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COURTESY DOLBY CHADWICK GALLERY

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Holes in the Ground

A catalogue of creatures living in the soil

I live off a dirt road, so the road to my house is also dirt. The only paving on the property is the concrete slab under the house and a couple of the outbuildings. Otherwise, it's all dirt: the paths and trails, and the ground along them, whether covered by meadow, brush, or forest. Everywhere I go, the dirt has holes in it. And for years now I've been trying to find out who is responsible.

Easing into recovery from a recent surgery, I've been going for daily walks. Or, let's say, I've been sauntering, or ambling. And the slower I go, the more holes I see—even in these summer months when the meadow is all dry straw and the ground is brick hard.

These Sierra foothill soils have to be some of the worst in the world, with every nutrient but iron leached out. A pick won't dig a hole when the dirt is as dry as now, yet new holes still appear. There are pencil-sized holes, dime-sized holes, quarter-sized holes. The more I look the more I find. This isn't even counting the larger and more obvious holes—mole and gopher holes, or ground squirrel holes or owl burrows—I know who makes those. But who is making all these small holes?

A List in Progress:

First off, the Mammalia, our own dear class of milk drinkers, are responsible for the largest holes, that's clear. We dig holes ourselves: postholes, outhouse holes, and trenches for pipes—but they are usually filled in. Soldiers, of course, dig holes, or used to, and call them foxholes. And foxes do dig holes, though our foxes seem to prefer an abandoned tree house.

Rabbits dig warrens, which are holes in the ground, though they must dig them in the densest and most inaccessible brush thickets, because I never find them. Many rabbit warrens, it is said, are connected underground. We have skunks, and skunks have long claws and dig dens. I *think* I found one of those once. Opossums will nest in holes if they can find one, but I've read that they don't dig their own. Sometimes they live in trees.

And the coyotes dig holes and live in them. I found one once, with pups in it, dug into the side of an embankment.

Actually, my little dog found the hole before I did. He was just a little scamp Peekapoo with long curly hair and big eyes that said "I love you, just stroke behind my ears,"

but when he heard a coyote howl, he put his chin way up in the air and made this sound like a coyote and trotted off like The Fool headed for the cliff. After about five minutes I heard a terrible yelp of pain way off in the manzanita and figured I'd better go find him. I did and there he was, kind of bloodied up and needing a stitch or two, and there was Mama, standing in front of her den looking at me, and behind her coyote pups looking out and thinking this was all the coolest thing that had ever happened.

Ground squirrels dig holes, of course, and they are easy to spot, as are gopher holes and mole holes, with the dirt piled around the entrances.

Moles tend to have their entrances in the center of the excavated dirt, so it looks like a volcano, while gopher holes are eccentric.

Moles and gophers make a lot of holes around here. I've lost a dozen fruit trees to gophers—but there may be even more moles. The cat catches gophers but she doesn't go after the moles. At least not anymore, not since one she had cornered attacked and grabbed on to her paw with his teeth and wouldn't let go. For a nearly blind animal that spends its whole life underground eating bugs, moles are pretty feisty.

Besides moles and gophers, there are shrews, mice, and voles. I'm not sure why voles are called "voles," which sounds like "moles," because it's shrews that are like moles. Voles are like gophers. Voles are often called "meadow mice," and I realize now that many of the small "gophers" caught by the cat were actually voles and that voles are probably responsible for a large number of the excavated holes that are slightly smaller than mole holes but have dirt around the entrances. Like gophers, voles are mostly vegetarian and seem to be better tasting to cats than the insectivorous moles and shrews.

Whoever is digging exactly which hole, there is a *lot* of bioturbation going on, and it is not all done by mammals, not by a long shot.

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Maybe some lizards dig holes. Skinks do, for sure. Alligator lizards dig to bury their eggs, but mostly I find them just under boards and under stuff lying on the ground. Fence lizards, whiptails—I don't know but they've got to sleep somewhere.

Some spiders dig holes: deep, clean holes. Trap-door spiders. And around here big wolf spiders dig a hole like a trap-door spider, just without the door. Close to quarter sized. The cat never sniffs at these holes. I had to go out at night with a flashlight to see the spider, and I did. It was there about half an inch down the hole with its legs on the rim. So I took a piece of straw and rustled some dry grass a couple of inches outside the hole. And, like, I *knew* what was going to happen, but when the spider rushed out I still jumped a foot into the air.

Most spiders, of course, live in webs.

Then there are the insects. And some in-between critters like centipedes. Centipedes dig holes. Mostly, I think, they dig holes and live in them. Except for the ones who come into the house and hide under a sofa until you are walking by at three in the morning headed for the kitchen, when they lunge at your toes. I *hate* that. *Why* do they do that? It makes me do that-forbidden-by-the-Buddha.

