

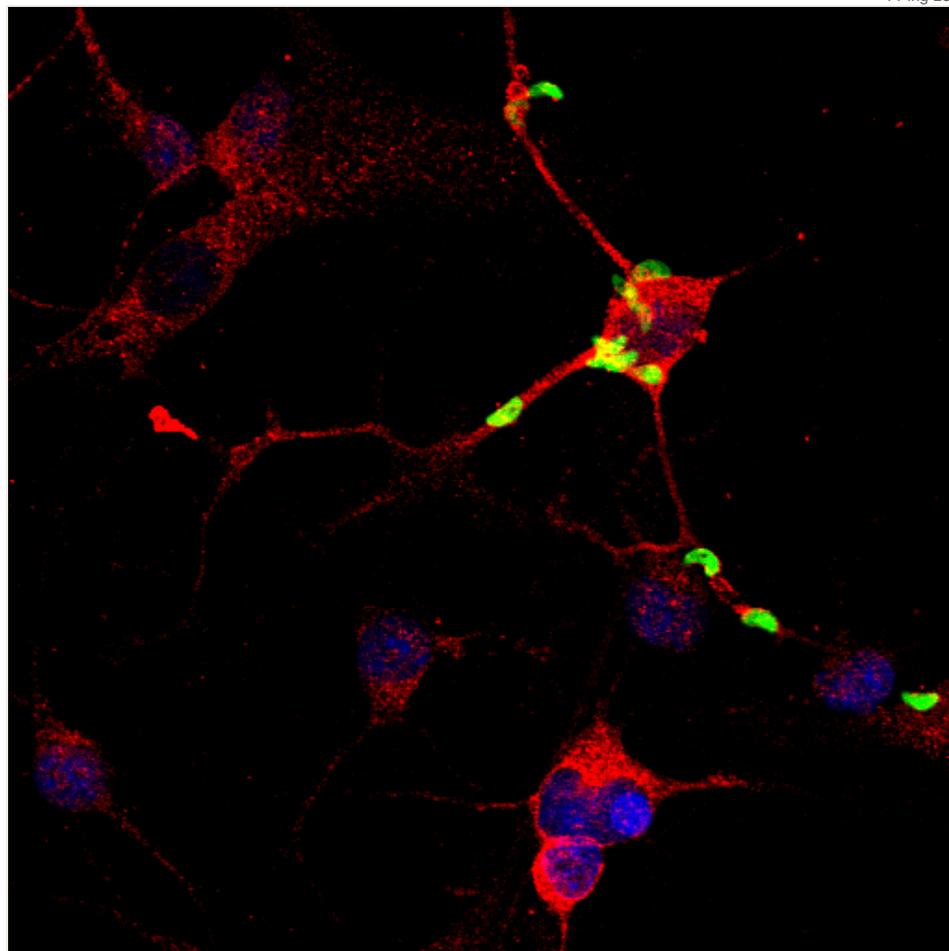
Parasite uses the power of sexual attraction to trick rats into becoming cat food

Could it be love? Rats infected with the parasite *Toxoplasma* seem to lose their fear of cats – or at least cat urine. Now Stanford researchers have discovered that the brains of those infected, fearless male rats show activity in the region that normally triggers a mating response when they meet a female rat. But that does not necessarily mean the rats find cats sexually appealing. It's a trick that *Toxoplasma* plays to have the rats eaten by cats, a clever manipulation of rat behavior that is part of the parasite's reproduction scheme.

BY LOUIS BERGERON

When a male rat senses the presence of a fetching female rat, a certain region of his brain lights up with neural activity, in anticipation of romance. Now Stanford University researchers have discovered that in male rats infected with the parasite *Toxoplasma*, the same region responds just as strongly to the odor of cat urine.

Is it time to dim the lights and cue the Rachmaninoff for some cross-species canoodling?



