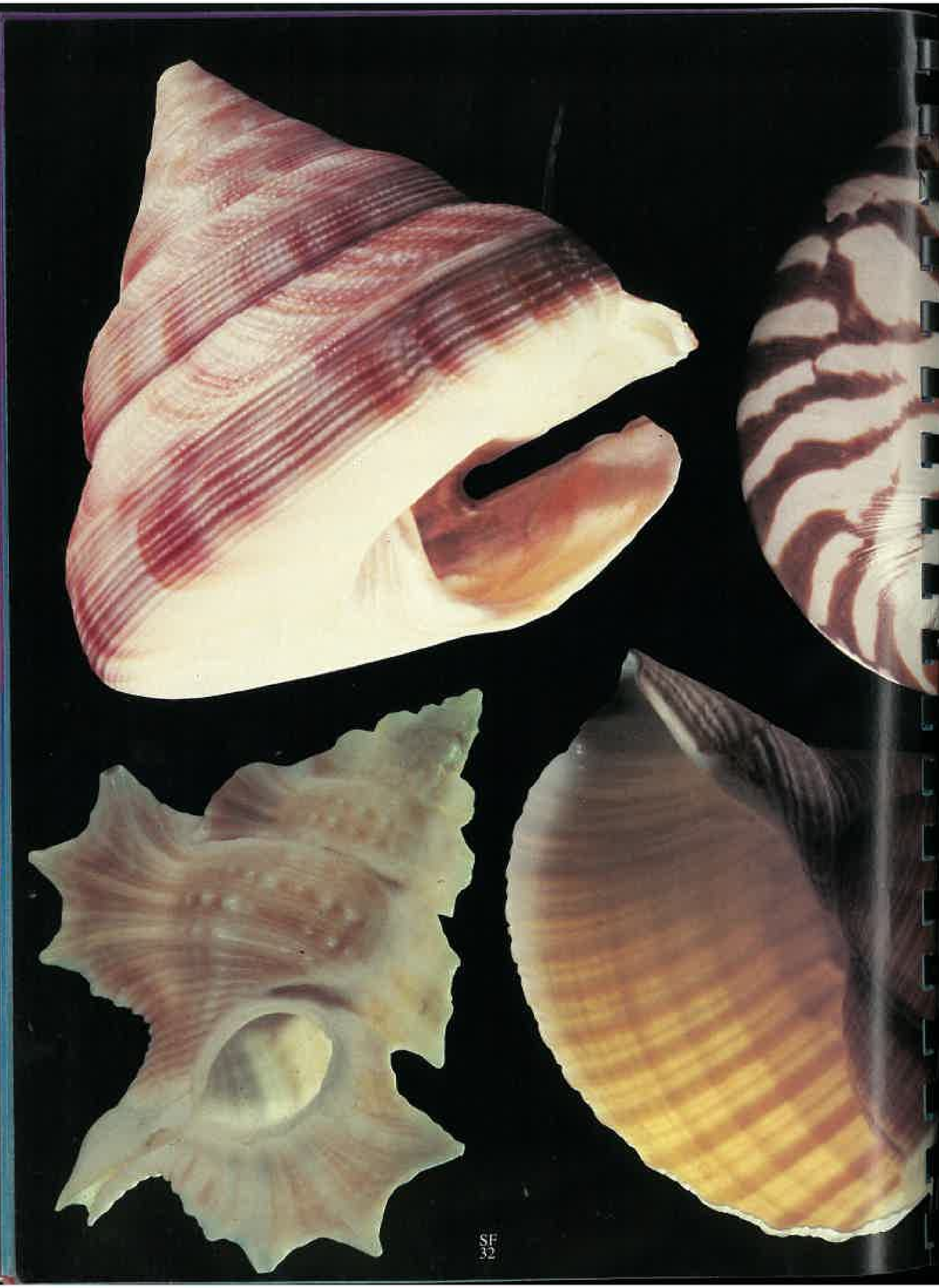

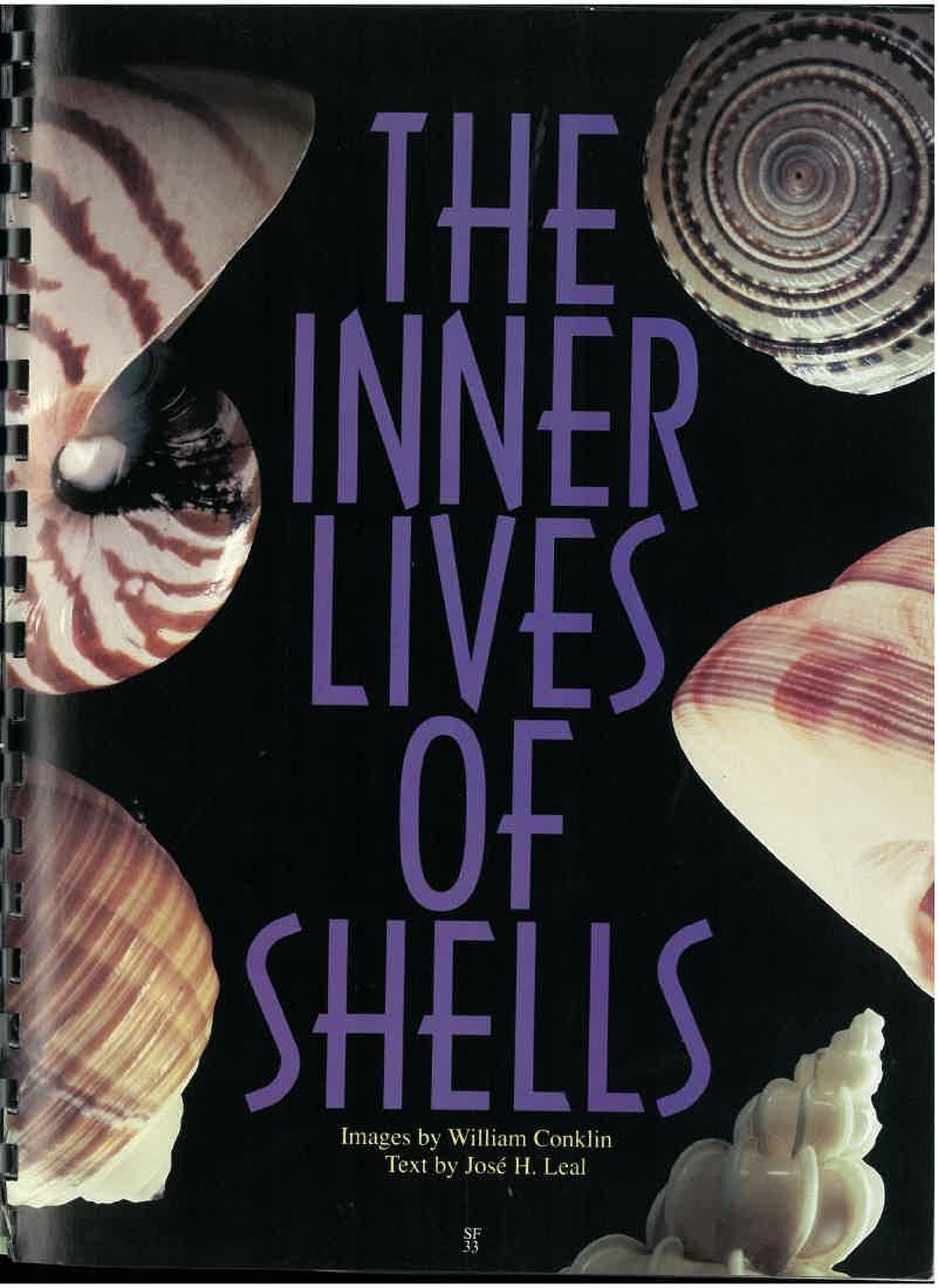

THE INNER LIVES OF SHELLS

Images by William Conklin
Text by José H. Leal

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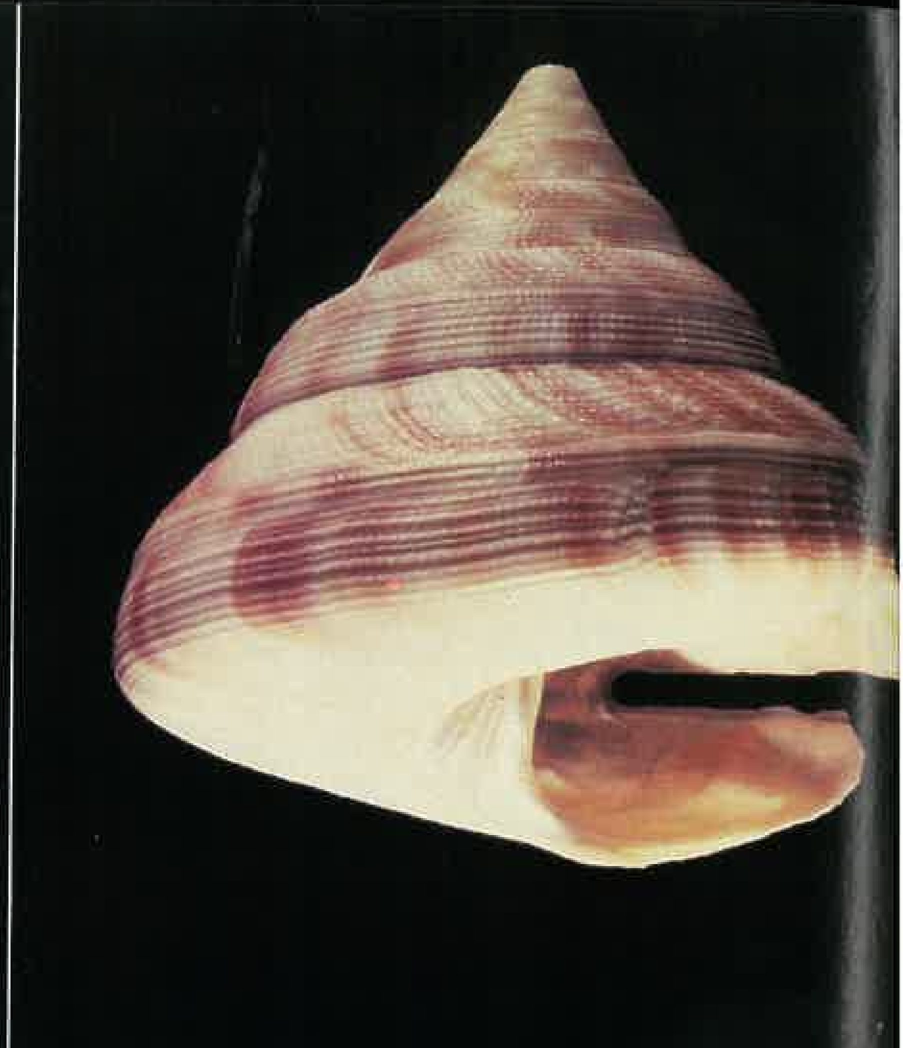
