# Antony van Leeuwenhoek

## Seeing God's Perfect Work through a Microscope

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from the Faith and Science Resource Center of
www.vaticanobservatory.org

FOREWORD:

Today when we think of scientists, we usually picture highly educated men and women working with giant pieces of machinery or computers at big laboratories or universities. It's surprising to see how different Antony van Leeuwenhoek was. He was self-educated. His instruments were very small, made by himself. And his only colleague was his daughter Maria.

And yet, when you think about it, what is more surprising is, in fact, how modern he was.

For one thing, until the invention of the telescope and microscope, science was the study of the parts of nature that anyone could see if they bothered to look. For the first time, Leeuwenhoek needed an instrument that not everyone had, to make his discoveries. That meant that he had to be very precise, and very honest, about what he saw and how he saw it. Those are the trademarks of a good scientist even today.

For another, he shared his discoveries with other scientists, read what they had to say, answered their questions, and in the process, improved his own work. Science is done as a part of a community of people in conversation with each other. "Lone geniuses" like you see in the movies, who keep their work hidden, do nothing to advance human

knowledge.  How could they if they don't share with the rest of humanity?

Finally, there is something very modern about the way that Leeuwenhoek relates his discoveries to the praise of God. Of course, such religious sentiments are not part of a typical scientific paper today.  But they do underlie the work that any scientist does… even those who think they don't believe in God.

For the work of science is painstaking, difficult, and at times very tedious.  We need something outside the science itself to keep us going back to the lab and doing the work. Ultimately that is a love of truth and the joy that comes when you suddenly realize a deeper insight into how the universe works.  Truth, and joy… and beauty, as Leeuwenhoek describes… are all hallmarks of the Creator.

Come, turn the pages and see what Leeuwenhoek saw. When we see truth, beauty, and joy, we are seeing God.

*Guy Consolmagno, October 20, 2021*

Antony van Leeuwenhoek was amazed by tiny things. Antony had taught himself how to build powerful microscopes. With one of these microscopes a person could see all sorts of tiny things. Seeing them was not easy, even with a microscope. Microscopes were difficult to use. But Antony loved to learn about the world of tiny things—tiny things whose little perfections revealed, he said, the power of God. Antony wanted to know what was true about the world and how it worked. So, he practiced making microscopes. He practiced using microscopes. He practiced writing down every little thing that he saw through the microscopes, and every little thing he did while using the microscopes. He became an outstanding scientist. He saw things that no human being had ever seen before. And he found those things amazing.

*A painting of Delft in Antony's time. The tower just right of center is the New Church.*

Antony van Leeuwenhoek lived almost four hundred years ago. He was born on October 24, 1632 in the town of Delft in Holland and was baptized a few weeks later in Delft's "New Church". In 1632, people lacked much of the scientific knowledge and most of the technological conveniences that we have today.

For example, in 1632 scientists had not learned how to study electricity very well. So, no one had electric lights, or phones, or air conditioning, or computers, or refrigerators, or anything else that uses electricity. No one had studied chemistry and physics enough to put those sciences to much use, either. So,

there were no engines to power ships or automobiles or factories. Ships were driven by sails. People travelled along roads in carriages pulled by horses. The few small factories of the time were powered by water wheels or windmills. There were certainly no rockets and no robots exploring planets like Mars and Jupiter.

And while in 1632 people had studied the sciences of living things and of medicine for a long, long time, there were many things, even very basic things, that they had not been able to learn. For example, what makes people get sick? What makes food spoil? Or even, where do certain living things come from?

Nevertheless, in 1632 people were hard at work learning many new things about science. One important thing that people had learned was how to make lenses out of glass. Glass lenses can be used to

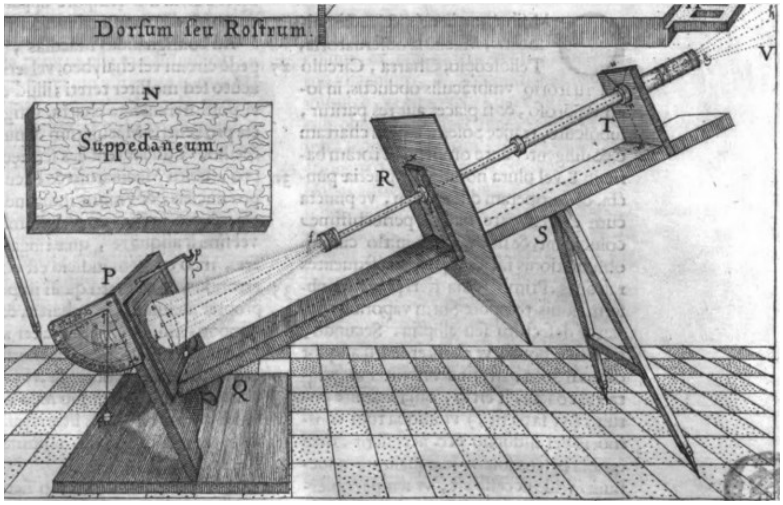
make an object like a penny appear larger or smaller to us. They also can make that penny appear nearer to us or farther from us.

*A glass lens, focusing an image of a light bulb onto a wall.*

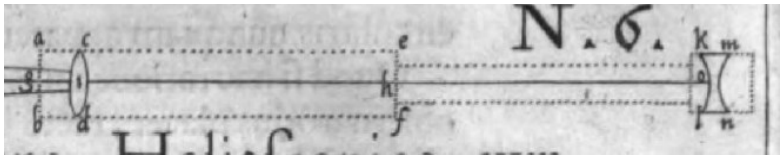
Because lenses can do this, they can be used to help people see. Some people cannot see anything clearly that is not close to them. Close things, like the books they might be reading, look clear to them, but things that are farther away, like the teacher in front of their classroom, are blurry—maybe so blurry they really just can't see anything that is farther away. Maybe you have this difficulty, which is called *nearsightedness*. But with the right lenses in front of their eyes, nearsighted people can see everything clearly. We call lenses like these *eyeglasses*.