But insects, yes. Now we are getting to the pencil-sized holes, or mostly.

Among the Hexapoda the most obvious and numerous hole diggers are the ants. Lots of them, and they seem able to dig into the very hardest of the hard-packed dirt right on the driveway. So we see them a lot.

In fact, I'm watching them right now. These are fairly sizeable ants, but fifty yards back there is an active nest of very tiny ants, and both colonies may move the same amount of dirt. They like to work in the cooler hours during the summer, late afternoon, and early evening. In the winter when it rains, I suppose these ant nests will become potholes.

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I'd tired out early, as I'm still recovering from a chemo, so sitting next to an ant hill seemed like a good place to rest. Then, as a result of my treatments, I had half of a mental whiteout: it was like a dust storm had come through and half of my brain was left resembling the Playa at Burning Man. Laura was with me.

"You know," I said, "there was an early tribe of humans who, being particularly observant of nature, decided that underground was the proper place to live. They saw other animals digging holes so they decided to do the same thing. They were called troglodytes and they ate lizards and other reptiles and small mammals and were known to be the fastest runners in the world, which is strange, if you think about it, because most of their lives they lived underground in Ethiopia and were so poor of eyesight that they took to herding large groups of moles from underground room to underground room with short sticks. Caesar wrote about them, but the book is lost."

"Caesar, huh," Laura asked, "like the salad?"

"Well, yes. And then Xerxes tried to hire them to dig tunnels under the walls of a city he was besieging in Lydia, but the troglodytes refused, explaining that such use of their chthonic skills would be sacrilegious and offensive to the gods of darkness, an explanation Xerxes accepted."

"Xerxes, huh, are you sure you don't mean Cyrus?"

"Yes, Cyrus, that's who I meant. … The problems all started when a Lydian king fell in love with his own wife—that ended up being how the Persians found out about the Greeks and went to war against them and why we run marathons. The Greeks all wished that the troglodytes had been more helpful to Cyrus and had finished the whole thing before the Spartans arrived, so they passed laws protecting people who lived underground in holes, exempting them from certain taxes and service on triremes. Cyrus and Croesus talked about it with Solon after they figured out who was the happiest person alive."

The fog was slowly lifting from my brain.

"See," I said, "the barbarian women considered it an affront to be seen naked … kind of like goddesses."

"What's this have to do with troglodytes?" Laura asked.

"Oh, because the troglodytes moved to Italy and became Christians, and then they moved to Cappadocia. One of their underground cities had eighteen-story buildings and a population of twenty thousand. Nobody believes that anymore, but you could look it up."

Laura said she knew about Cappadocia.

I returned my attention to the ants. Some couldn't seem to find their way back to the nest. One, holding a huge seed in its mandibles, missed the nest twice, and was now more than a foot away and walking in the wrong direction. Other ants touched antennae with it, but it still hadn't got the message.

"See," I said, "the continued existence of underground civilizations is a tightly held secret of the government: the very existence of these cells is such a threat to national security that they release occasional pictures of UFOs instead."

At that Laura concluded that I needed to walk some more, so she helped me up and we started off again, but now my eyes were tuned in to holes and we had to keep stopping. I saw one very clean quarter-sized hole, or nearly so, that I was sure was a new wolf spider hole. It even had some paper-like web around the wall of the tunnel. I didn't stick my finger in.

Once we watched scores of flying ants hatching out of several holes right in the driveway. They were orange and black with blue wings and they just kept crawling out of the holes and taking off into the air. I think the ants opened new holes just for the hatching and then abandoned the nest. At least the holes always *seemed* to be abandoned, until I happened to walk by them one night when the moon was out. Then I saw that the holes were indeed occupied, by largish red and black ants that only come out long after dark.

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Diptera: Flies, Midges, Gnats.

Not many insects live underground as adults, but many live underground as larvae or pupae. I've see crane flies dipping their ovipositors into the ground laying eggs. And after the larvae pupate and the adults emerge, they leave little holes behind them. Most of the little holes that are left open are probably emergence holes—kind of like an inter-dimensional passageway. Holes in regular use get stuffed with gravel or straw.

Most Diptera prefer soil rich in decaying matter. Here, that's under the oak trees.

Hemiptera: True Bugs.

This is such a large order there must be some of them that dig holes. Cicadas, for sure, in the suborder Homoptera, produce large numbers of emergence holes.

Isoptera: Termites.

California has the western subterranean termite. As their name implies, these termites nest in the ground, preferably in a buried log. Their nests can get quite large, many galleries connected by tunnels, the whole thing sometimes hundreds of feet in diameter.

Orthoptera: Crickets, Katydids, Grasshoppers.