I-Ping Lee

"Well, we see activity in the pathway that normally controls how male rats

Individual *Toxoplasma* parasites (green) are shown invading neurons (red) grown in a petri dish in the lab. The blue areas are fluorescently tagged cell nuclei.

respond to female rats, so it's possible the behavior we are seeing in response to cat urine is sexual attraction behavior, but we don't know that," said Patrick House, a PhD candidate in neuroscience in the School of Medicine. "I would not say that they are definitively attracted, but they are certainly less afraid. Regardless, seeing activity in the attraction pathway is bizarre."

For a rat, fear of cats is rational. But a cat's small intestine is the only environment in which *Toxoplasma* can reproduce sexually, so it is critical for the parasite to get itself into a cat's digestive system in order to complete its lifecycle.

Thus it benefits the parasite to trick its host rat into putting itself in position to get eaten by the cat. No fear, no flight – and kitty's dinner is served.

House, the lead author of a paper about the research published in the Aug. 17 issue of [Public Library of Science ONE](#), works in the lab of Robert [Sapolsky](#), a professor of biology and, at the medical school, of neurology and neurological sciences.

Scientists have known about *Toxoplasma*'s manipulation of rats for years and they knew that rats infected with *Toxoplasma* seemed to lose their fear of cats.

It is an example of what is called the "manipulation hypothesis," which holds that some parasites alter the behavior of their host organism in a way that benefits the parasite. There are several known examples of the phenomenon in insects.

But the details of how the little single-celled protozoan *Toxoplasma*, about a hundredth of a millimeter long, exerts control over the far more sophisticated rat have been a mystery.

Sapolsky's group previously determined that although the parasite infects the entire brain, it shows a preference for a region of the brain called the amygdala, which is associated with various emotional states. Once in the brain, the parasite forms cysts around itself, in which it essentially lies dormant.

House was interested in how the amygdala is affected by the parasite, so he ran a series of experiments with both healthy and *Toxoplasma*-infected rats. He exposed each male rat to either cat urine or a female rat in heat for 20 minutes before analyzing its brains for evidence of excitation in the amygdala.

For the experiments, he used cat urine he purchased in bulk from a wholesaler. No actual cats participated in the experiments.

House analyzed certain subregions of the amygdala that focus on innate fear and innate attraction.

In healthy male rats, cat urine activated the "fear" pathway.

But in the infected rats, although there was still activity in the fear pathway, the urine prompted quite a bit of activity in the "attraction" pathway as well. "Exactly what you would see in a normal rat exposed to a female," House said.

"*Toxoplasma* is altering these circuits in the amygdala, muddling fear and attraction," he said.

The findings confirmed observations House made during the experiments, when he noticed that the infected rats did not run when they smelled cat urine, but actually seemed drawn to it and spent more time investigating it than they would just by chance.

Although House doesn't have the data yet to speculate on just how the cysts in the rats' brains are causing the behavioral changes, he is impressed with what *Toxoplasma* can accomplish.

"There are not many organisms that can get into the brain, stay there and specifically perturb your behavior," he said.

"In some ways, *Toxoplasma* knows more about the neurobiology of fear than we do, because it can specifically alter it," Sapolsky said.

Because *Toxoplasma* reproduces in the small intestine of cats, the parasites are excreted in feces, which is presumably how rats get infected. Rats are known to be extremely curious, tasting almost everything they come in contact with. *Toxoplasma* is also frequently found in fertilizer and can infect virtually any mammal.

Approximately one third of the world's human population is infected with *Toxoplasma*. For most people, it appears to present no danger, although it can be fatal in people with compromised immune systems. It also can cross the placental barrier in a pregnant woman and lead to many complications, which is why pregnant women are advised not to clean cat litter boxes.

House said humans acquire the parasite by eating undercooked meat or "eating little bits of cat poop, which I suspect happens more often than people want to admit." Or know.

Although *Toxoplasma* has not been shown to have any ill effects in most people, one can't help but wonder whether it truly has no effect in humans.

"There are a couple dozen studies in the last few years showing that if you have schizophrenia, you are more likely to have *Toxoplasma*. The studies haven't shown cause and effect, but it's possible," House said. "Humans have amygdalae too. We are afraid of and attracted to things – it's similar

circuitry."

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