Eyeglasses were helping people to see better when Antony was born in 1632.

Lenses can help people see in other ways, too. Lenses can be arranged so that they make far away things appear much, much closer. The name we have for lenses that do this is a *telescope*.




*A telescope, used by Fr. Christopher Scheiner of the Society of Jesus for studying the sun around the time Antony Leeuwenhoek was born.*




*A diagram by Fr. Scheiner that shows how lenses were placed in his telescope.*

In 1632 scientists were using telescopes to learn all sorts of new things about the sun, the moon, planets like Jupiter and Mars, and the stars. These scientists were *astronomers*. What astronomers saw through the telescopes was making them change their ideas about the universe.

For example, before telescopes, astronomers had long thought that planets like Jupiter circled around the Earth. They thought the sun, the moon, and the stars circled Earth, too. But the telescopes showed that planets did not circle around the Earth—they circled around the sun.

Now in 1632 astronomers were arguing with each other about the things that had been discovered with telescopes. Was the Earth a planet? Did it circle the sun? Or did the planets circle the sun, while the sun circled Earth, which stood still? These were not easy questions to answer. Sometimes the arguing over

science turned into fighting about science, all because of what had been seen with the lenses in telescopes.

Eyeglasses and telescopes were not the only things that could be made with lenses. Lenses could also be used to make very small things look much, much larger. The name we have for lenses that do this is a *microscope*. Antony van Leeuwenhoek grew to love turning lenses into very powerful microscopes, microscopes that he would use to study very tiny things.

No one really knows why Antony grew to love microscopes and tiny things so much. Antony was not raised to be a scientist. His father's family had been in the business of making baskets. His mother's family had been in the business of brewing beer.

Antony's education was very basic. He never learned any language other than his native Dutch, the language spoken by people in Holland. Almost all of

his writing was in Dutch. He did write a very little Latin. He would use Latin names for certain things, or he would write "Laus Deo", which is Latin for "Praise God", on a business receipt.[1] This was probably much like someone today who speaks only English yet who sometimes says "adios" instead of "goodbye", or says "gesundheit" when someone sneezes instead of "bless you".

*One of the microscopes Antony van Leeuwenhoek built. The lens is very small, located near the top.*

When Antony was sixteen, he began to learn the business of selling cloth and other material for making

clothes. In 1654, when he was twenty-one, he married Barbara de May. They were wed at the New Church in Delft, the same one where Antony was baptized.

*A painting of Antony van Leeuwenhoek when he was about fifty-four years old.*

The young Leeuwenhoek family then bought a house on Hippolytus Street in Delft. This house also served as their cloth shop. Some of the bills of sale that Antony wrote out for their customers still exist. These show that at the Leeuwenhoek shop customers could buy silk and common cloth, buttons and button loops, different kinds of ribbon, and more. All of this Antony would have to measure out and record carefully, both in order

to be sure that the customers were satisfied, and to make sure that he kept track of the supply of merchandise in the store.

When Antony was twenty-seven, he also took a job working for the city of Delft. His job was to make sure that the building that housed the judge, the sheriffs, and the law officers of Delft was kept in good shape. Over time he obtained more jobs related to the city. He became a surveyor, a person who measured land. Later he was elected to be a wine-gauger, a person who made sure that the measurements of wines and spirits sold in Delft were correct.

Antony lived almost all of his life in Delft. His family stayed in the house on Hippolytus Street, and kept running the shop. He kept working for the city. You might then think that Antony lived a very peaceful and quiet life. But Antony experienced much sadness. He and Barbara had five children. However,

all but one of their children died as babies. Only their daughter Maria, born in 1656, lived to grow up. All that suffering and loss must have been very hard on Antony and Barbara.

Then in 1666 Barbara died. Barbara was buried at the "Old Church" in Delft. Antony was only thirty-three years old. Maria was nine.

*A painting, made during Antony van Leeuwenhoek's lifetime, of the Old Church in Delft.*

Perhaps all the sadness in the Leeuwenhoek home led Antony to start playing around with lenses as a way to keep his mind off his troubles. The Leeuwenhoeks certainly would have kept a magnifying lens in their shop so that they could carefully inspect cloth with it. Maybe Maria started playing with it. Maybe she showed her father how the lens could be used to discover things about the world, not just to inspect the stuff they bought and sold. Perhaps she found that with the cloth-lens she could look at flowers and bugs and leaves and see them in great detail.

The delight of discovering things with the lens might have helped Antony and Maria find joy amid their sadness and loss, and so Antony started learning to make still better lenses that would discover even more. We do not know. There is no record of how

Antony became so interested in lenses, and so incredibly good at building and using microscopes.

What we do know is that in April 1673, when Antony was 40 and Maria was 16, a doctor in Delft named Reinier de Graaf wrote to a group of scientists in England to tell them about Antony. Reiner told them that Antony was a "most ingenious person" who had built far better microscopes than any that the scientists had seen at that point. Reinier said that the English scientists, who were known as the "Royal Society", should write to Antony and ask him to tell them about his microscopes and what he had seen with them. They did. In August 1673, Antony wrote back.

