Captain James Cook's first voyage to Tahiti was one of many expeditions to use the 1769 transit of Venus to measure the distance from Earth to the Sun.

CAPTAIN G. TOBIN (1768–1838)/MITCHELL LIB. STATE LIB. OF NSW/THE BRIDGEMAN ART LIB.

ASTRONOMY

On the track of the transit

Owen Gingerich enjoys two histories of the expeditions that aimed to measure the passage of Venus across the face of the Sun.

Chasing Venus: The Race to Measure the Heavens
ANDREA WULF
Knopf/William Heinemann: 2012. 336 pp. $26.95/£18.99

The Day the World Discovered the Sun: An Extraordinary Story of Scientific Adventure and the Race to Track the Transit of Venus
MARK ANDERSON
Da Capo: 2012. 304 pp. $26, £17.99

The bright planet Venus put on a dazzling evening show when it passed Jupiter in March, but it will soon drop into the sunset. The transition from evening to morning star — which occurs when the planet overtakes Earth, every 584 days on average — usually goes unnoticed, the planet running just above or below the solar disk. But this year it will transit right across the face of the Sun, visible on 5 June in the United States (including Alaska and Hawaii) and on 6 June on the other side of the International Date Line (including in Europe). This rare phenomenon will not be repeated until 2117.

A transit of Venus is visible to the naked eye, but staring at the Sun without a filter is not recommended. Such transits passed unobserved until 1639, when the tables of planetary motion became good enough for Englishman Jeremiah Horrocks to anticipate and view one. In 1716, the astronomer Edmond Halley pointed out that transits of Venus simultaneously observed from far-flung points on Earth could be used to determine the distance to the Sun, which at the time had been only roughly guessed.

Transits of Venus come in pairs, 8 years apart, at intervals of more than a century, so the earliest opportunities to test Halley's idea came in 1761 and 1769. The eighteenth century was an age of exploration, and countries vied with each other to send expeditions to remote parts of Earth to capture the essential astronomical data — and to see what else could be found. Nowadays, the distance to the Sun has been securely established by other methods (including radar), but the transits remain rare touristic occasions, and writing about their history has become a cottage industry. Two excellent accounts are among this year's yield, both concentrating on the heroic eighteenth-century expeditions.

Historian Andrea Wulf's *Chasing Venus* is beautifully paced, alternating between expeditions, with lush descriptions of the often arduous journeys involved. She describes each group's experiences in the climactic days of the transits, some meeting disappointment as clouds ruined their pursuits. Perhaps no story was more frustrating than that of French astronomer Guillaume Le Gentil. He had intended to view the 1761 transit from India, but the English had captured the port of his destination. During the transit he found himself on the high seas without the use of his pendulum clock or an established location, so his observations were useless.

Le Gentil stayed in Asia for 8 years to wait for the second transit of the pair, exploring as far as Manila until the French Academy of Sciences ordered him back to India for the 1769 conjunction. The weather was perfect until the day of the transit, and then clouds appeared. To rub salt into the wound, the sky was clear in Manila.

Journalist Mark Anderson's arresting *The Day the World Discovered the Sun* begins with the 1761 transit, but concentrates on the three most significant journeys of the 1769 event. These were Captain James Cook's voyage to Tahiti; the Hungarian Jesuit Maximilian Hell's frigid journey to Vardø, above the Arctic Circle in Norway; and French astronomer Jean-Baptiste Chappe d'Auteroche's sweaty and insect-ridden expedition to San José del Cabo in Baja California, present-day Mexico. Anderson serves up a rich broth ▶

of details — such as that British sailors did not have soap in their rations until the 1780s, or that Cook's small ship *Endeavour* had more than 90 people on board, in part because it was expected that half the crew on a round-the-world trip would die of scurvy. (In the event, Cook engaged in a medical experiment with a diet of sauerkraut for the crew, and not a single sailor was lost to the condition.)

Both Wulf and Anderson give much attention to Chappe, the only observer to time the entrance and exit of Venus on both transits. Chappe wrote vivid and extensive travel notes, which both authors use to great effect. His wide-ranging interests would have made him, thinks Anderson, the French Benjamin Franklin. Alas, in a scene drenched with pathos, Chappe died of typhus within two weeks of writing his last journal entry in Baja California.

