



A WORLD IN

ONE

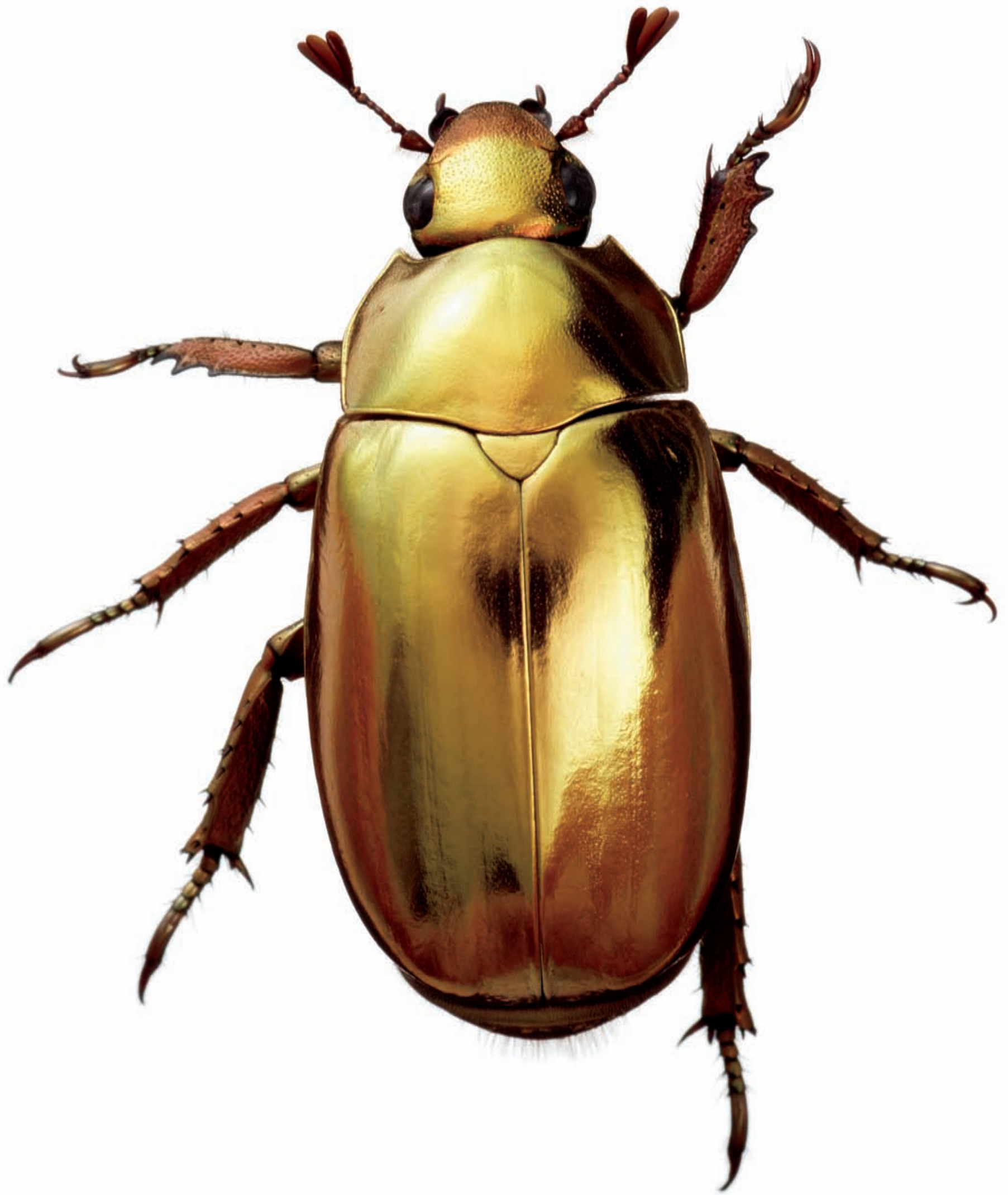
PORTRAITS OF
BIODIVERSITY

FOREWORD BY
E. O. WILSON

CUBIC