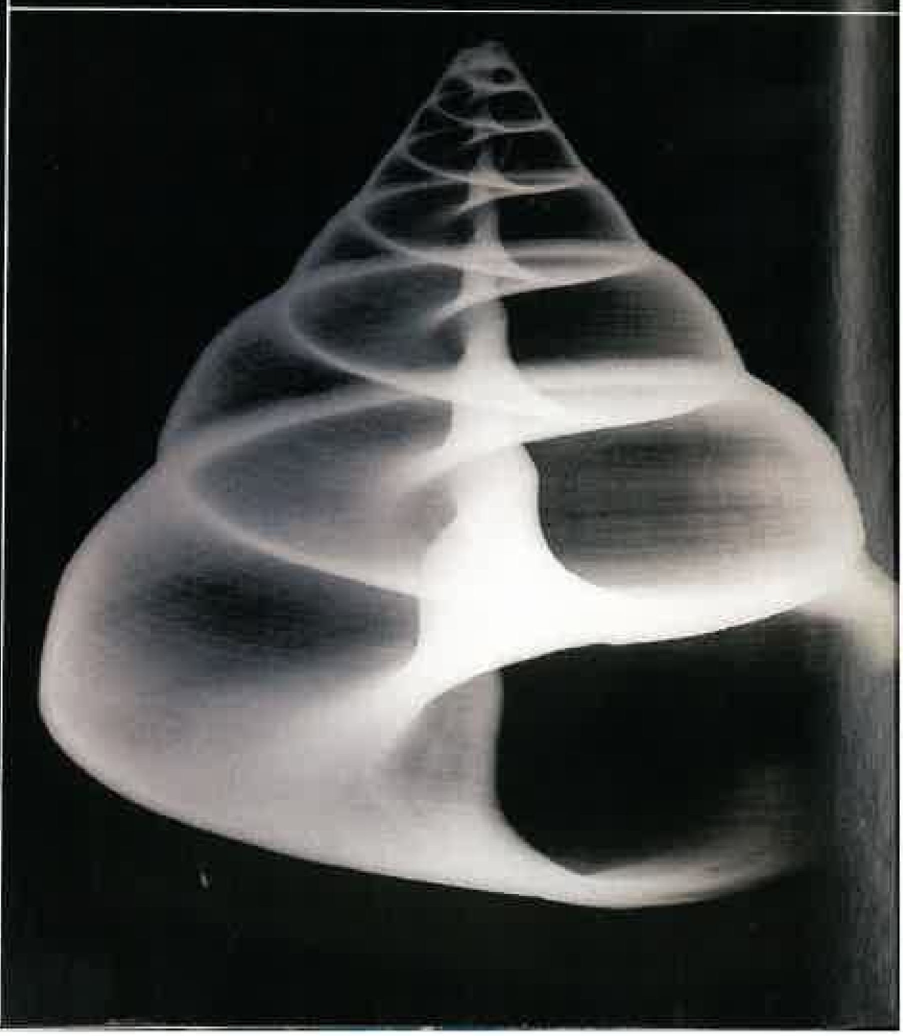
Eerily beautiful, X-ray images of seashells help explain the structural evolution of some extraordinary animals. The universe of shells is filled with variety. Shapes range from flattened limpets to elongated spindle shells and include globose moon snails, bizarre star shells, and disklike sundials. Yet, an underlying, common pattern is present that links all this diversity. The basic structures and growth patterns of molluscan shells stem from the mutual ancestry that apparently all mollusks share.

