NEWS & VIEWS

PLANETARY SCIENCE

Titan's lost seas found

Christophe Sotin

When the Cassini spacecraft found no methane ocean swathing Saturn's moon Titan, it was a blow to proponents of an Earth-like world. The discovery of northern lakes on Titan gives them reason for cheer.

The saturnian moon Titan is the second largest satellite in the Solar System, trumped only by Jupiter's Ganymede. It is the only Solar System satellite with a dense atmosphere, which produces a surface pressure 1.5 times that at Earth's surface. And it shares with Earth the peculiarity that nitrogen is the principal component of its atmosphere. The list of similarities does not end there, and, as Stofan *et al.* report[1], it has just been augmented. The authors' account of what seem to be lakes at high northern latitudes on Titan appears on page 61 of this issue.

The lakes are not formed of water, as they would be in earthly climes, but of the second most abundant component of Titan's atmosphere, methane (CH_4). The bounteous presence of methane and aerosols in Titan's enveloping cloak hides the surface of the moon at visible wavelengths. For this reason, little was known about Titan's inner life before the arrival of the joint NASA/European Space Agency Cassini–Huygens mission in the Saturn system on 1 July 2004.

The lifetime of methane is short on geological timescales: the molecule lasts some tens of millions of years before it becomes dissociated by sunlight. Before the first results arrived from Cassini–Huygens, two hypotheses had been advanced to explain how, in the face of this slow depletion, Titan replenishes its atmospheric methane. First, that a methane-rich hydrocarbon ocean covers Titan's solid surface, and supplies the atmosphere in a cycle of evaporation and condensation[2]. Alternatively, that underground methane reservoirs exist just below the surface or deep in Titan's interior, which deliver methane to the outside through 'cryovolcanic' processes or when the surface is punctured by meteorite impacts. The first of these pictures was the more popular, and would have made Titan even more similar to Earth, with the extraordinary shared feature of a surface ocean. The Huygens probe, which was to be released by the Cassini spacecraft as it flew past Titan, was designed to survive for several minutes on reaching the assumed ocean's surface.

On 26 October 2004, a couple of months before it did release Huygens, Cassini performed its first close fly-by of Titan, skimming its atmosphere 1,174 kilometres from the surface. Three remote-sensing instruments trained on the surface failed to detect a global ocean. What they detected instead was even more fascinating: impact craters, mountains, cryovolcanoes, dunes and river beds[3]. The lack of a global ocean and the discovery of these surface features, together with characteristics of Titan's atmosphere such as its nitrogen and carbon isotopic ratios[4], strongly implied that the source of the atmospheric methane was internal. With Stofan and colleagues' discovery[1] of lakes at northern latitudes, the pendulum starts to swing the other way once more.