FOOT

DAVID LIITTSCHWAGER



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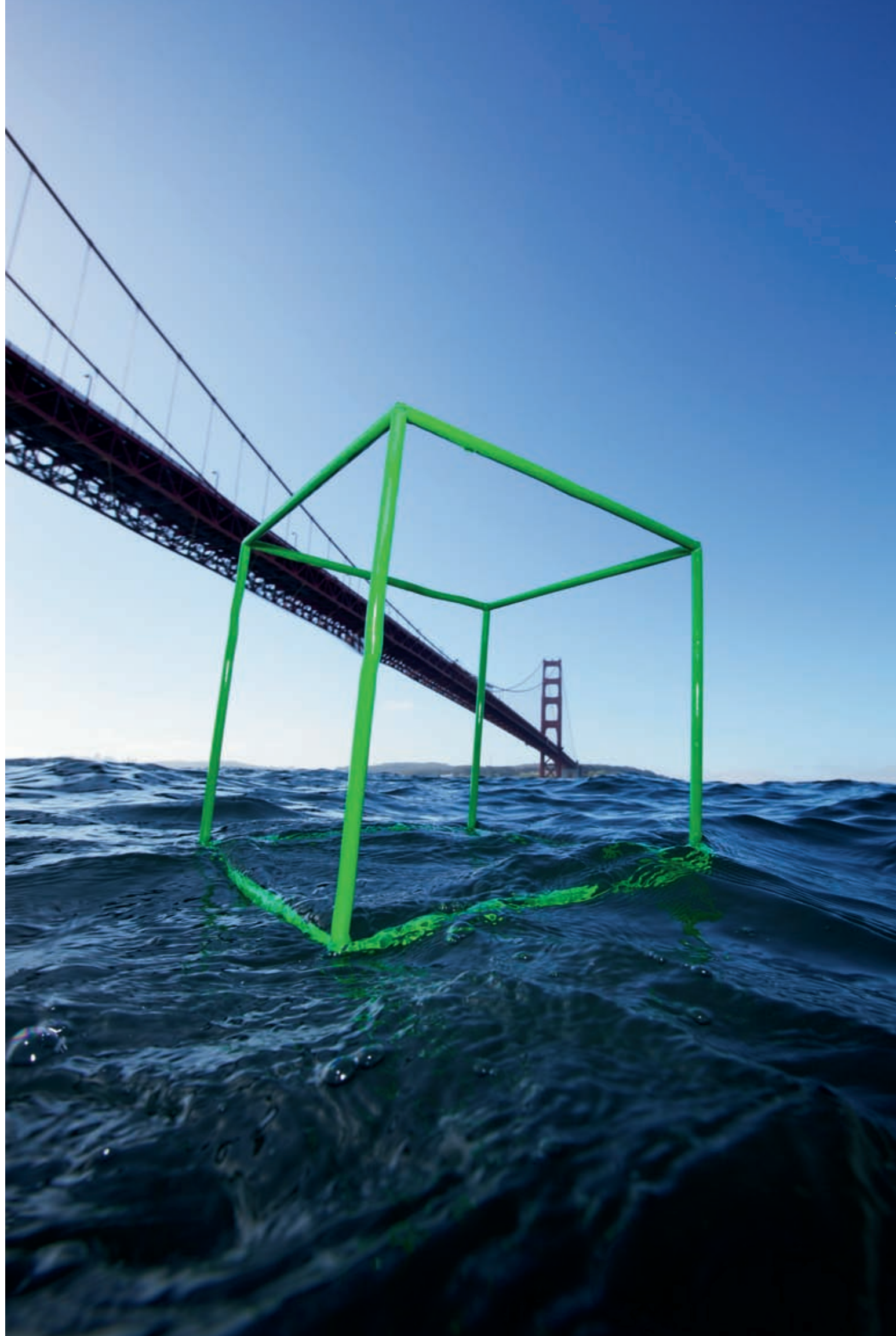


