Abstractions

FIRST AUTHOR

Planets form when dust particles in a rotating disk of dense gas orbiting a star clump together to form larger bodies. Scientists understand how dust grains collide to form boulders, but not how boulders assemble into planets. On page 1022, PhD student Anders Johansen at the Max Planck Institute for Astronomy in Heidelberg, Germany, and his colleagues detail a model for planet formation. It shows that turbulence in the disk creates conditions that concentrate boulders into dense clumps — a crucial step in becoming a planet.

Does your work depend on astronomical observations?

No, it is theory driven. Metre-sized boulders don't emit detectable infrared radiation. So we have to deduce amounts of gas, for example, from the planets in our Solar System (which used to be a protoplanetary disk) to reconstruct and model pre-planet conditions.

Why can't you model boulders in the same way as dust?

A boulder model must include different parameters. Unlike dust, boulders are too large to stick together and they lose orbital energy when they grow too big to flow with the gas — which causes them to fall into the star.

What is the key piece of your model?

It's Pencil Code, a collaborative, international open-source project, which was developed to solve equations describing hydrodynamic flows with magnetic fields. I added modules to factor in dust and boulder dynamics, including the boulders' gravity. One key development was to treat dust as individual particles — not as a fluid as in previous work.

What did these adjustments reveal?

Gas rotates more slowly than the boulders, and as the boulders move through the gas, this difference in speed creates turbulence. We show that the turbulence allows boulders to accumulate in higher-density pockets in the disk such that they start dragging the gas with them. This turns off the head wind that would otherwise cause the boulders to spiral inwards towards the star. Isolated boulders are then incorporated into the growing clump as they pass by.

When might your theory be confirmed?

We have to wait 5–10 years. Our model also applies to centimetre-sized bodies in the outer edges of the disc, which emit infrared radiation detectable by the Atacama Large Millimeter Array (ALMA) telescope being built in Chile. That goes online in 2012 and should be able to confirm or refute whether clumps form in pockets as we suggest. ■

MAKING THE PAPER

Catherine Dulac

Pheromone switch determines female sexual identity in mice.

Precise descriptions of female mouse behaviour are scarce. When, five years ago, Catherine Dulac and her co-workers began analysing mutant mice that lack proper pheromone processing, she was determined to spend equal time studying the behaviour of males and females.

The mice were missing an ion channel crucial for the proper functioning of the vomeronasal organ (VNO), a nasal brain projection that detects pheromones. In 2002, the team published the results of its first work with mice. "That study looked exclusively at male behaviour — somewhat to my despair," says Dulac, who is based at Harvard University. Mutant males failed to distinguish between males and females for mating. But colleagues in the field continued to ask about the female mutants.

Then postdoctoral fellow Tali Kimchi, a trained observer of wild-animal behaviour, joined Dulac's group. Kimchi began by placing a normal male together with a mutant female. In a role-reversal, the female tried to mount the male. Astonished, Dulac double-checked that it was indeed a female mouse.

This revealed an interesting twist in VNO function. In the female, loss of the organ seemed to scramble the animal's sexual identity. This, says Dulac, raised the question "what is the relationship between pheromone detection and knowing who you are sexually?"

There were two possibilities. Loss of VNO function could disrupt proper brain development of female sexual identity. Alternatively, it might reveal a 'male' behaviour circuit already present in the female brain. To test these theories, Kimchi wanted to compare genetic mutants with animals in which the VNO had been surgically removed. But Dulac was doubtful, because previous experiments that removed the VNO had been inconclusive. Keen observation by Kimchi provided a breakthrough.

Normally, animals are given one week to recover from surgery, then tested for behavioural changes. But Kimchi noticed that the mice were not moving their whiskers in the usual way when picking up olfactory cues. She discovered blood clots in their noses that blocked their normal sense of smell — an impairment sure to affect mating behaviour. To remedy the problem, she gave the animals three weeks to recover, combined with daily nasal cleaning.

Whether VNO function was ablated by genetics or by surgery, female mice showed the same high level of male-mating behaviours (see page 1009). These included mounting, pelvic thrusting and vocalizations — all of which occurred without significant changes in the animals' levels of sex hormones. The group concludes that the female brain includes the neuronal connections for male behaviour. Somehow, VNO pheromone detection acts as a switch to turn on female behaviour and/or repress male behaviour.

In this way, development can have "one common brain organization per species and the difference between male and female is just the trigger", Dulac says. She would like to find the corresponding "hidden female inside the male", but it's hard to foresee experiments to test this when males lack the anatomical requirements for birthing and lactation.

Whether the human brain is similarly wired is hard to say. Humans lack a definitive pheromone system, and human sexuality is not so strongly linked to olfaction. "We are controlled more by visual and auditory cues," says Dulac. "This is why we have something called pornography." ■

FROM THE BLOGOSPHERE

Nautilus (http://tinyurl.com/2j7fzp) highlights Wikiversity, a community for the creation and use of free learning materials and activities. Wikiversity, part of the online encyclopaedia Wikipedia, creates and hosts free content, multimedia learning materials and curricula for all ages in all languages, and will develop collaborative learning projects and communities. Teachers and 'students' (anyone wanting to learn) are invited to join the community, where anyone can edit the pages.

Wiki technology promotes collaborative webpage editing, which can be thought of as a set of 'learning projects' — participants learn as they edit and explore topics of interest.

With such open content, Wikiversity is unlikely to ever be officially recommended by schools or universities. But college students in many countries are already keen users of online educational resources, so there are certainly opportunities for educational publishers and Wikipedia to forge links between online learning resources and textbooks, and for academic teachers to consider these when recommending resources to students. ■

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