"Many times different gentlemen have encouraged me to write down on paper what I have seen through my newly-invented microscope," he wrote. "But I have always told them 'no'." Antony gave three reasons why he always said "no":

*First, I am not a good writer, so I find it difficult to express my thoughts properly. Second, I have been brought up to do business, and not for art and language. Third, I do not put up well with other people criticizing my work.*

And what is more, he added, he was bad at drawing. Plus, there were no scientists in Delft who were interested in microscopes who might be able to help him. So, he said, his work came only from his own curiosity about the world. But, he added, if the Royal Society would keep all these things in mind, he would share with them what he had learned. And over the next fifty years Antony did just that. He shared his microscopic discoveries with the scientists of the Royal Society, and with others, too.[2]

Microscopes amazed people of Antony's time. They revealed things that were part of everyone's ordinary world, but that no one could see.

Microscopes showed people that surrounding them all was an entire world of tiny things that no one had known anything about.

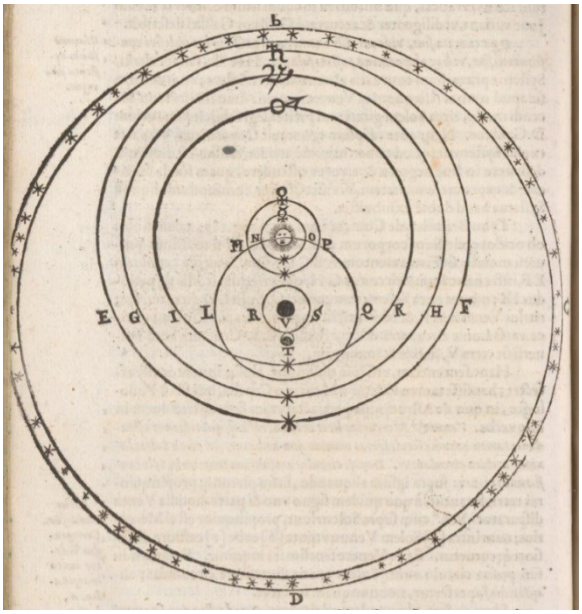
In this way microscopes were very different from telescopes. Telescopes revealed new things about the moon and the planets, for example, but people could already see the moon and planets with their own two eyes. Since people had been looking at these objects since time beyond memory, people had very settled ideas about them.

For example, for two thousand years astronomers had been studying Jupiter, using just their eyes, or using simple tools that were much like rulers and protractors. It seemed clear from their studies that Jupiter circled around Earth. One of the greatest of all astronomers, a man named Ptolemy, had written this all down in around the year 150 (about one thousand, five hundred years before Antony was born).

Ptolemy's ideas about how Jupiter circled the Earth, and how the Earth stood still, made a lot of sense. They had been taught in schools for over a thousand years.

But then the telescope changed things. In 1614 an astronomer named Simon Marius, who had studied Jupiter through a telescope, wrote a whole book just about that planet. He said that careful


*A portrait of Simon Marius. The tube below his arm is his telescope.*



*Ptolemy was wrong, said Simon Marius, because planets circled the sun, not the Earth. The sun, moon and stars, he said, circled the Earth, like in this diagram.*

study with his telescope had shown that in fact Jupiter circled the *sun*, not the Earth.


*Galileo also said Ptolemy was wrong, but he said that planets and the Earth all circled the sun, like in this diagram. It took a lot of time for astronomers to figure out how to prove whether Marius or Galileo was right. During that time when no proof could be found there was much arguing over whether the Earth moved or not.*

Simon was saying that what Ptolemy had written, and what was being taught in schools (and had been taught for so long), was wrong. Simon thought that Ptolemy still was right about some things, like about Earth not moving. Simon said Jupiter circled the sun, while the sun circled the Earth.

However, other astronomers argued that the truth was that Ptolemy was wrong about even more things. One of these astronomers was Galileo Galilei, who had studied the planet Venus with his telescope and

found that it circled the sun. He thought that since planets circled the sun that meant Earth probably did, also.

But whether Earth moved or not, telescopes had shown that Ptolemy was wrong, that people's settled ideas about the moon and planets were wrong, and that schools would have to change what they taught. Change, especially change of something that had worked so well for so long, bothered many people. So sometimes there were angry arguments over what had been discovered through telescopes.

Discoveries with microscopes were different. People could not look with just their eyes and see the tiny things revealed by microscopes, like they could look up and see the moon or Jupiter or Venus. What the microscopes revealed was completely new. For this reason, people did not already have settled ideas about the microscopic world. There were no

thousand-year-old ideas about the microscopic world that had been taught in schools, because no one had even known that the microscopic world existed.

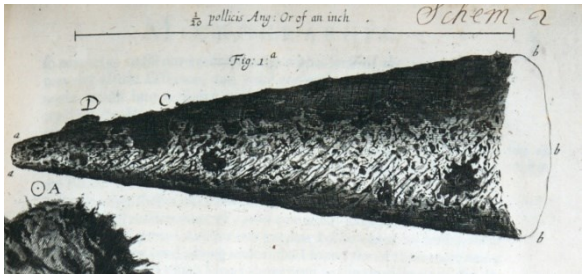
For these reasons people did not get into so many angry arguments about what microscopes revealed. What they did do was marvel at how much stuff there was in the microscopic world, and how amazingly interesting it all was.