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In the Golden Gate, a mile-wide maw of currents churned by the confluence of the Pacific and San Francisco Bay, the cube wasn't anchored in place, as in other locations. Instead, it demarcated an imaginary yet precise location—150 yards southwest of the north tower of the Golden Gate Bridge. Here the Bay is about 99 percent salt water, 1 percent fresh, feeding in from the Bay's two main tributaries, the San Joaquin and Sacramento. David used a sailboat towing plankton nets and pushing at two knots against the tides to take samples of what might possibly swim, drift, or wiggle in and out of the cube. One of the nets was super-fine mesh, its opening less than a foot across. But it brought up half a million creatures a minute—larvae of all kinds, tentacled hydra, buttonlike diatoms. Extrapolate out to what a cubic foot could capture, and you'd get something like 1.8 million creatures a minute.



UNDER THE GOLDEN GATE BRIDGE, SAN FRANCISCO, CALIFORNIA

“What do you think, Subhuti? Are there many particles of dust in the 3,000 chiliocosms?”

— *The Buddha*

“Very many, World-Honored One.”

— *Subhuti*

From the *Vajracchedika Prajnaparamita*—or *Diamond*—*Sutra*

A couple of turkey vultures, wings unfurled like spinnakers, dry and groom themselves in the late morning sun atop Yellow Bluff.

Below them to the south the deck of the Golden Gate Bridge vibrates with automobile traffic: sedans, hatchbacks, El Caminos, Pintos, Cabriolets, blue, red, white, gray, black, countless variations thereof—40 million a year, nowadays, and around two billion total since the bridge went up in April 1937.

Inside the metal and plastic vehicle housings are “sentient beings,” in whose housings of bone and tissue imaginings, dreams, and phantom conversations are being played and replayed, as all the while their senses are taking in the spectacle of the Bay, its headlands, its islands—billions of neurons squirting, firing, making their passage through dark archways and into adjacent realms.

“Subhuti, if there was as many Ganges Rivers as the number of grains of sand in the Ganges, would you say that the number of grains in all these Ganges Rivers is very many?”

— *The Buddha*

“Very many, indeed, World-Honored One.”

— *Subhuti*





Worm larvae, copepod larvae, and diatoms
.003"-.03" (.08-.8 mm)



Ochraceous Wren

Troglodytes ochraceus

3.15" (8.0 cm) long



Geometer moth
Leuciris fimbriaria
0.35" (0.9 cm) long

Reef creatures seem a cartoonist's doodlings come to life, from a translucent postlarval octopus to a brown-eyed polychaete worm. Like its residents, the reef grows best in clean, sun-drenched water with no sediment. At Temae Reef off the Pacific island of Moorea, Liittschwager worked with scientists from the Moorea Biocode Project—a venture to inventory every species on Moorea large enough to be gripped in the finest tweezers. He photographed more than 600 individuals, not counting the plankton swarm that sent tens of thousands of shrimplike hatchlings drifting through the cube one moonless night. Biocode researchers are conducting DNA sequencing on Liittschwager's collection, part of a larger effort to assign a unique identifier to each species. "Such detail will give us a new way to look at the ecosystem," says Smithsonian research zoologist Chris Meyer. This small survey only hints at the reef's full diversity: Many animals flee during sampling and, Meyer says, "if you moved the cube over just a few feet, a third of your finds might be different."



TEMAE REEF, MOOREA, FRENCH POLYNESIA

CORAL REEFS are sometimes compared to cities and sometimes to rain forests. Both comparisons are apt, which gives you an idea of how extraordinary they are—and how hard to categorize. Reefs are part animal, part vegetable, and part mineral; they are at once mostly dead and, at the same time, teeming with life.

At the surface of a reef is a thin layer of living tissue made up of lentil-size animals known, unflatteringly, as polyps. They belong to the phylum Cnidaria, along with sea anemones and jellyfish, and they are shaped a bit like a flower, with six (or a multiple of six) tentacles surrounding a central mouth. The polyps of a reef are all connected to one other and, in many cases, genetically identical. In their tentacles are stinging cells, known as nematocysts, which they use like tiny harpoons, to spear even tinier prey. Meanwhile, residing inside the polyps are microscopic algae known as zooxanthellae. Zooxanthellae are photosynthesizers, producing sugars that they then share with their coral hosts. This symbiotic relationship is crucial; it's what gives the polyps the extra energy needed to excrete the vast exoskeleton of calcium carbonate that forms the reef's structure.

