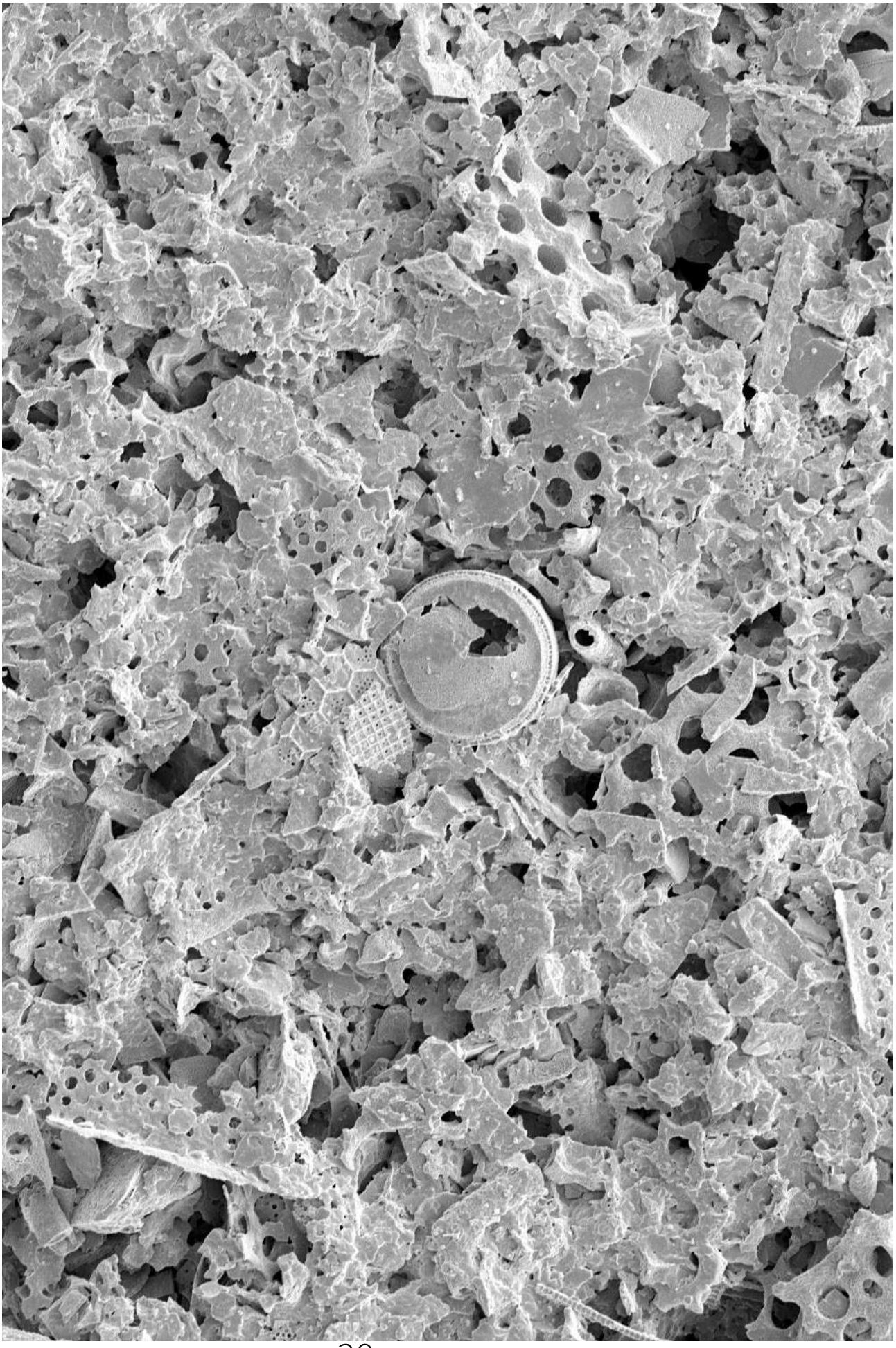
As promised, here is a selection of fossils to color; enjoy. Diatoms are single-celled algae with “bones” of hydrate silicon dioxide, a.k.a. glass.
They produce, when alive, a big part of the worldwide oxygen. In the next few pictures, you see the “skeletons” of very, very old diatoms. This powder is sold as “diatomaceous earth” and used as a pesticide. It’s a physical badass pesticide for killing small insects. And when I say badass, I mean it. The fine powder acts as tiny, tiny blades that can damage some insects' exoskeleton, killing them.

They also look intricate and beautiful, and this is why there are so many pictures of them in this chapter. A pleasure to color them in different ways.