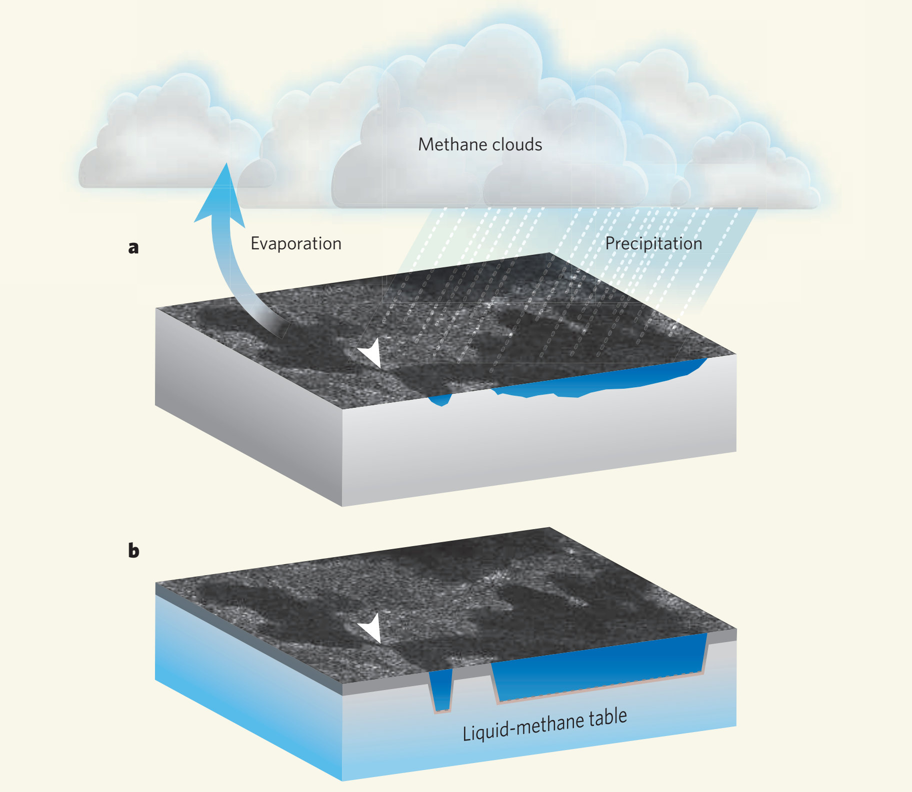

Figure 1 | Routes to Titan's lakes. The lakes discovered by Stofan *et al.*[1] might be either **a**, filled by methane rain, either directly or through river inflow, or **b**, in depressions filled from an underground liquid-methane table. The surface images are taken by the Cassini spacecraft, and seem to show liquid bodies, two of which are connected by a channel (arrow). (Cassini image taken from ref. 1.)

Their report is based on observations made by Cassini's radar instrumentation in July 2006. These revealed around 75 radar-dark patches, ranging from 3 to 70 km in size, at latitudes between 70° N and 83° N. Such dark areas are characteristic of very smooth surfaces. Their liquid nature is inferred from the presence of channels leading to them, seeming to indicate that rivers supply at least part of the liquid. Although the composition of the liquid cannot be determined from radar observations, methane is the most plausible candidate: it is one of few molecules to be liquid under the conditions of Titan's surface.

The findings provide further strong evidence, complementary to that inferred from the river beds observed by the Huygens probe during its descent[5], that methane on Titan plays the role of water on Earth: liquid methane evaporates; the vapour eventually condenses; and rainfall replenishes the surface liquid (Fig. 1a). An alternative is that the surface liquid comes from a 'liquid-methane' table that fills in the topographic lows of the surface (Fig. 1b). By comparison with the morphologies of terrestrial lakes, the authors suggest that the depressions could be impact craters, volcanic calderas or the sinkholes (dolines) characteristic of karst landscapes. Such landscapes are formed on Earth by the dissolution of carbonate rocks by rainwater.

The fact that lakes are found only at high latitude in Titan's northern hemisphere seems to indicate that they expand during the winter and shrink in the summer as a result of increased evaporation (it is winter in Titan's northern hemisphere at the moment). This cycle is linked to the 29.5 years it takes Saturn to orbit the Sun. On longer timescales, Titan's atmosphere might also be replenished in methane by cryovolcanic activity, as geomorphological features observed by Cassini imply[6].

The Cassini mission is now halfway to the end of its nominal mission, and the detailed morphology of Titan's surface is becoming steadily clearer at each fly-by. Like a giant puzzle, our understanding of Titan's dynamics is coming together as we connect the pieces. There will undoubtedly be other discoveries during the next 22 Titan fly-bys, the next of them due on 13 January. By the end of the planned mission, however, Cassini's radar will have covered only 15% of Titan's surface, and its Visual and Infrared Mapping Spectrometer just a few per cent, at a resolution of less than a kilometre per pixel. An extended mission, currently under discussion, is necessary to gain better coverage of Titan's surface. Cassini's optical and infrared instrumentation could then also be used to monitor the evolution of the northern lakes — currently shrouded in the darkness of the titanian winter — as they enter the Saturn system's summer season next year.

Stofan and colleagues' findings[1] add to the weight of evidence that Titan is a complex world in which the interaction between inner and outer layers is controlled by processes similar to those that must have dominated the evolution of any Earth-like planet. Indeed, as far as we know, there is only one planetary body that displays more dynamism than Titan. Its name is Earth. ■

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NEUROBIOLOGY

Scent secrets of insects

Rachel I. Wilson

The perception of carbon dioxide provides insects with sensory data on their environment, and informs many insect behaviours. It seems that this sense relies on two dedicated neural receptors.