Coral reefs grow in a great swath that stretches like a belt around the belly of the earth, from 30° north latitude to 30° south latitude. As a rule, the oceans in this region are nutrient poor—so much so that they are sometimes referred to as liquid deserts. The lack of nutrients limits the growth of phytoplankton, which can cloud the seas, so the waters in this belt are often a crystalline blue. Paradoxically, though, reefs are some of the most densely populated habitats in the world, with an estimated one million and perhaps as many as nine million species living in or around them.

How is it that so many creatures can thrive in this liquid desert? The answer seems to be a highly efficient recycling system through which nutrients are, in effect, passed from one reef-dwelling organism to another. In this tightly interconnected system every creature has a role to play—from the worms that bore into the reef and the sea squirts that attach themselves to the surface to the jellyfish that float like specters above.

A mosaic of 190 crabs representing seven taxonomic families, more than 22 genera, and at least 32 species. The largest family—the showy pebble crabs—are deadly poisonous to would-be predators. Other pieces of the mosaic include five more crab families—hermit, guard, spider, porcelain, and gall—and squat lobsters, whose claws can be several times the length of their body.





Fynbos, derived from Dutch, refers to the “fine-leaved” vegetation that grows in the mountainous areas of the Cape Floristic Region (CFR, as botanists call the unique area of floral diversity at the southern tip of Africa). The soils here are rocky and nutrient poor, the scrub prone to going up in flames. Yet adversity has fostered one of the richest concentrations of plant diversity in the world: Some 9,000 native species live in the CFR—many of them evolved here and live nowhere else. Liittschwager’s shovelful of fynbos came out of Table Mountain National Park, the monumental mesa that towers over Cape Town. Sifting through samples, the photographer counted 90 separate species, including 25 types of plants just on the soil surface, along with some 200 seeds representing at least five of those species. Root masses held a host of crawlies, and the sticky leaves of a carnivorous sundew plant—looking too pretty to be predatory—offered another fistful of insects to the tally.



TABLE MOUNTAIN NATIONAL PARK, SOUTH AFRICA

The biological wonders of the Cape Floristic Region at Africa's southern tip offer a bottomless box of mysteries. The magnificent floral diversity and the multitude of minute and intricate survival strategies of the plants and animals in this confined area never cease to amaze.

The region stretches in a narrow 60 to 120 miles wide by 700 miles long coastal belt. Yet despite its small size (only .06 percent of Earth's land area, equivalent to Portugal or Austria), it contains a staggering three percent of all floral diversity—50 times what would be expected for an area so small. Perhaps more impressive is that more than two-thirds of its 9,000 or so vascular plant species are restricted to the region, probably because it is so removed from any similar environments. The particular Mediterranean-type climate here—cold, wet winters, hot, dry summers, and the consequent propensity to burn—is only found in such far-off locations as Western Australia (the most similar to Africa's southern tip), Chile, California, and the Mediterranean Basin.

Two biomes predominate in the Cape Floristic Region—the arid Succulent Karoo and Fynbos, where we placed our cubic foot. While the term *fynbos* is derived from the Dutch for “fine bush,” there are a few theories as to why it is described as fine. It could mean fine looking, which, when Fynbos is viewed in full bloom in spring or early summer, is difficult to deny; or fine scale, an allusion to its minute detail; or even fine leaved because of the preponderance of small shrub species here, most from the daisy, pea, and heather families. Other characteristic groups that give the Fynbos its ambience and occasionally paint whole landscapes with color are the stunning array of irises of every hue; the wide variety of proteas, ranging from small trees to prostrate creepers; and the broad assortment of Cape reeds of various sizes, colors, and textures.