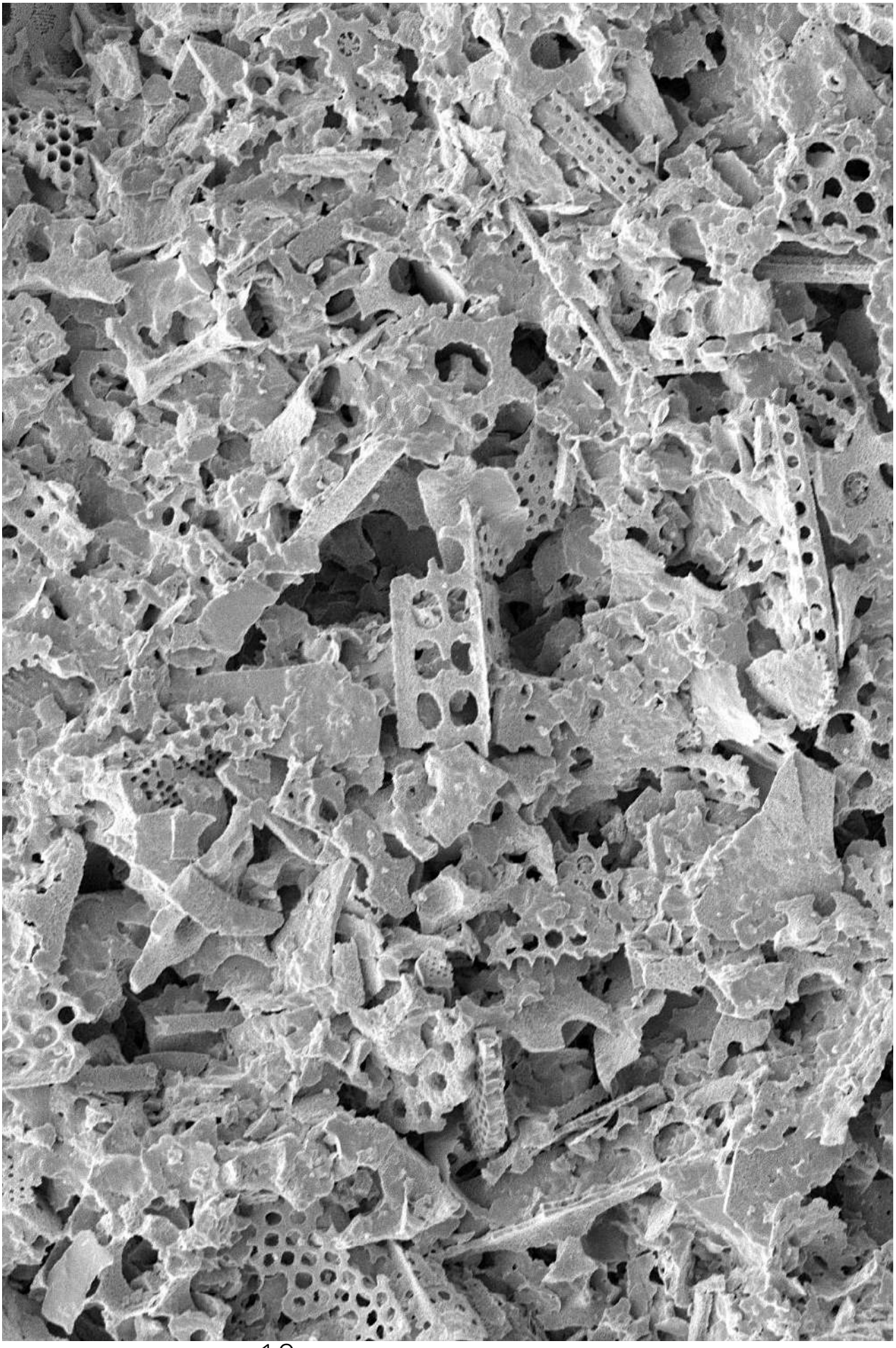


10 µm

10 - Diatoms

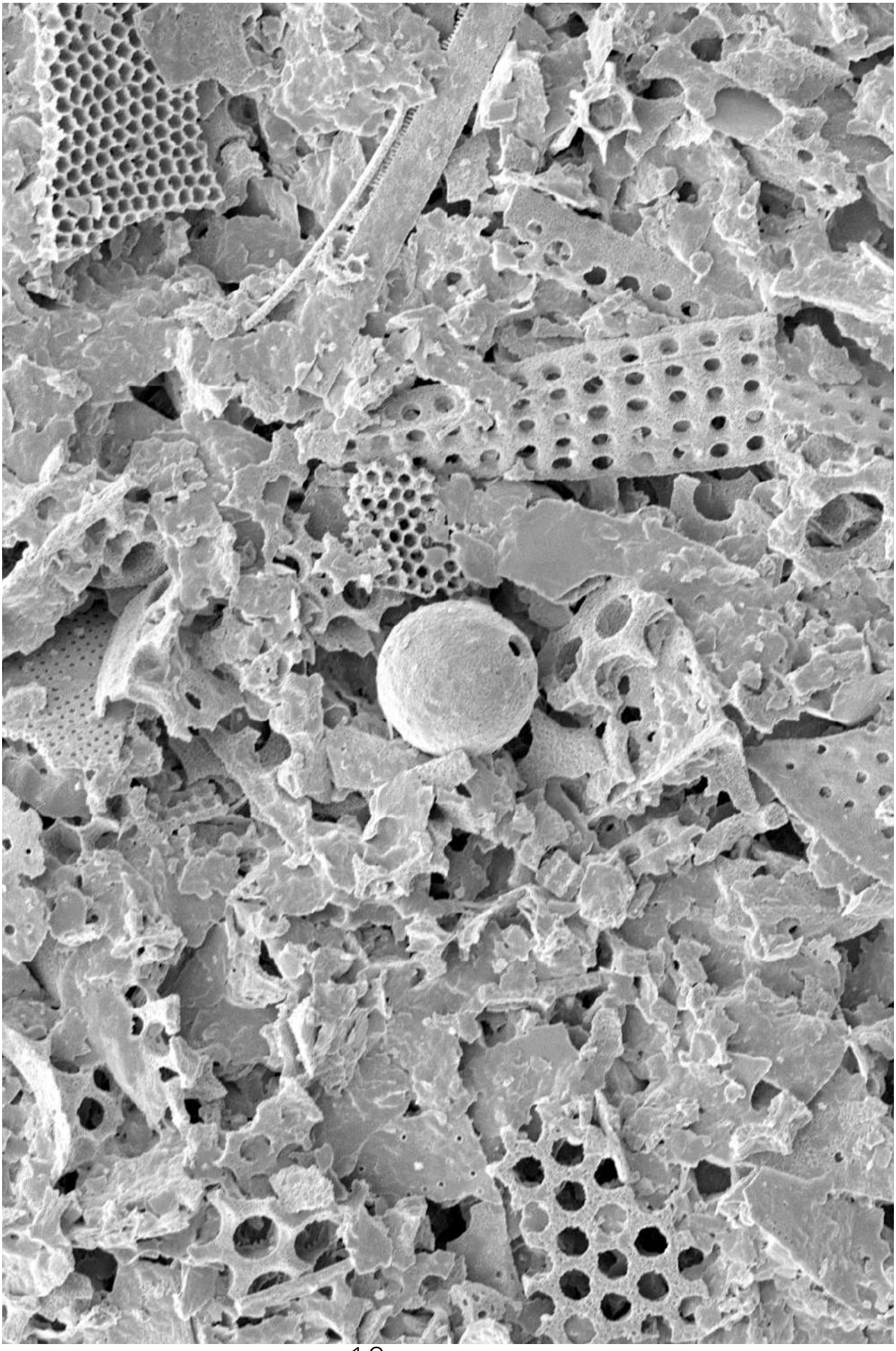


10 - Diatoms



10 µm

10 - Diatoms



10 µm

10 - Diatoms

40 µm

10 - Diatoms