Robert Hooke, one of the scientists in the Royal Society, made a microscope. He used it to study things made by human beings as well as things from the natural world. In 1665 he wrote a book about what he saw. He called the book *Micrographia*. He reported that the things made by human beings looked coarse and crudely made when seen greatly enlarged through the microscope, while things of nature appeared far more perfect and finely

*No portrait of Robert Hooke still exists. The artist Rita Greer read descriptions that people who knew him had written down, and made this painting of what she imagined him to look like, based on those descriptions.*

crafted. Here is what he had to say about what the point of a needle looked like:

> *The point of a needle is made so sharp, that the naked eye cannot distinguish any parts of it. It very easily pierces and makes its way through all kinds of bodies softer than itself. But if viewed with a very good microscope, we may find that the tip of a needle (though it seems very sharp to our senses) appears a broad, blunt, and very irregular end.*
>
> *Now though this point be commonly accounted the sharpest (so that when we want to express the sharpness of a point the most superlatively, we say, 'as sharp as a needle') yet the microscope can afford us hundreds of instances of*



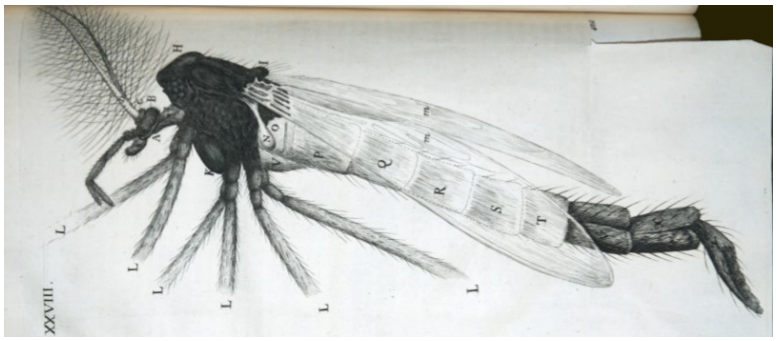

*Robert Hooke's drawing of the point of a needle as seen through a microscope, showing how rough and crude it looked.*

*points many thousand times sharper: such as those of the hairs, and bristles, and claws of multitudes of insects; the thorns, or crooks, or hairs of leaves, and other small vegetables.*

*Robert Hooke's drawing of the sharp claws of a flea.*

Robert added that such fine crafting of tiny things showed the power of God in action:

*In the case of man-made needles the more we see of their shape, the less appearance will there be of their beauty, whereas in the works of nature, the deepest discoveries show us the greatest excellencies—an evident argument, that he that was the Author of all these things, was no other than Omnipotent, being able to include as great a variety of parts and contrivances in the yet*



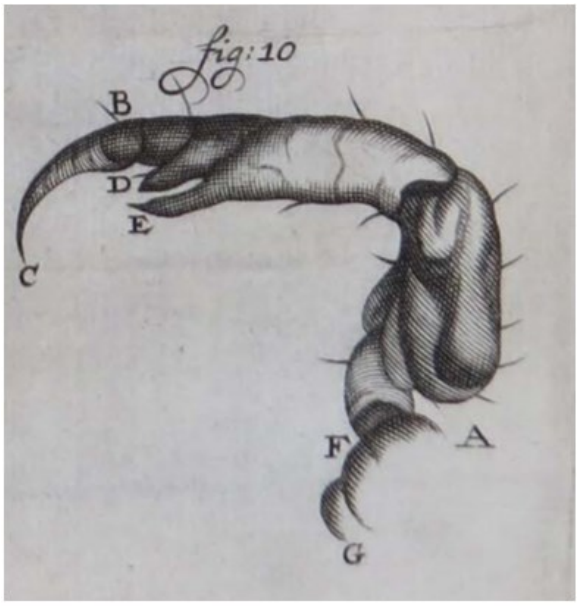

*Robert Hooke's drawing of a gadfly, seen through a microscope.*

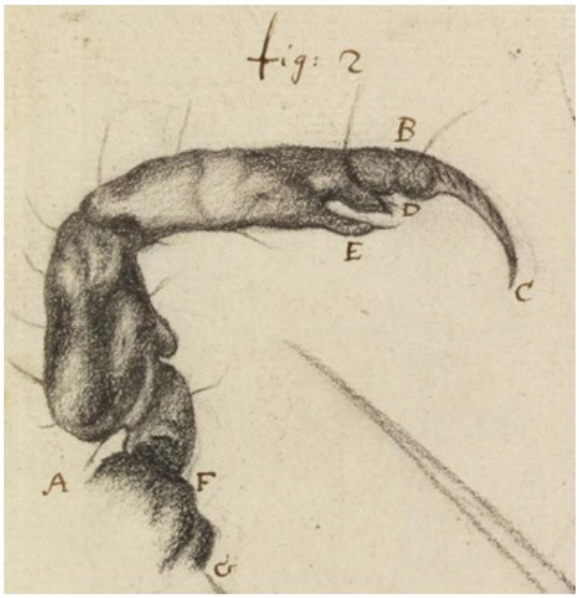
*smallest discernable point, as in those vaster bodies (which comparatively are called also points) such as the Earth, Sun, or Planets.*

Even an insect, he said, when seen through a microscope, might look as amazing and complex as an elephant. Writing about a gadfly seen through his microscope he wrote:

*Take this creature altogether, and for beauty and curious contrivances, it may be compared with the largest animal upon the Earth. Nor does the All-wise Creator seem to have shown less care and providence in the fabric of it, than in those which seem most considerable.*

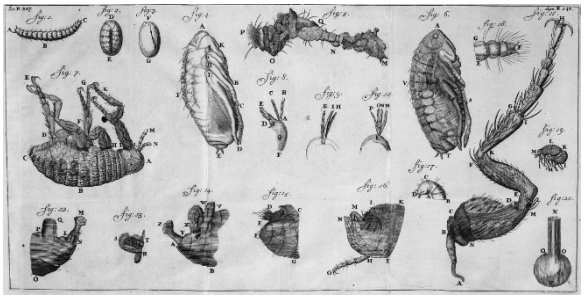
Antony likewise marveled at what he saw through his microscopes. One day he, Maria, and an artist he had hired to make drawings for him watched a tiny creature for three hours. Antony wrote down what they saw and remarked that "we thought it one of the most delightful things that could be seen".[3]