We inhabit a different sensory universe from that of many of the animals around us. We are deaf to high-pitched sounds that dogs perceive, blind to ultraviolet light that honeybees see, and numb to electric fields that sharks feel. And there is a world of chemicals swirling around us that we cannot smell, but that carry pungent signals for other species.

One such signal is carbon dioxide, which many insects sense through specialized neurons. At very high concentrations, CO_2 can be perceived by the human nose — recall the last time you opened a can of carbonated soda and sniffed before sipping. But many insects are exquisitely sensitive to concentrations we never notice, and monitoring CO_2 levels in the environment is crucial to many insect lifestyles. For example, some ticks can detect CO_2 fluctuations as small as 20 parts per million[1]; for a blood-sucking insect, elevated CO_2 means that a potential host animal might be nearby. Inside a beehive, high CO_2 levels mean that ventilation is needed to improve air quality[2]. But the molecular basis of CO_2 sensing in insects has remained a mystery.

On page 86 of this issue, Jones *et al.*[3] report the identification of two receptor proteins that together are required for CO_2 perception in the fruitfly *Drosophila melanogaster*. This advance contributes to our understanding of the way in which very small volatile molecules such as CO_2 are sensed by cells, and it has the potential to facilitate innovative insect control strategies.

The perception of volatile chemicals begins when molecules in the air interact with receptor proteins on the surface of olfactory neurons. In fruitflies, these neurons reside in two specialized organs, the antennae and the maxillary palps (Fig. 1). Among the approximately 1,200 olfactory neurons in each antenna are 45 CO_2-sensitive neurons. Whereas most other antennal neurons are activated by several different volatile chemicals, CO_2-sensing neurons in fruitflies respond to just this one stimulus[4]. These neurons do not express any of the olfactory receptor genes that are responsible for sensing other odours. Instead, previous work showed that they express a receptor that is similar to taste receptors, so it was classed as a gustatory receptor (GR)[5,6], even though it is evidently unrelated to taste. The gene encoding

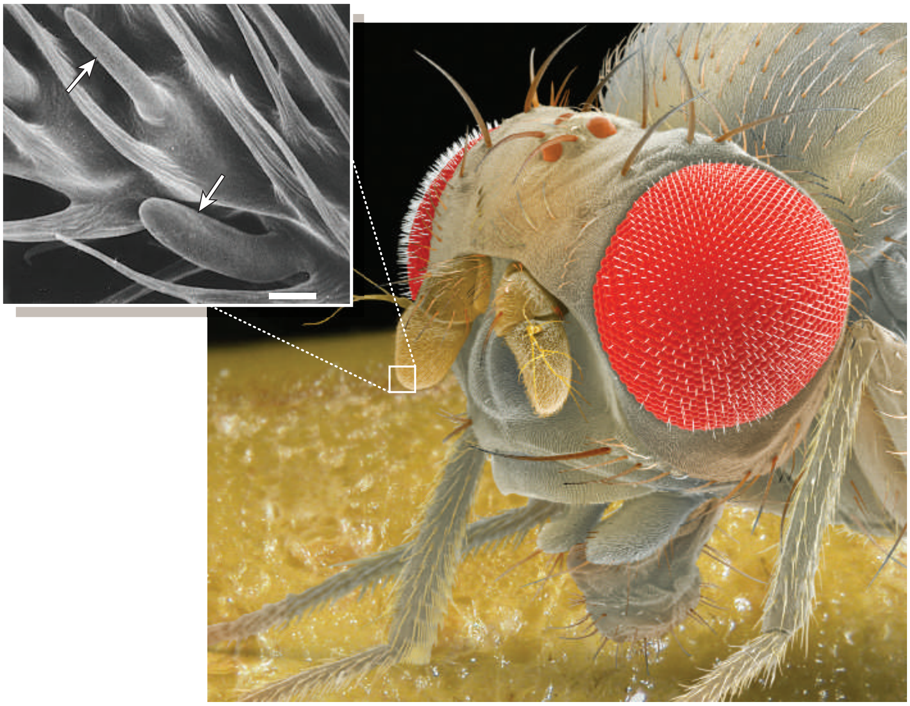

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Figure 1 | **Sensing carbon dioxide.** The fruitfly *Drosophila* has carbon dioxide-sensitive neurons on its antennae (inset, arrows). Inset: scale bar, 0.2 μm; reproduced from ref. 12.