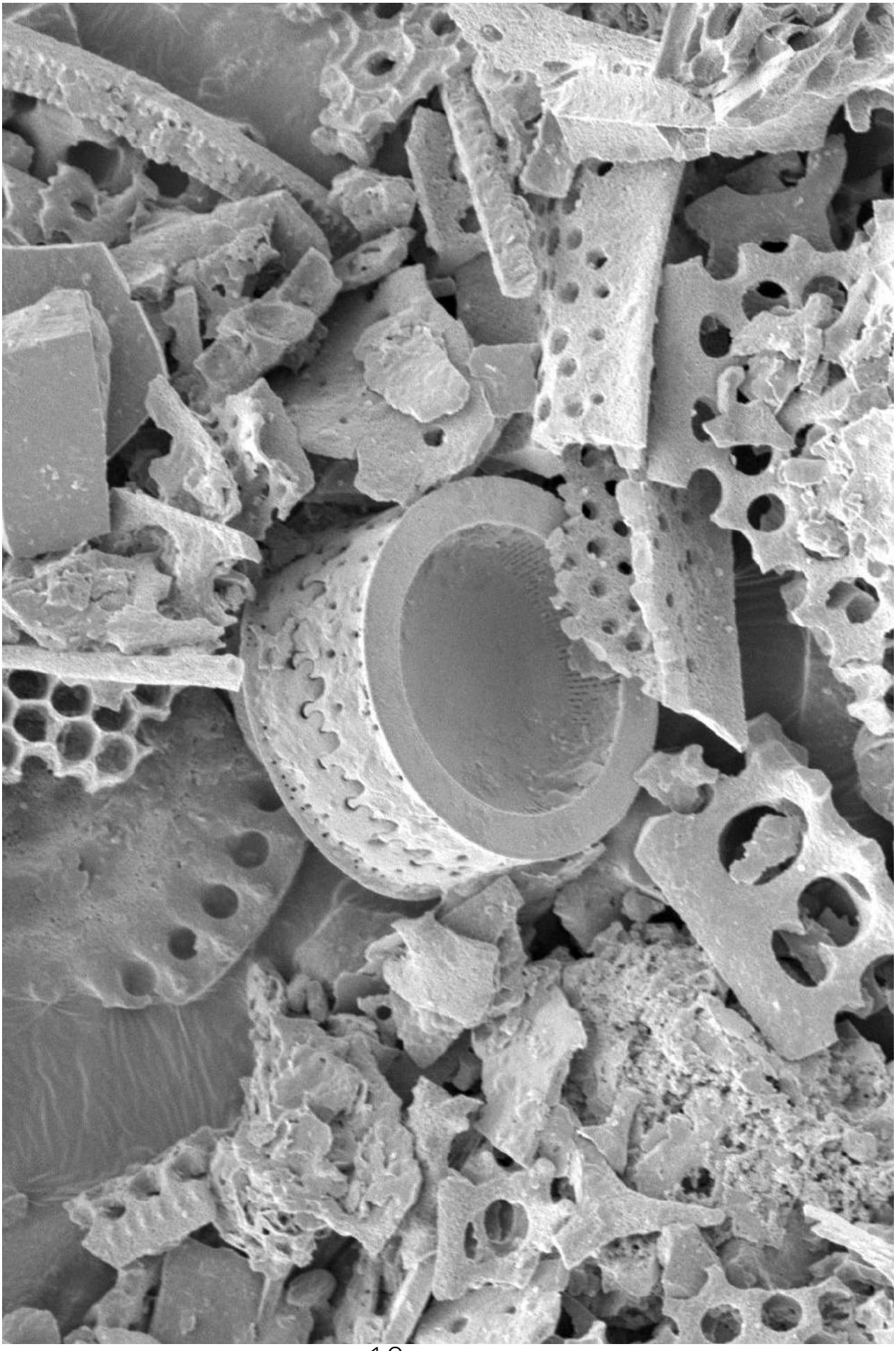
40 µm

10 - Diatoms

20 µm

10 - Diatoms

10 - Diatoms



10 µm

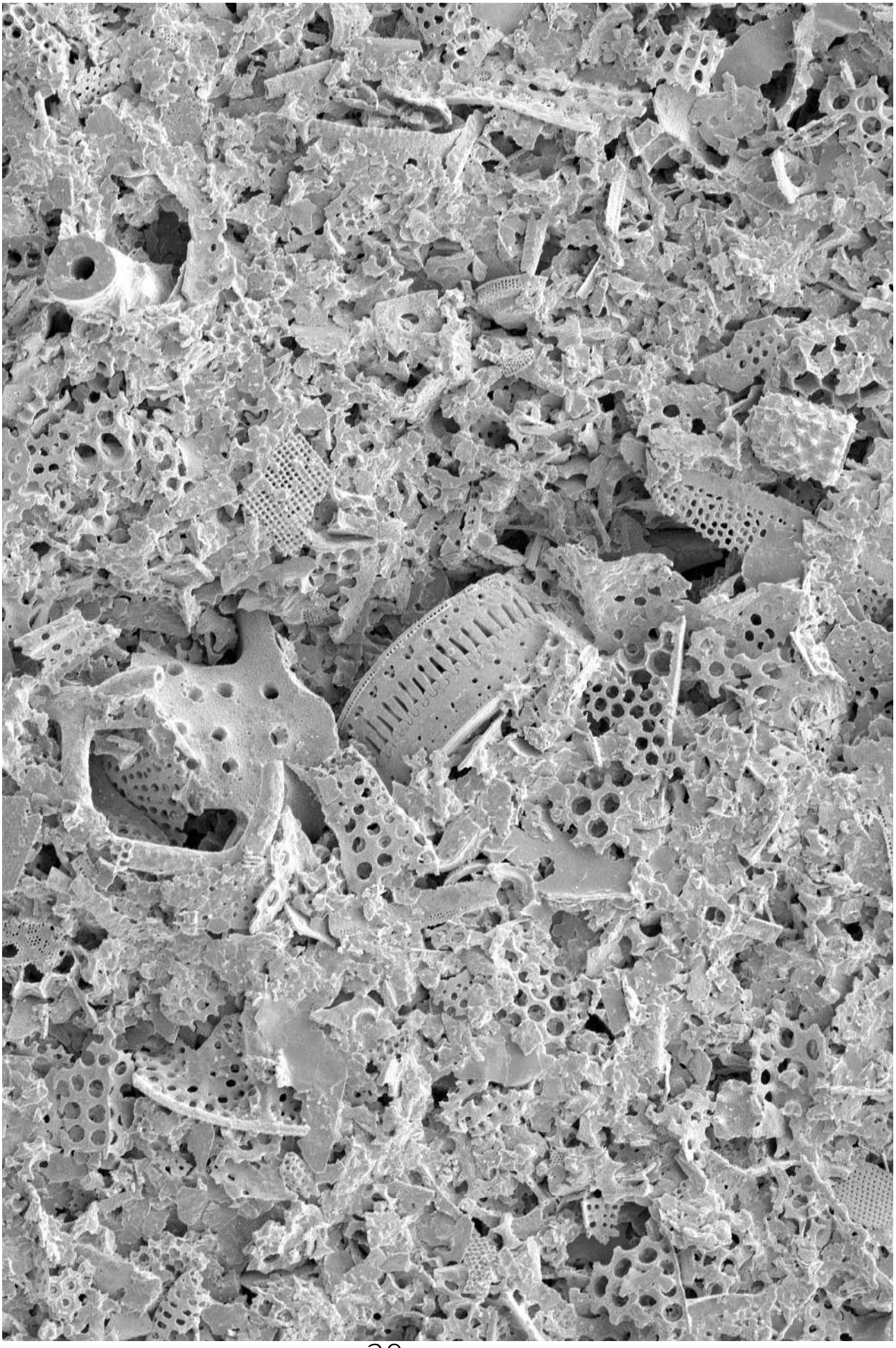
10 - Diatoms

40 µm

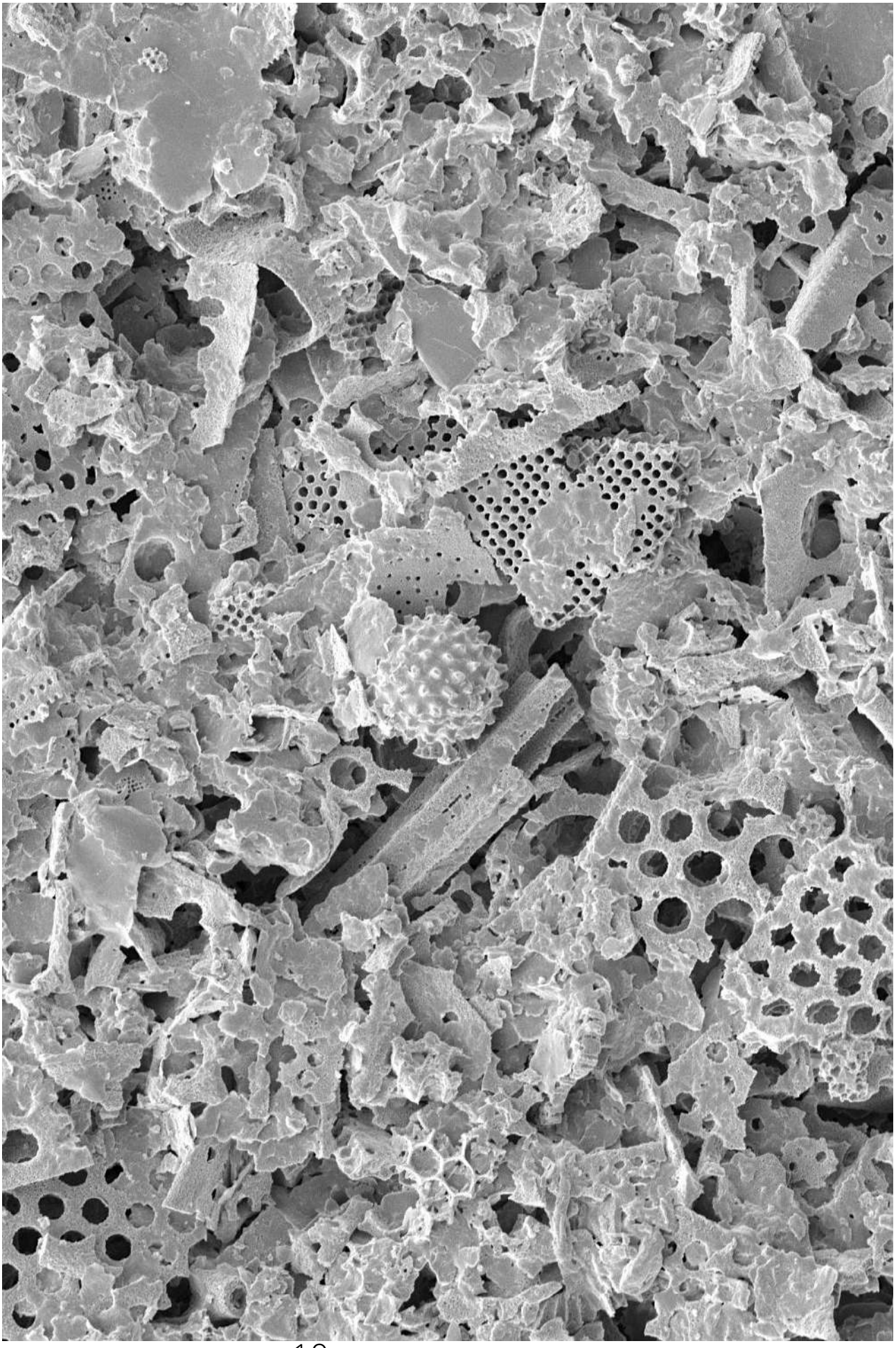