Unfortunately, neither book explains in simple terms why the astronomers were so keen to record to the second when Venus entered and exited the solar disk. They were triangulating the distance to the Sun with long skinny triangles, the base being the separation of the stations on Earth — which is why it was crucial to know the terrestrial coordinates of the stations.

Venus provided a reference point by which apparent positions on the Sun's face could be measured from two different locations. The duration of the passage gave the length of the path across the Sun, which could then be fitted uniquely onto the observed solar disk. The angular separation of the apparent lines of transit as seen from two different stations, plus the relative distances of Venus and Earth from the Sun and the distance between the two stations, then yielded the distance to the Sun. The numbers from the three principal stations (Tahiti, Vardø and San José del Cabo) gave a mean distance within 1% of the 149,598,000 kilometres accepted today.

The eighteenth-century efforts to track the transit helped to establish the distance to the Sun, but the accuracy was far from what astronomers had hoped for. The results of the campaigns to track the next pair of transits, in 1874 and 1882, were better but still ambiguous. Yet these simultaneously competitive and cooperative efforts set the international stage for our now-accurate measure of the solar distance — the baseline from which all cosmic distances, and ultimately the age of the Universe, are reckoned. ■ SEE COMMENT P.303

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WESTEND61/REX FEATURES

Breast milk aided the evolution of the large human brain — but it can contain toxins.

BIOLOGY

Mammary chronicles

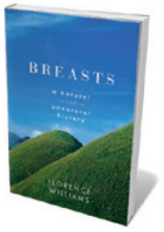
Josie Glausiusz celebrates an environmental history of the human breast.

The breast looms large in human culture and biology. The essential proteins and long-chain fatty acids in breast milk help to build babies' big brains, and the cornucopia of other components, such as virus-slaying macrophages and oligosaccharides that feed beneficial bacteria in the baby's gut, offer crucial immune protection. Unfortunately, breast milk can also contain pesticides, mercury, benzene and minuscule amounts of paint thinners, dry-cleaning fluids, rocket fuel and flame retardants.

This contaminant-crammed elixir is uniquely modern, as Florence Williams details in *Breasts*. This is no salacious tell-all, but a lively, absorbing, meticulously researched book covering all aspects of breasts, from anatomy to their role in evolution, attraction and infant bonding; changes during puberty, pregnancy and cancer; and Western society's passion for flaunting, grading and inflating them. At heart, however, the book is an environmental history of "how our breasts went from being honed by the environment to being harmed by it".

Williams, a US science journalist, uses her own body as a research tool. She sends her milk to Germany to be tested for flame retardants, delves into her family history of breast cancer and visits a suave Texas surgeon for advice on silicone breast implants. To mimic a study on early puberty, she and her seven-year-old daughter, Annabel, valiantly try to give up plastic-wrapped food as well as products containing endocrine-disrupting phthalates — including Williams's car.

Intimate explorations of breast biology have a distinguished history. In 1840, British surgeon Astley Cooper published *The Anatomy and Diseases of the Breast*, in which he observed — after injecting dyes into more than 200 disembodied breasts — that blood is transformed into milk in grape-like lobules, inside tissue cavities called alveoli. The milk then enters a network of lobes that empty into 12 or so orifices in the nipple.



Breasts: A Natural and Unnatural History
FLORENCE WILLIAMS
Norton: 2012. 352 pp. $25.95, £16.99)

Unlike any other organ, human breasts do most of their development well after birth. These plump orbs are also unique in that no other primate is so endowed: females of other species develop swellings only during lactation. Evolutionary biologists have devised elaborate stories to explain the permanent adult presence of human breasts; the most popular is that they are an adornment, like a peacock's train, for attracting the opposite sex. Williams leans more towards the ideas of anthropologist Frances Mascia-Lees, who posits that breasts' ever-present fat reserves are easily mobilized during lactation to keep pace with the baby's rapidly growing brain.

The immune support offered by human breast milk is formidable. The average new mother produces roughly 454 grams of milk from each breast every 24 hours. This elixir is not unlike cultured yoghurt, carrying 100–600 species of live bacteria, most new to science. (Mysteriously, the US National