*Drawings of the leg of a louse seen through Antony's microscopes. Antony sent these to the Royal Society "in order that you might see the perfect shape of such a tiny creature".*

Antony's microscopes were much more powerful than Robert Hooke's. Robert studied insects or needles up close, but people could see insects and needles with their eyes. Antony's microscopes could reveal to him creatures so tiny that no one could see them at all. He saw that the young of fleas were attacked and fed upon by a minute parasite. Fleas are very small, and they themselves are parasites that bite and feed on animals and people. The poet Jonathan Swift put the idea of those tiny fleas having their own still tinier "fleas" into part of a very long poem that he wrote in 1733 about poets, and how poets pick on other poets, like tiny fleas biting larger fleas:



*Antony van Leeuwenhoek's drawing of fleas.*

*The vermin only tease and pinch*
*Their foes superior by an inch.*
*So Naturalists observe, a flea*
*Has smaller fleas that on him prey,*
*And these have smaller still to bite 'em*
*And so proceed ad infinitum:*
*Thus every poet in his kind*
*Is bit by him that comes behind.*[4]

Antony called these tiny creatures he discovered "animalcules", and he thought they were amazing. He wrote about how in one kind of animalcule he could see, "not only their little feet, but also their head, and their very short and pointed little tail". He added, "At such perfection in this tiny creature I did greatly marvel."[5] Elsewhere he wrote, regarding another tiny creature he was studying, "Once more we see here the unconceivable Providence, perfection, and order, bestowed by the Lord Creator of the Universe upon

such little creatures which escape our bare eye."[6] Antony found even moths to be marvelous works of God:

> *Can any man in his sober senses imagine, that the moth, which I have described, which is fitly provided by nature with the means to propagate its species, furnished with eyes exquisitely formed, with horns, with tufts of feathers on its head, with wings covered with such multitudes of feathers, all of different shapes, and these exactly covering the wings in every part; can this moth, I say, adorned with so many beauties, be produced from corruption? For, in a word, in this little creature, contemptible as it seems to us, there shines forth so much perfection and skill in the formation, as to exceed what we observe in larger animals.*[7]

The fact that tiny animals could have as many parts, as perfectly formed and beautiful as large animals, may have led Antony to start thinking hard about the true nature of all animals, and of all living things.

In Antony's time, many people thought that living things could just spring up out of the Earth. Now you might be thinking to yourself, "sure, I understand that—if I plant bean seeds in some dirt in a pot, and water them, and put the pot in the sun, bean plants will soon sprout up". However, that is not what the people in Antony's time who thought that living things could just spring up out of the Earth had in mind. They were thinking that living things could come out of just the Earth itself—just dirt and water, and maybe sunshine, would produce living things. No seeds required!

For example, people thought frogs could form right out of the ground. People had long believed that, at the right time, you could find frogs in the act of forming, so that parts of them were alive, while other parts were still unliving mud. An ancient writer named Pliny had described this idea:

*Aelianus said, that as he travelled in Italy near Naples, he saw many different frogs by the road, whose fore-parts and head did move and creep, but whose hind-parts were formed and like to the slime of the Earth. This caused the poet Ovid to write thus:*

*Dirt has his seed*
*engendering frogs full green,*
*Yet so as feetless*
*and without legs on earth they lie,*
*So as a wonder*
*unto passers-by is seen,*
*One part has life,*
*the other earth full dead is nigh.*

*And a strange thing is seen in frogs. After they have lived some six months, they dissolve into a slime or mud—no one knows how. And afterward, with the first rains in the spring, they*

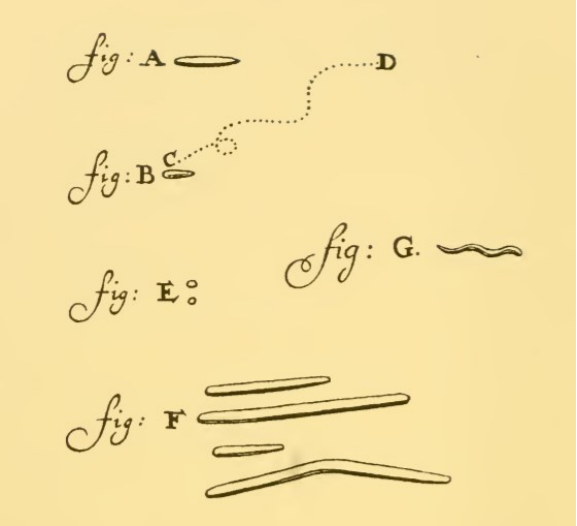
*return again to their former state, in just the same way as they were once first shaped. What their first shape came from, no one knows. The way this happens is also unknown, secret, and beyond comprehension. Yet ordinarily it happens every year.*[8]

People figured that all matter must contain some kind of natural life force, so that if conditions were right, all matter could naturally generate life. They thought that frogs, moles, mice, snails, snakes, insects, and many other creatures could be generated *spontaneously*, right out of mud heated by the sun, with no parents required. Ancient Jewish Rabbis discussed whether the earth from which a mouse might be spontaneously forming would be unclean, since in the Bible Leviticus 11:29 lists mice as being among the various "creeping things" that are unclean.[9]

