The Open University

Biology: Uniformity and Diversity

Suspension feeders: investigating filter feeders

Voice over:
Creatures that feed on particles suspended in the water are a speciality for Mimi Köehl.

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Three-quarters of the Earth's surface is covered with water, and that water is full of particles and a vast array of different kinds of creatures make their living by filtering those particles out of the water. Some of them, like anchovies and whales, swim around and let the water move through their filters as they go. Other animals, like sea fans and feather duster worms and feather stars, sit on the bottom and put their filters up in the current, and as the water blows through they capture particles. What all these different kinds of suspension feeders have in common is that their filters are all made up of a row of cylinders and the water moves through the cylinders, so if we want to understand how all these diverse creatures catch their food, we need to understand how a row of cylinders catches particles.
And one obvious way to catch particles is if a particle is bigger than the hole between those neighbouring cylinders, then as it's carried along in the flow it bangs into it and it's caught.
We also know that organisms in fact catch particles that are much smaller than the gap between the cylinder, like this little model of a particle might indicate, and that's sort of a mystery. Here we've got cylinders, particles smaller than them, and you can see that they aren't caught, they aren't strained out, but what's different about my model and real organisms is that real organisms have sticky cylinders and we can ask what happens to these small particles when they flow past sticky cylinders and, as you can see, particles are happily caught.
And if you calculate the sizes of particles that are caught by any filter you discover that filter is a selective filter, it catches certain sizes of particles much more readily than other sizes.

Voice over
Inertia and viscosity are both important in the watery world of filter feeders.

Mimi
Now there's a simple expression for how important inertia is relative to viscosity for any kind of flow situation, and that's the Reynolds number. When Reynolds number is high what we have is a situation like us stirring the tea, where inertia dominates, and the flow is messy and turbulent. When we have low Reynolds number it's a situation like us stirring the honey where the viscosity is a much bigger force than the inertia.
Now something to think about is the size of the organism that's stirring the fluid. When you and I stir tea, we're large, we displace a lot of water and it has a lot of inertia, keeps moving. If a copepod, which is the size of a flea, were in there stirring the tea it's only displacing a tiny volume of water and that little tiny volume doesn't have a lot of inertia, so the viscous forces in the water are bigger than the inertial forces for this little tiny animal.

Voice over
For small creatures water seems much more like honey.

Mimi
But let me show you a movie of a copepod with water moving past it. Now to see the water moving past it what I did was just mix a little food colouring with some seawater and I released that from a micro pipette near the copepod so we could see what the water looks like. And let's just run this movie and have a look at what that's like.

And as you can see, this is just water but it looks like honey. See how the dye stream sticks together and even though the animal's flailing its appendages around it doesn't get all mixed up and it's not turbulent like water flows around us. But this is water.
Well we can calculate what the Reynolds number would be for the second maxillae of different kinds of copepods and what we find is some species operate at very low Reynolds numbers, as low as 10 to the minus 2 (10^{-2}).

Voice over
It's the Reynolds number that determines whether the second maxillae are leaky like sieves, or act more like paddles.

Mimi
So let's start out to look at Centropages; this is an animal that operates at second maxillae at a Reynolds number of one, so we expect it to be leaky. It's in an orientation with it's head towards you and its second maxillae flapping like this, so they're going to be here on the picture, and we've marked some water with some food colouring so let's watch what happens when the second maxillae sweep through some dye.
Here's the animal, the second maxillae are folded up here; here's the dye and the second maxillae – woop! - do the flip through that. Now let's watch it frame by frame. Here come the second maxillae flinging apart – this one's going to move right through this dye so it's nice and leaky, just like we predicted.
Now let's look at an animal that operates at Reynolds number 10 to the minus 2 (10^{-2}) – Eucalanas – again it's a misorientation, second maxillae are flapping here; here you can see the individual setae of the second maxillae, here's the dye. And look at this – as it flaps through the dye it doesn't move through those gaps, and if we look frame by frame, here's the gaps and as it sweeps through you can see the dye doesn't move through. Even though there are holes there, they're functioning just like paddles.

Voice over
Whether they paddle or they leak, suspension feeders still manage to eat using different methods to achieve the same result.

Mimi
The animals that operate at Reynolds number 1 that are good and leaky, it's easy to imagine. They fling their second maxillae apart; when they squeeze them back together the water squirts through those gaps between the hairs and they filter the particles, just like you'd imagine.
Now let's look at an animal that operates at Reynolds number 10 to the minus 2 (10^{-2}), when the second maxillae fling apart, they draw a parcel of water towards the mouth of the animal and that algal cell is carried with that water towards the mouth, and they close over that parcel of water they've caught and they come in with some other appendages and they stuff that algal cell in the water into their mouth. So we have animals that are doing the same behaviour, they're flinging and squeezing the second maxillae, but the animals that operate at Reynolds number 1 are filterers, and the animals that operate at Reynolds number 10 to the minus 2 (10^{-2}) are catching those particles by moving the water around.
So we here have a Centropages and you see her from the side; here's the second maxillae folded up over the animal's body, and these other appendages are flapping and creating a current of water past the animal. Now when an algal cell approaches – woop! – you can see the second maxillae actually moves and catches this particle. So let's stop this and back it up, and have another look at that so we can see exactly what happens when the animal catches that particle. OK now, if we run it more slowly, what you can see is here comes the algal cell and then the animal flings its second maxillae apart and squeezes them back together as it catches the particle.