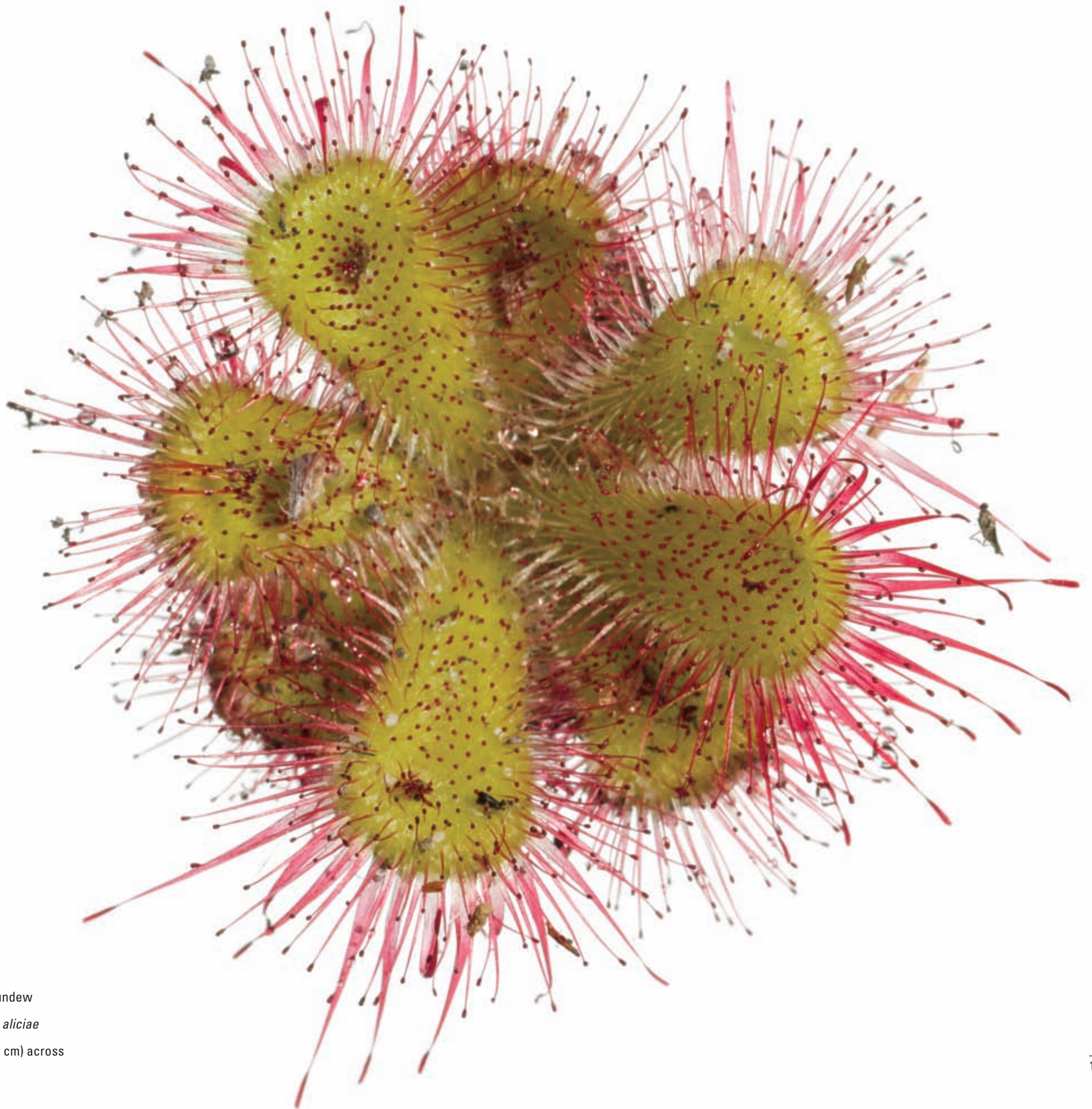
In the course of 24 hours, the one cubic foot of Mountain Fynbos we sampled revealed almost 30 plant species and roughly 70 invertebrates. But being stationary, the cube couldn't capture what is arguably the most amazing component of Fynbos diversity—how much it changes from location to location. If we picked the cube up and walked ten feet, we could get as much as a 50 percent difference in the plant species