10 - Diatoms

20 µm

10 - Diatoms

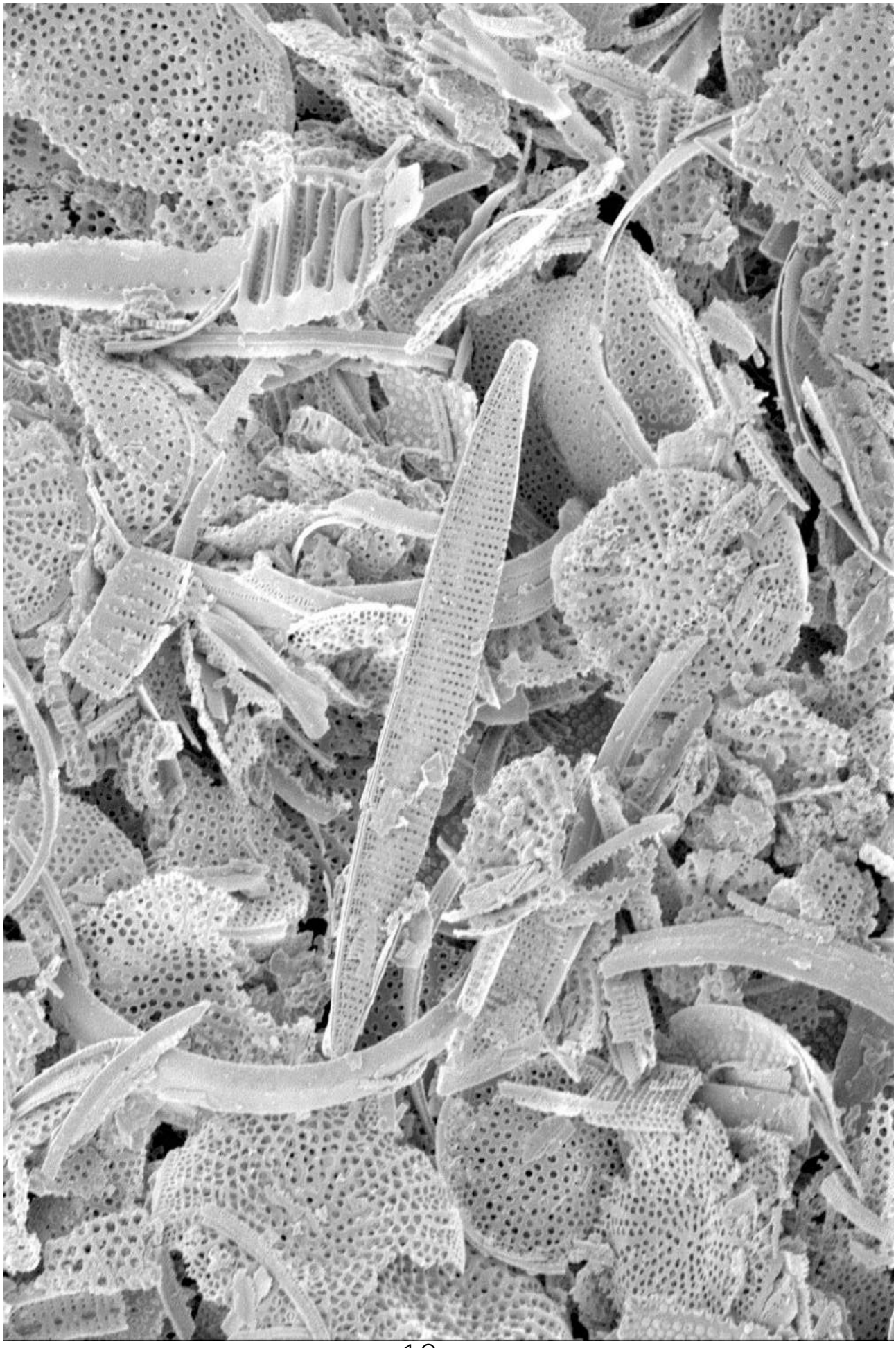


10 - Diatoms



10 µm

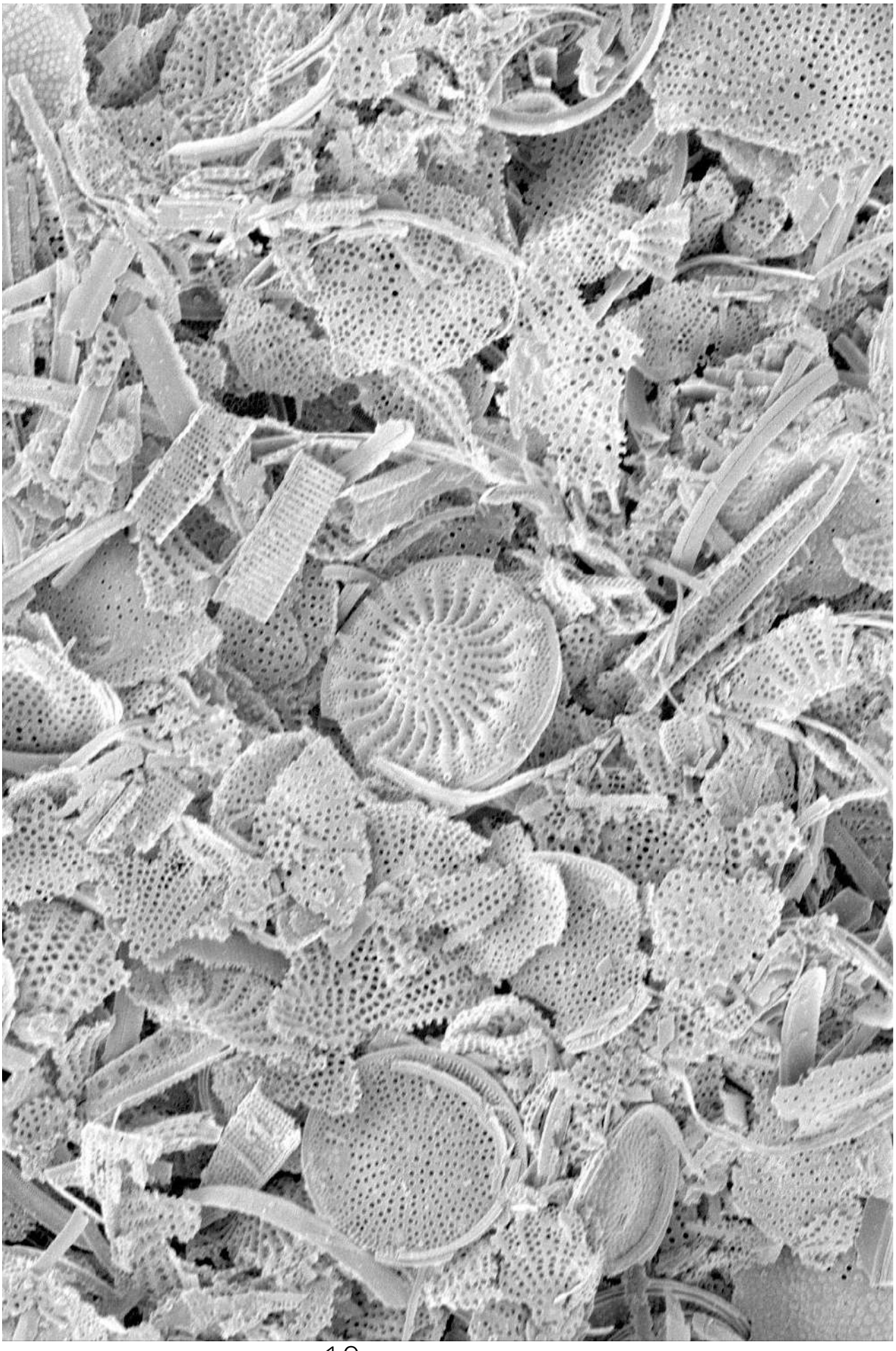
10 - Diatoms



10 - Diatoms

30 µm

10 - Diatoms



10 µm