Molluscan shells are built by the soft animals living inside them to provide protection against predators, parasites, and the environment. Mollusks remove calcium from seawater and use it to manufacture microscopic calcium carbonate crystals—their building blocks. Crystals are deposited at the shell opening, which is progressively enlarged as the snail grows. Most snails and some cephalopods build shells like very long ice-cream cones that curl up on themselves. Some ancient, extinct gastropods and cephalopods built uncoiled, tubelike





EMPEROR'S SLIT SHELL

shells, but these ungainly covers grew too long and cumbersome to carry around. As an evolutionary response, animals began to coil their long cones into a more manageable package. Coiling offered the elegant solution to managing the burden of too much protection.

Changes in the angles of coiling, the shape of the cross-section of the cone, the rate at which the openings expand, and the degree of overlapping of two successive whorls help determine the general shape a grown-animal's shell will take. In the late 1910s, the British naturalist and mathematician D'Arcy Wentworth Thompson first defined shell-growth parameters. Since then, mathematicians, biologists, and computer specialists have further explored these dimensions and angles to invent formulas that describe, in a formal, scientific fashion, the way shells grow and acquire their exquisite shapes.

Much of what they describe can be seen in the X-ray images on these pages. William Conklin, a radiography technician for 27 years, knows

SUNDIAL SHELL

plenty about X-raying human bones, and he has transformed what he knows into an art. He says: "Anyone who is familiar with X-ray technology remembers an old-fashioned film that was great for detail, but not good for contrast. This film is no longer used by hospitals, but I have a lot of it."

Conklin is welcomed back to work at night in his local hospital, when the radiographic equipment is not in ordinary use. He brings his shell collection, X rays his shells, and then brings home the X rays to photograph them with Panatonic ASA 32 film. He develops the Panatonic with high-contrast chemicals and prints on very high-contrast paper. The black-and-white results offer both great detail and good contrast.

To shoot his shells in color, Conklin invented an array of equipment to enhance an in-house studio. He built platforms and hangars that suspend the shells in space, and he manipulates four fluorescent tube lights to get a three-dimensional effect in his portraits. He shoots his color shell studies with Kodachrome ASA 25, using a Pentax Super ME 1.4 and a 50 macro lens.

CHAMBERED NAUTILUS

The spiral shell of the chambered nautilus (*Nautilus pompilius*) resembles an ice-cream cone tightly wrapped along a plane, around an imaginary point. Its lines mimic the results of the work of tidy people when they roll up their garden hoses neatly near the backyard water spigot. Its X ray offers hints to the animal's name: The nautilus shell is successively partitioned into separate chambers. The animal occupies only the last chamber; others are partially filled with water and the gas that help maintain adequate buoyancy for vertical displacement. Living nautiluses move vertically by controlling the relative amounts of nitrogen gas and water in their chambers. They pump or remove nitrogen through a tubelike organ called a siphuncle that runs inside the chambers.

The giant tun (*Tonna galea*) is a formidable predator of sea urchins and other echinoderms, which it engulfs and digests with the aid of acid secretions. Its shell is relatively thin and sculpted with numerous channels so deeply impressed that they can be seen on the shell's internal surface.