Alice Sundew

Drosera aliciae

0.6" (1.52 cm) across



Alice Sundew

Drosera aliciae

1.7" (4.3 cm) across









SPECIES KEY

1. Daisy, *Ursinia paleacea*
2. Moth, order Lepidoptera
3. Sugar ant, *Camponotus niveosetosus*
4. Beaded weevil, *Oosomus* sp.
5. Wood sorrel, *Oxalis polyphylla*
6. Grasshopper, family Acrididae
7. Moss, *Campylopus introflexus*
8. Nutcracker ant, *Pheidole* sp.
9. Earthworm, order Annelida
10. Balloon fly, family Empididae
11. Spotted sugar ant, *Camponotus* sp.
12. Sedge-like iris, *Bobartia filiformis*
13. Ground beetle, family Carabidae
14. Woodlouse, order Isopoda
15. Sac spider, *Clubiona* sp.
16. Moth, order Lepidoptera
17. Velvet mite, family Parasitengona
18. Rove beetle, family Staphylinidae
19. Rugged ponerine ant, *Pachycondyla pumicosa*
20. Cockroach nymph, order Blattaria
21. Cricket, *Cophogryllus* sp.
22. Buchu seedling, *Adenandra villosa* subsp. *sonderi*
23. Beetle, family Carabidae
24. Springtail, order Collembola
25. Proboscis fly, *Philoliche lateralis*
26. Harvestman, order Opiliones
27. Weevil, family Curculionidae
28. False flower beetle, family Scrautiidae
29. Sugar ant, *Camponotus niveosetosus*
30. Cape zebra cockroach, *Temnopteryx* sp.
31. Restiad seed, *Hypodiscus aristatus*
32. Moth, order Lepidoptera
33. Mite, *Tencateia villosa*
34. Beetle, *Pagurodactylus* sp.
35. Beetle larva, family Tenebrionidae
36. Ponerine ant, *Pachycondyla peringueyi*
37. Beetle, family Bruchidae
38. Stink bug, family Pentatomidae
39. Ant, *Pheidole* sp.
40. Bulb
41. Iris seedling, *Watsonia* sp.
42. Wood sorrel bulb, *Oxalis polyphylla*
43. Mealy bug, order Isopoda
44. Seedling
45. Iris seedling, *Watsonia* sp.
46. Daisy seedling, *Othonna coronopifolia*
47. Iris seedling, *Watsonia* sp.
48. Grass seed, *Pentaschistis colorata*
49. Daisy seed, *Othonna* sp.
50. Bagworm moth caterpillar, family Psychidae
51. Leaf beetle, *Exosoma* sp.
52. Ten-spotted ground beetle, *Thermophilum decemguttatum*
53. Inchworm caterpillar, order Lepidoptera
54. Fly larva, order Diptera
55. Cricket, *Cophogryllus* sp.
56. Unidentified insect larva
57. Cricket, *Cophogryllus* sp.
58. Crab spider, *Xysticus urbensis*
59. Beetle larva, order Coleoptera
60. Fly, family Muscidae
61. Golden Sunshine Bush, *Leucadendron laeolum*
62. Harvestman, order Opiliones
63. Rat fecal pellets, from *Otomys* sp.
64. Midge, family Dixidae
65. Spider, order Araneae
66. Beetle larva, family Tenebrionidae
67. Midge, family Dixidae
68. Springtail, order Collembola
69. Spotted sugar ant, *Camponotus* sp.
70. Beetle larva, order Coleoptera
71. Cockroach nymph, order Blattinae
72. Earthworm, order Annelida
73. Midge, family Dixidae
74. Thrip, family Thripidae
75. Spotted orbweaver spider, *Neoscona blondeli*
76. Stick insect, family Bacillidae
77. Springtail, order Collembola
78. Jumping spider, *Aelurillus* sp.
79. Rove beetle, family Staphylinidae
80. Wood sorrel bulb, *Oxalis polyphylla*
81. Cricket, *Cophogryllus* sp.
82. Alice Sundew, *Drosera aliciae*
83. Beetle larva, order Coleoptera
84. Scented geranium bulb, *Pelargonium* sp.
85. Rove beetle, family Staphylinidae
86. Proboscis fly, *Philoliche rostrata*
87. Ground beetle, family Carabidae
88. Pill millipede, *Sphaerotherium* sp.
89. Flea beetle larva, family Chrysomelidae
90. Beetle pupa, order Coleoptera
91. Leafhopper, *Cephalelus* sp.
92. Weevil, family Curculionidae
93. Mite, order Araneae
94. Mite, *Mypongia* sp.
95. Cape gorse, *Aspalathus serpens*
96. Restiad with small bug, *Ischyrolepis cincinnata*
97. Bristle bush, *Metalasia cephalotes*
98. Springtail, order Collembola
99. Restiad, *Hypodiscus willdenowia*
100. Mite, *Biscirus* sp.
101. Restiad, *Ischyrolepis capensis*
102. Thyme, *Struthiola ciliata*
103. Shrub, *Penaea mucronata*
104. Beetle, order Coleoptera
105. Sedge, *Tetralia flexuosa*
106. Sedge, *Tetralia fasciata*
107. Buchu, *Adenandra villosa* subsp. *sonderi*
108. Heath, *Erica muscosa*
109. Flower, *Thesium densiflorum*
110. Restiad, *Hypodiscus willdenowia*
111. Heath, *Erica labialis*
112. Lobelia, *Lobelia comosa*
113. Sedge, *Corymbium africanum*