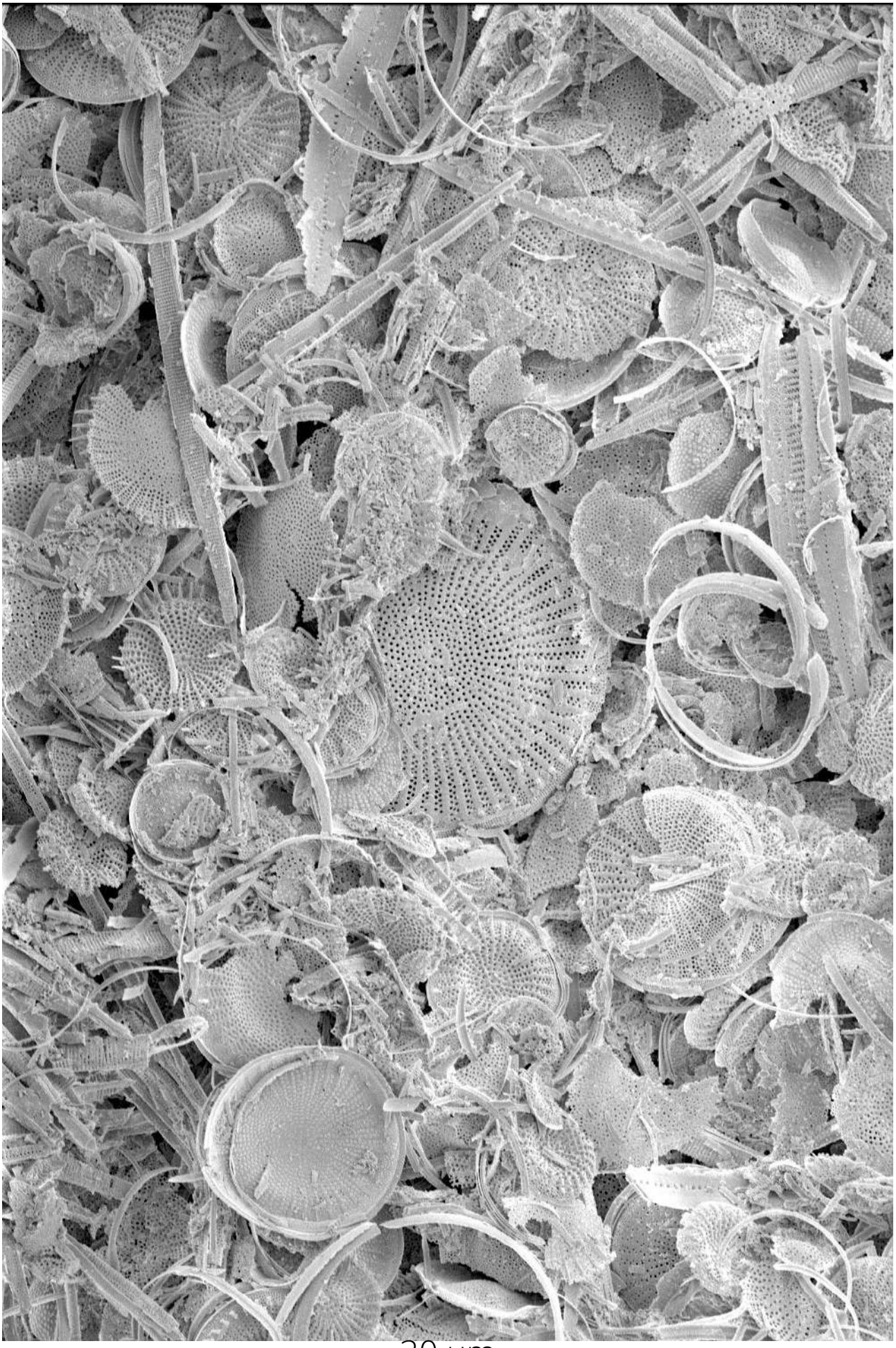
10 - Diatoms

20 µm

10 - Diatoms

20 µm

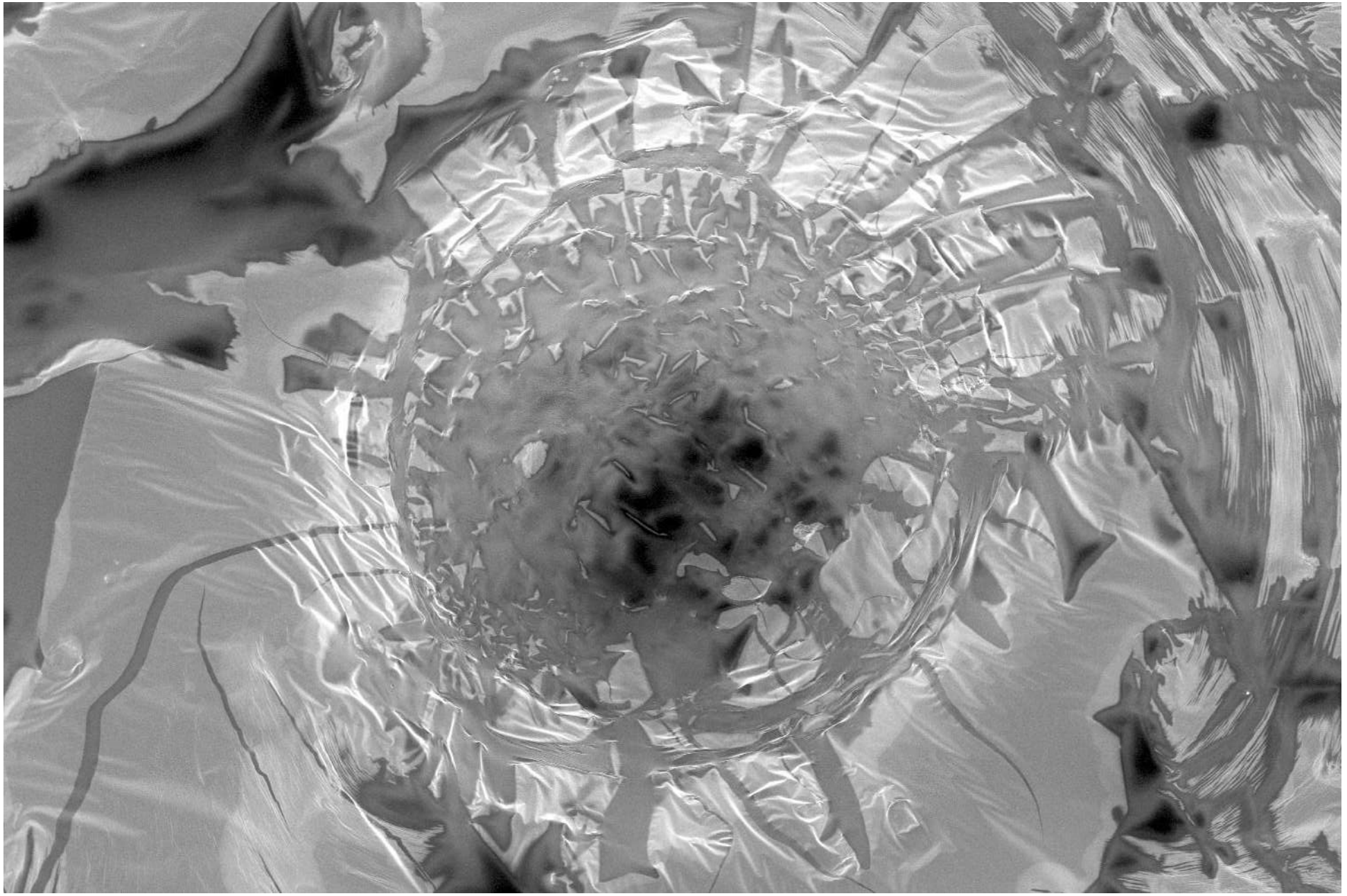
10 - Diatoms



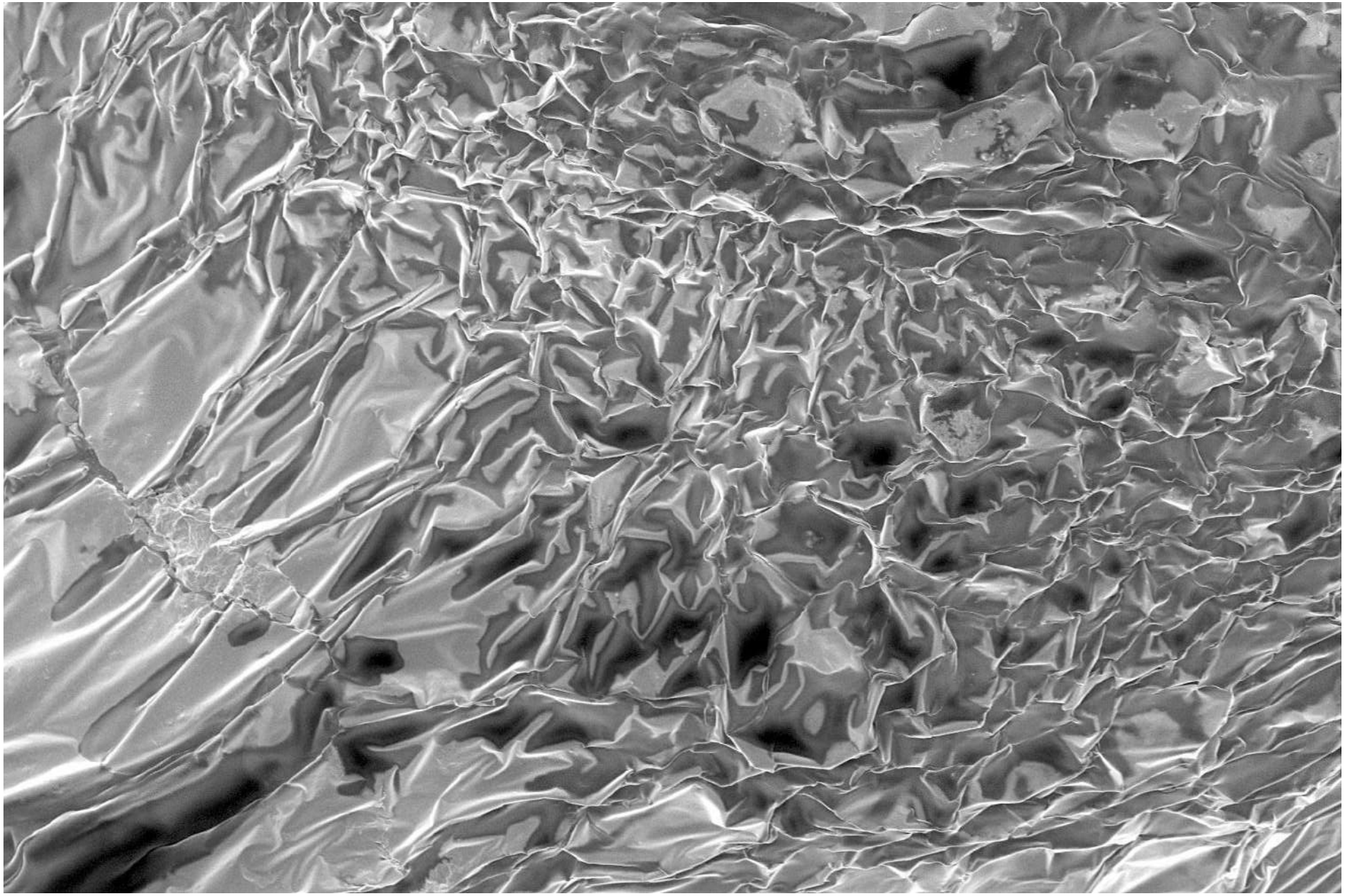
10 - Diatoms

11 - Extra