An ancient writer named Lucretius had said that even large animals and people had once been spontaneously generated from the Earth. Today, he said, we see large animals and people come into existence by being born as babies from their parents, and not springing out of the ground, but that is because the Earth's life force has been used up over time. Today, said Lucretius, the Earth only contains enough life force to spontaneously generate small, lowly creatures, like insects, snakes, mice and frogs. Lucretius even thought that the Earth and the entire universe had been spontaneously generated from elementary particles that just happened to come together once upon a time, in just the right way.[10]

Antony did wonder at one point whether his microscope might be revealing spontaneous generation to him. On May 23 of 1676 he was looking at animalcules in a container of water and discovered

some oval-shaped creatures he had not seen before. He could see nothing in the water that looked like the young of these creatures, and yet over the next two days the number of the oval animalcules grew and grew. By May 26 there were thousands of them in a single drop of water. He wrote about this in a letter he sent the Royal Society in October of that year,




*Antony's drawings of animalcules he found in "white matter, which is as thick as if it were batter", from between his teeth. He had examined the white matter, and wrote, "I judged (although I could see nothing moving in it) that there yet were living animalcules therein. I have therefore mixed it, at different times, with clean rain-water (in which there were no animalcules), and also with spittle, that I took out of my mouth, after ridding it of air-bubbles (so the bubbles would not make any motion in the spittle). And almost every time saw, with great wonder, that in that mix there were many very little living animalcules, moving along very prettily. The biggest sort had the shape of Fig. A. These had a very strong and swift motion, and shot through the water (or spittle) like a pike does through the water." These animalcules are what we today call "bacteria" that live in our mouths.*

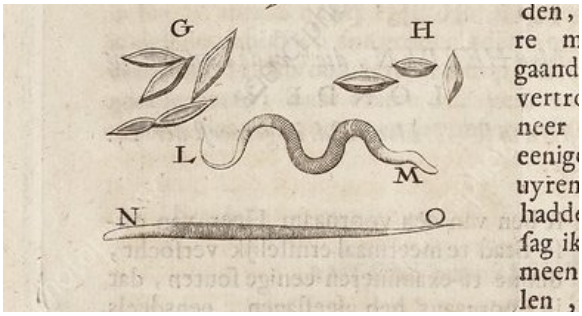
> *Seeing these little animals increase to so vast a number, but also not being able to detect that they did grow in bigness, and not being able to*

*see any similar creatures drifting in the water, I wondered to myself whether these animalcules might not well be put together in an instant, so to speak.*[11]

By "put together in an instant" he meant spontaneously generated. But as Antony kept observing tiny creatures, he began to question the idea that they could be produced spontaneously. For example, he studied some tiny eel-like creatures that could survive in water mixed with vinegar (many animalcules could not). In that same October letter to the Royal Society he reported on what happened as he was studying creatures in vinegar water:

*I observed one big drop of water almost from day to day. And after the lapse of about 2 or 3 weeks, I saw that the little eels in this mixed water were greatly increased. Where at first I had seen but 10 eels, I now saw fully 200 of them. And among*

*the rest I saw a great number of very little eels, each one about the same bigness*




*Little eels in vinegar, as Antony drew them.*

*as the other, whose length, to my eye, equaled about 1/4 or 1/5 part of the biggest eels of all. But despite further observations that I made, I was able to discover no smaller eels, nor yet any particles that looked like any of the very little animalcules I have mentioned.... Seeing this multitude of little eels, I imagined that surely they were not generated from any particles which might have been in the water, nor from any which might have been in the vinegar… but I felt firmly persuaded that these little eels had increased in number by procreation.*[12]

In other words, Antony was persuaded that those little eels that were 1/4 or 1/5 the size of the bigger eels were babies being born from mother eels. He was sure that the eels were increasing in number through procreation, or sexual reproduction—male and female eels mating and the females giving birth to babies. The eels were not being spontaneously generated from particles in the vinegar water. "The more observations I made on this matter, the clearer did I demonstrate that the small living eels come out of eels," wrote Antony to the Royal Society. He added that he had even been able to see pregnant female eels with little eels obviously alive inside them.

Antony found that people in his country commonly assumed that all eels, even large ones swimming in the rivers and canals of Holland, were spontaneously generated. "Respectable and learned men," said Antony, had told him that eels were generated from dew, "in confirmation of which they add, that if no dew has fallen, there will be no eels found". That is what those men had probably been taught, because the notion that eels of all kinds did not procreate was older even than the ideas of Ptolemy.[13]

But Antony was suspecting that all living things come from parents of some sort. He was thinking that in fact, no living thing is spontaneously generated. With careful study of larger eels, he was able to see that they produced tiny young. He wrote,

*This sight gave me great pleasure, partly because, after taking so much pains, I had now*

*discovered the manner of the propagation of eels; and partly, because this was a complete answer to those who said behind my back, "Since Mr. Leeuwenhoek is trying to show that all animals are generated through procreation, let him show us in what manner eels are bred."*[14]

Antony's observations of different living things convinced him that he was right about spontaneous generation. Everything that lives, he said, both plants and animals, comes from parent creatures in some way, whether we can directly see how that happens or not.[15] Nothing comes to life from dead material, from "corruption", as he often said it. He wrote, regarding the procreation of all living things:

*In all the observations I have made, we can clearly see the incomprehensible perfection, the exact order, and the inscrutable providential care with which the most wise Creator and Lord of the*

*Universe, has formed the bodies of these Animalcules, which are so minute as to escape our sight, so that the different species of them may be preserved in existence. And this most wonderful disposition of Nature with regard to these Animalcules, for the preservation of their species, while it strikes us with astonishment, it also must surely convince everyone of the absurdity of those old ideas that said that living creatures can be produced from corruption*.[16]

The form and structure of every creature, he wrote, and the powers implanted in it, must be ascribed to God alone, the Creator of the Universe.[17] Antony wrote that he wished that the eyes of everyone would be opened—

*to the truth of the regular reproduction of all the animals and vegetables on this earth; and to admire the infinite wisdom of the Creator, in the*

*formation of all things at the Beginning, and in the wonderful and infinitely diversified provision made for their propagation through all succeeding ages of the world.*[18]

It was important to Antony that he learn what was true. He believed that for human beings to learn true things about the world and at the same time glorify God, we must carefully study the world, and we must also share what we learn with everyone.