Restiad seed

Hypodiscus aristatus

0.4" (1 cm) long



Restiad

Ischyrolepis capensis

0.8" (2 cm) long
(portion shown)

A WORLD IN ONE CUBIC FOOT

Portraits of Biodiversity

DAVID LIITTSCHWAGER

With a Foreword by E. O. Wilson

Twelve inches by twelve inches by twelve inches, the cubic foot is a relatively tiny unit of measure compared to the whole world. With every step, we disturb and move through cubic foot after cubic foot. But behold the cubic foot in nature—from coral reefs to cloud forests to tidal pools—even in that finite space you can see the multitude of creatures that make up a vibrant ecosystem.

For *A World in One Cubic Foot*, esteemed nature photographer David Liittschwager took a bright green metal cube—measuring precisely one cubic foot—and set it in various ecosystems around the world, from Costa Rica to Central Park. Working with local scientists, he measured what moved through that small space in a period of twenty-four hours. He then photographed the cube's setting and the plant, animal, and insect life inside it—anything visible to the naked eye. The result is a stunning portrait of the amazing diversity that can be found in ecosystems around the globe. Many organisms captured in Liittschwager's photographs have rarely, if ever, been presented in their full splendor to the general reader, and the singular beauty of these images evocatively conveys the richness of life around us and the essential need for its conservation. The breathtaking images are accompanied by equally engaging essays that speak to

both the landscapes and the worlds contained within them, from distinguished contributors such as Elizabeth Kolbert and Alan Huffman, in addition to an introduction by E. O. Wilson. After encountering this book, you will never look at the tiniest sliver of your own backyard or neighborhood park the same way; instead, you will be stunned by the unexpected variety of species found in an area so small.

A World in One Cubic Foot puts the world accessibly in our hands and allows us to behold the magic of an ecosystem in miniature. Liittschwager's awe-inspiring photographs take us to places both familiar and exotic and instill new awareness of the life that abounds all around.

David Liittschwager is a freelance photographer and a contributor to *National Geographic* and other magazines. His work has been exhibited at such institutions as the California Academy of Sciences and the American Museum of Natural History. He is the author of *Skulls* and coauthor of *Archipelago: Portraits of Life in the World's Most Remote Island Sanctuary*, *Remains of a Rainbow: Rare Plants and Animals of Hawaii*, and *Witness: Endangered Species of North America*. Liittschwager also lectures and shows his work around the world in both fine art and natural history contexts.

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