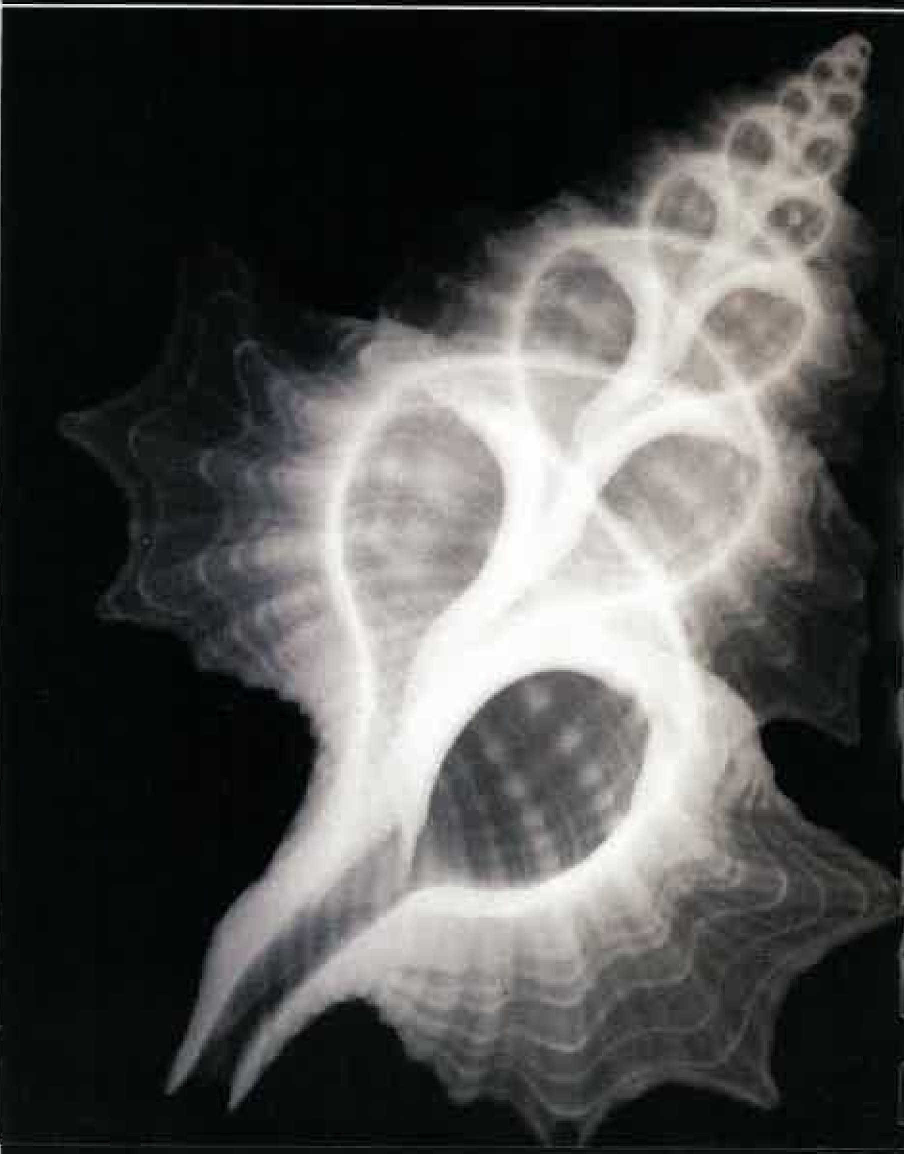
GIANT TUN

The X-ray image of the giant tun reveals that earlier growth stages are perfect miniatures of the final product.

The pure-white precious wentletrap (*Epitonium scalare*) was considered by British shell-studies historian Peter Dance to be "the most desirable shell known in Europe." In the 18th century, the precious wentletraps became the subject of fine, elaborate forgeries handcrafted from rice paste. Like the chambered nautilus, their shells take the shape of a cone coiled around an axis. Here, the X-ray image confirms what has been only hinted at by the color photograph: Successive coils, or whorls, do not touch each other. Only the thin sculptural ribs, known as varices, join one whorl to the next.

Varices also support the shell of the maple leaf triton (*Biplex perca*). In contrast to about ten varices per whorl of the precious wentletrap, only two support the maple leaf triton, giving this shell the flattened appearance of a dry maple leaf. The X ray emphasizes the gradual thinning of the varices toward the periphery.

MAPLE LEAF TRITON



The sundial *Architectonica* lacks a solid columella. The resulting hollow central chamber of the shell, when viewed from below, resembles the spiral staircases in old buildings.

The impressive emperor's slit shell (*Mikadotrochus*) belongs to a family of marine snails that first appeared about 220 million years ago in the Triassic period. Because they are geologically very old, have a striking appearance, live in deep water, and are very hard to get, slit shells are a prize catch both for collectors and biologists. Shell collectors usually are dazzled by the superb, many-hued, nacreous shells. By studying a live slit shell, biologists have a rare chance to examine a relict animal that seems to have changed little over time. The slit that gives the snail its popular name allows the animal to direct body-waste water away from the shell aperture, where the head and sense organs are located.

***William Conklin's work has been exhibited at major U.S. science museums. It also has appeared in many publications, including his book* Nature's Art.**

PRECIOUS WENTLETRAP