> *We will hope then, that those who enquire into Nature's works, by diving deeper and deeper into her hidden mysteries, will more and more place the discoveries of those truths before the eyes of everyone, so as to produce an aversion to the errors of former times, which all those who love the truth ought diligently to aim at. For we cannot in any better manner glorify the Lord and Creator of the Universe, than by contemplating with the utmost admiration the display of His Omniscience and Perfections in all things, however so small they appear to our naked eyes,*

*which nevertheless have received the gift of life and power of increase.*

Carefully observing the world and sharing what we learn is doing science. Antony made sure to do certain very important things so that the observations that he shared would be correct, and so that other people could also do those same observations and see the same things he did. One of these important things was to report all the details of every observation he made. If he was collecting a sample of rainwater to observe, for example, he would describe all the steps involved in how he collected the water:

*I took a big porcelain dish, and put it in my courtyard, in the open air, upon a wooden tub about a foot and a half high. In this way no earthy particles would be splashed into that dish by the falling of the rain at that spot. With the water first caught, I swilled out the dish, and also*

*the glass in which I meant to preserve the water, and then flung this water away. Then, collecting water anew in the same dish, I kept it.*[19]

And if he stored that rainwater in his closet, he would give all sorts of details about the closet—what sort of wood the closet was made of, how many windows it had, which direction it faced, and so forth. If people could not reproduce his observations and see exactly what he saw, then it would not be possible for them to verify that he had discovered true things. It would also not be possible for them to discover whether he had made a mistake or was wrong about something.

Probably his experience working in the cloth business and working for the city of Delft helped him to be careful about these things. If cloth or land or wine was being sold, and all the people involved in the sale could not verify for themselves all the details

about how much was being sold, what the price was, and so on, then there would be trouble. People might feel they were being cheated, and grow angry. So, it was probably natural to Antony for him to make sure that everyone knew every detail about his scientific work, too.

The other important thing he did was to make sure that he was able to reproduce and re-verify his own observations. He would repeat experiments many times and make sure that they were successful. He would even ask the artists who he hired for help with drawings to check what he was seeing. In other words, he would have others repeat his observations. One time he had four different artists look at a particularly interesting grain of sand.[20] By repeating work, Antony could be as confident as possible that he was not wrong and had not made mistakes.[21]

Antony wanted to get things right, but he was not afraid of someone finding out that he had been wrong. Since it was the truth that mattered, he would be happy to change his views if proven wrong:

> *I have said many times that it is not my intention to stick stubbornly to my opinions, but as soon as people urge against them any reasonable objections, whereof I can form a just idea, I'll give mine up, and go over to the other side. That is because my efforts are ever striving towards no other end than, as far as is possible for me, to set the Truth before my eyes, to embrace it, and to lay out to good account the small Talent that I've received, in order to draw the world away from its old heathenish superstition, to go over to the Truth, and to cleave unto it.*[22]

Antony's work usually was true, however. In 1680 the Royal Society unanimously decided to make

him a member of their group—or a “fellow”, as they called it. Antony may not have been brought up to be a scientist, but they realized that he was one anyway, and that he was a good one. Few people could really question his work, because no one was as good as he was at making and using microscopes. Robert Hooke said in 1692 that Antony stood alone in the science of microscopy. Many of his discoveries would not be verified by other scientists for years.

In fact, for a while, some people claimed that Antony was just imagining the things he saw, because no one else at the time could see them. This was not quite the same sort of problem that users of telescopes encountered, but it could annoy Antony anyway. But in time microscope technology improved so that more people could build and use them. Then they could see what he had seen. Eventually all scientists became convinced of the truth of his discoveries.

Antony had been the first to discover the *microbes*, creatures that are invisible to the eye alone, such as bacteria. Microbes can be helpful to people by aiding us in the digestion of our food and helping to break down and recycle dead material. They can also be harmful to people by making us sick and causing food to spoil.

In time all scientists also became convinced of the truth of Antony's ideas about spontaneous generation. This took a very long time. Antony thought that people hung on to the idea of spontaneous generation because that is what they had been taught.[23] This was much like astronomers with what they had been taught from Ptolemy regarding the Earth standing still.

However, it took longer to convince scientists that spontaneous generation did not occur than it took to convince them that the Earth did not stand still. Almost two hundred years after Antony's work, certain respected scientists were still arguing that some sort of spontaneous generation of life occurred, at least for the smallest creatures. In the end, however, no observations of spontaneous generation could ever be verified. Eventually scientists became fully convinced that living things do not just come to

life from non-living material—that every animal, plant, and microscopic organism alive came from its parents, just as Antony had said.