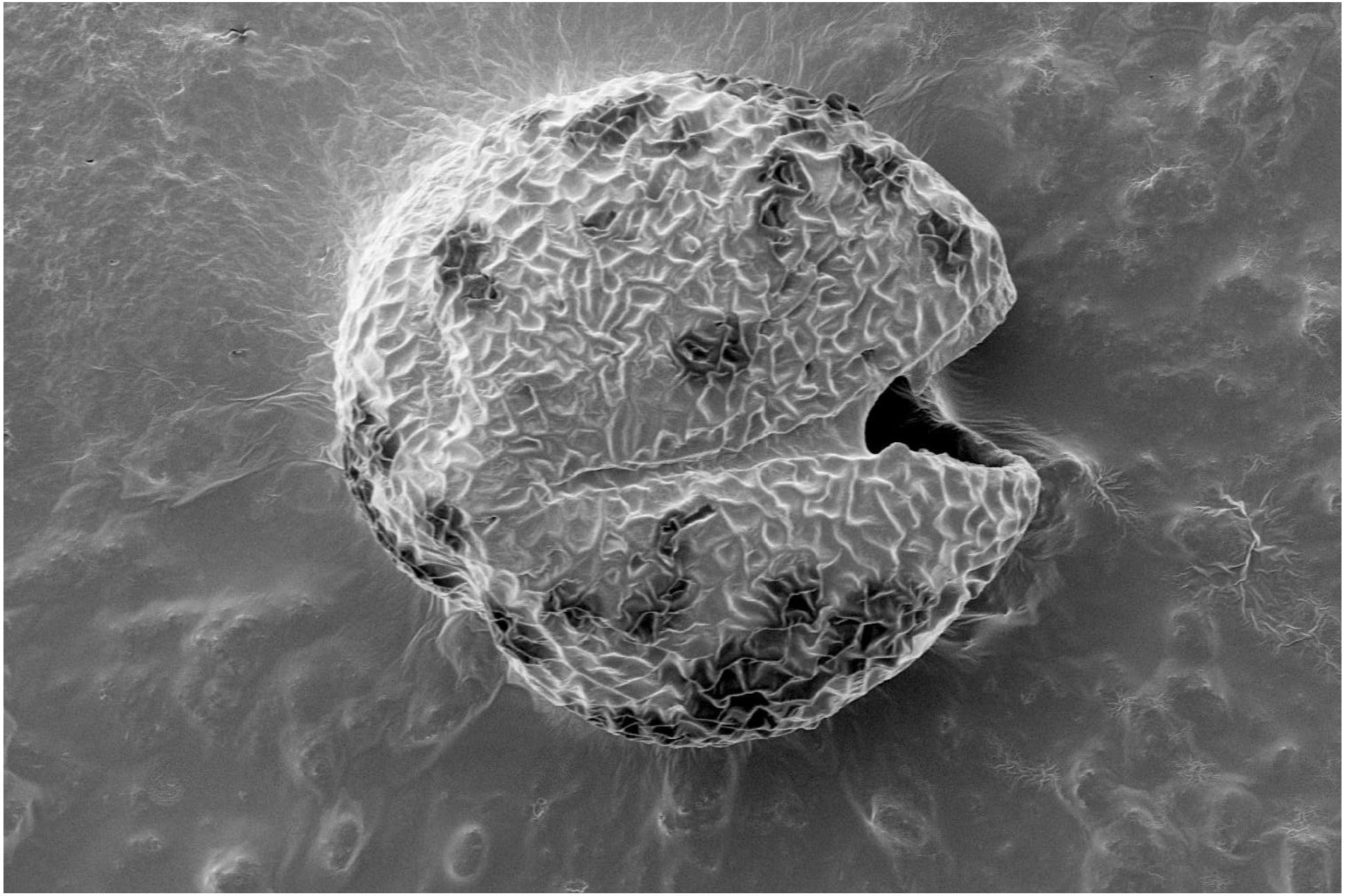
Sometimes, certain samples do not behave correctly on SEM. Other times, there may be contamination on the samples, and although they are scientifically useless, some