Antony died on August 26, 1723, at age ninety. He was buried in the Old Church in Delft. He left a cabinet of twenty-six microscopes to be given to the Royal Society. His daughter Maria, who had lived with her father at the house on Hippolytus Street and had been his helper for her whole life, sent the cabinet to the Royal Society in October of that year. The scientists in turn sent Maria a silver bowl as a token of their thanks. Maria kept all the rest of Antony's microscopes for the rest of her life—over 240 microscopes plus almost two hundred other lenses. Many of the microscopes were made of silver, and a few were made of gold. Some of Antony's microscopes still exist, thanks to Maria. The Royal Society lost their cabinet. It might have been

destroyed in the 1800s in a fire. It might be stored away somewhere, and people have just lost track of where. No one knows for sure.[24]

*The Leeuwenhoek monument in the Old Church, erected by Maria in Antony's honor. The inscription at the base of the monument reads "To her most beloved Father this monument his daughter Maria van Leeuwenhoek mourning has erected."*

Maria had a monument erected in her father's memory in the Old Church, and when she died in 1745, she was buried there, too. You can go today to the town of Delft and visit the Old Church. There you will see the tomb of Antony van Leuwenhoek, the cloth-seller who both discovered amazing tiny things in the world, and shared those discoveries with others

so that they could see them for themselves. And there beside his tomb is the tomb of his daughter Maria, whose lifelong assistance to her father helped make possible those discoveries he shared.

NOTE FROM THE AUTHOR TO THE READER:

Antony van Leeuwenhoek wrote in Dutch, not English. This means that all the quotations from him in this book are not exactly what he said. They are translations. For example, on page 51-52 there is a quotation of Antony saying, “We will hope then, that those who enquire…”. That is not actually what he wrote. Here is that quotation as Antony actually wrote it:

> *Wy willen dan hoopen, dat de ondersoekers der natuurlyke zaken, die tot nog toe verborgentheden dieper en dieper sullen op delven, om alsoo meer en meer de waarheid voor de oogen gestelt hebbende, van veele oude dwalingen, een afkeer te doen krygen, waar na alle die de waarheid lief hebben behooren te tragten. Want wy en konnen den Heer en Maaker van het geheel Al, niet meer verheerlyken, als dat wy in alle zaken, hoe klein die ook in onse bloote oogen mogen zyn, als ze maar levenen wasdom hebben ontfangen,*

*zyn Al-wysheit en Volmaaktheit, met de uitersle verwondering sien uit steken.*

Likewise, the Pliny and Ovid quotations are translations, too—they wrote in Latin.

Finally, even people who wrote in English in Antony's time used the English language somewhat differently than people do today. I have translated Robert Hooke's English a little bit, too. For example, on page 30 there is a quotation of Robert saying, "The point of a needle is made so sharp…". Here is how he actually wrote it:

*The Point of a Needle is made so sharp, that the naked eye cannot distinguish any parts of it: It very easily pierces, and makes its way through all kind of bodies softer then it self: But if view'd with a very good* Microscope*, we may find that the* top *of a Needle (though as to the sense very* sharp*) appears a* broad, blunt, *and very* irregular *end.*

Finally, some readers may want to know where all the quotations and other information in this book come from.

They might like to look up more about Leeuwenhoek and his microscopes.  On the next page is a listing of the sources I used.

# SOURCES/NOTES

[1] *Antony van Leeuwenhoek and his "Little Animals"* by Clifford Dobbell, Fellow of the Royal Society (New York, 1932), page 30.
[2] *"Little Animals"*, page 42.
[3] *The Select Works of Antony van Leeuwenhoek*, by Samuel Hooke (London, 1816), vol. 1, page 88.
[4] "Anthony Van Leeuwenhoek, the First Bacteriologist", by David Fraser Harris, Fellow of the Royal Society, published in *The Scientific Monthly*, vol. 12, no. 2 (1921), page 157.
[5] *"Little Animals"*, page 147; figure from "Antoni van Leeuwenhoek, His Images and Draughtsmen", by Sietske Fransen, published in *Perspectives on Science*, vol. 27, no. 3 (2019), page 489.
[6] *"Little Animals"*, page 267.
[7] *Select Works*, vol. 1, page 34.
[8] "Pictura's Fertile Field: Otto Marseus van Schrieck and the genre of sottobosco painting", by Karen Leonhard, published in *Simiolus: Netherlands Quarterly for the History of Art*, vol. 34, no. 2. (2009/2010), pages 102-107
[9] "Two Notes on Hellenistic Lore in Early Rabbinic Literature", by Pieter W. van der Horst, published in *Jewish Studies Quarterly*, vol. 1, no. 3 (1993/94), page 252.
[10] "Pictura's Fertile Field", pages 103-104.
[11] *"Little Animals"*, page 136.
[12] *"Little Animals"*, page 151-153.
[13] *Select Works*, vol. 2 page 62-64; On eels not procreating being an old idea, "Leeuwenhoek and the Campaign against Spontaneous Generation", by Edward G. Ruestow, published in *Journal of the History of Biology*, vol. 17, no. 2 (1984), page 230.
[14] *Select Works*, vol. 2 page 64.
[15] *Select Works*, vol. 1, page 173-174.
[16] *Select Works*, vol. 2, page 214.
[17] *Select Works*, vol. 1, page 168.
[18] *Select Works*, vol. 2, page 344.
[19] *"Little Animals"*, page 122-125.
[20] "His images and draughtsmen", pages 492, 526-527.
[21] *Select Works*, vol. 1, pages 15, 183, vol. 2, pages 213, 232, 274.
[22] *"Little Animals"*, page 74.
[23] *"Little Animals"*, page 75.
[24] "What were the missing Leeuwenhoek microscopes really like?", by Brian J. Ford, published in *Proceedings of the Royal Microscopical Society,* vol. 18, no. 2 (1983), pages 122-124.