pictures are aesthetically pleasant. Here is a small collection of “unknown” stuff.



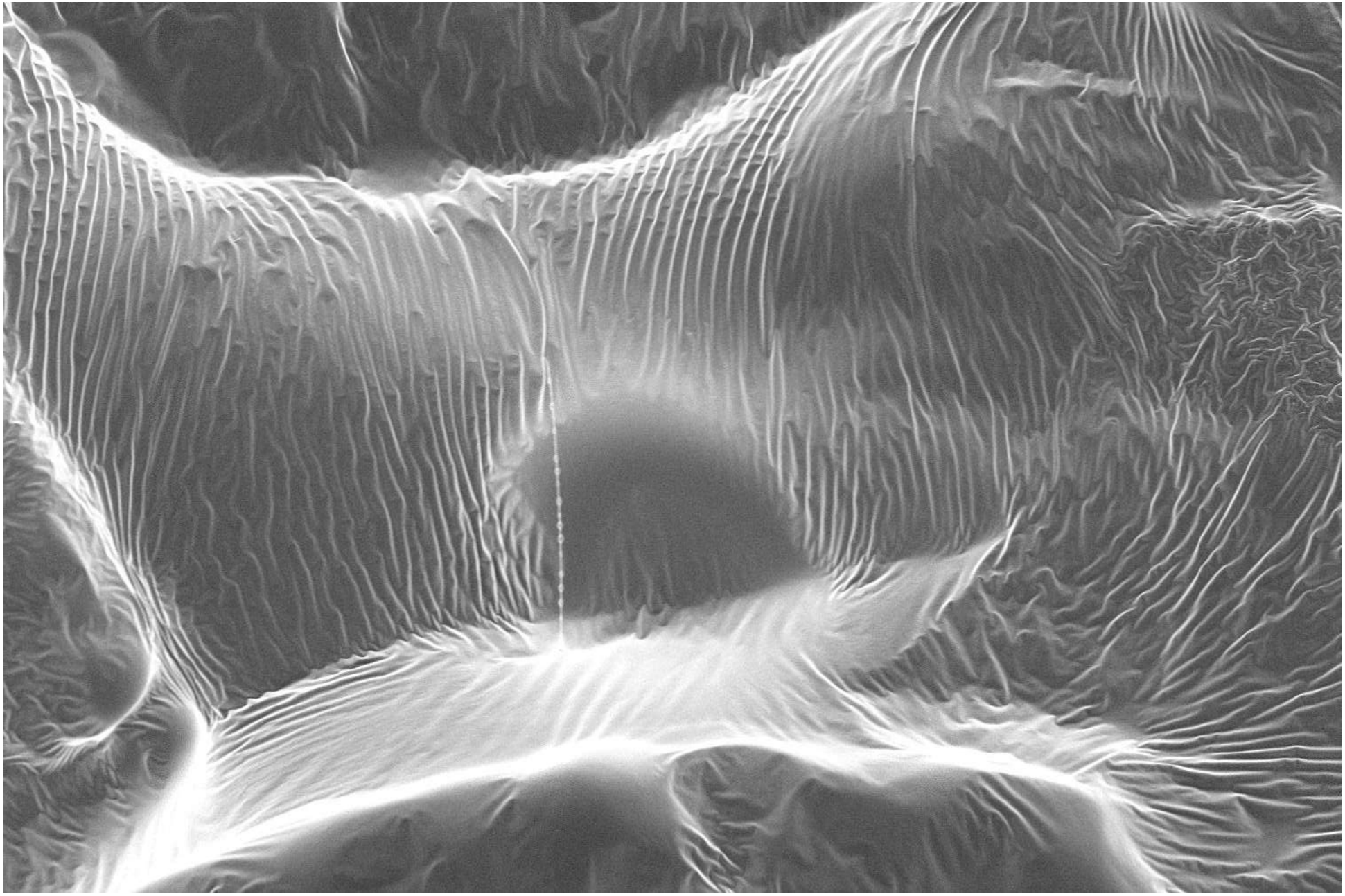
11 - Extra



11 - Extra



11 - Extra



11 - Extra

Acknowledgment

I would like to thank Andrea Roig Alba, Aldrik Velders, and Banu van Moerkerk for the help, suggestions, and proofreading.
The SEM is wonderfully maintained by the Wageningen Electron Microscopy Center.