Mole crickets live in the ground. The one we see the most is the Jerusalem cricket, also called *niña de la tierra*. Is there any bug more definitive of bugginess? I mean, they are BUGS. They're huge, and they have those bald heads that look like the bugs in the game "Cootie." They are harmless, but they will hiss and spit at you if you "bug" them too much.

Laura and I were still walking but I could feel the white noise returning and closing down the left side of my brain.

"You see," I said, "the verb *to bug*, as in 'don't bug me, man,' actually does come from bugs. Well, more from beetles. From that annoying characteristic of beetles, in particular, to come right back at you after you brush them away. It's like, you try to be nice and just knock them ten feet away from your sleeping bag instead of crushing them and what do they do? They turn right around and come back. And they'll keep doing that. And that's how the verb *to bug* came about, from backpacking beatniks, Jack Kerouac and Japhy Ryder, I think, who finally said 'Hey, that bug is BUGGING us.'"

Laura: "Uh huh."

"Well, yes. Or maybe it started before then, maybe in Harlem, in some seedy jazz club, with cockroaches."

Laura, who had lived in New York City for years, thought that the latter etymology was more likely.

There are also some ground crickets in this order that dig holes. And the California camel cricket, *Ceuthophilus californianus*, lives in underground burrows.

The subject of grasshoppers brings us to blister beetles and thus to the Coleoptera. Blister beetles get their name from the ability of some species to secrete cantharidin, which blisters human skin. Cantharides is also known as "Spanish fly." It should never be used as an aphrodisiac, but preparations are sold as a topical treatment to remove warts. There are more than a hundred species of blister beetles in California, but few if any of them cause blistering.

Female blister beetles lay hundreds of eggs in meadows or other grassy areas where grasshopper larvae are in the ground. The blister beetle eggs hatch into a larva that looks like a cross between a silverfish and an earwig. These crawl around when it is warm, checking out every crack and hole in the ground they can find, looking for a grasshopper nest.

Entomological writing gets more colorful the further back one goes in time. This may be because the earlier generations of entomologists spent a lot of time lying on the ground on their stomachs. Here's Robert Evans Snodgrass (1875–1962), on the triungulin of the striped blister beetle:

> *"Though the young scapegrace of a beetle is a housebreaker and a thief, his story, like that of too many criminals, unfortunately, makes interesting reading."*
>
> —*Insects: Their Ways and Means of Living* (1930)

Finding a nest, the triungulin devour the grasshopper eggs and then molt into a completely different-looking grub. Eventually, after a number of successive moltings, a pupa hatches into a new adult, which crawls out of a hole in the ground.

Coleoptera: Beetles.

Besides blister beetles, the most obvious diggers in this order are the burying beetles, Nicrophorus. Beautifully described in Bernd Heinrich's *Life Everlasting: The Animal Way of Death* (2012), Nicrophorus beetles can dispose of a mouse carcass in hours. If the ground beneath the carcass is soft enough, a pair of beetles, after a brief marriage ceremony, together dig the ground out from underneath the carcass, meanwhile chasing away wasps, flies, and other beetles. When the carcass is buried, the female lays her eggs on it. I haven't seen these colorful beetles yet, though I keep hoping to attract them by putting out half-eaten mouse carcasses left by the cat.

I've read that if the ground is too hard, the burying beetles will crawl under the carcass, turn over on their backs, and walk the carcass off of them with their legs. This I want to see! I mean, how do they coordinate that? "No, darling, I think we should go this way." "No, you always say that, but what happened last time, huh, bug guy?"

Most of the other subterranean beetles live in the ground during the larval stage, such as the stink beetle and the tiger beetle. Entomologists calculated that in southern Wisconsin, depending on the type of soil, an acre of ground contained between fifty thousand and two hundred thousand grubs.

Eleodes larvae live in the ground until they emerge as adult beetles. The *Eleodes* beetle is a large and all-black darkling beetle that will stand on its head if disturbed and spray a foul-smelling amber liquid, hence "stink beetle" or "stink bug." My mother called them "pinacate beetles," a name more usual in the Southwest, derived from the Nahuatl word for "black beetle."

The best study of holes in the ground that I know of was by a Kansas entomologist, H. R. Bryson, in the 1920s and 1930s. He described the types of holes made by a wide variety of insects (mostly Coleoptera and Hymenoptera), along with the soil type, the depth of the hole, the characteristic branching, incline, diameter, length, and even weight of the excavated soil—as close to an identification key as one is going to find.

Hymenoptera: Wasps, Bees, Ants.

While beetles inhabit the ground almost exclusively in the larval stage, the Hymenoptera typically live in the ground as adults. Bumblebees and mining bees dig burrows, as do many solitary wasps. Yellow jackets also live in the ground, in large nests (as anyone who has ever disturbed one knows), but evidently they don't dig the burrows themselves, instead relying on finding abandoned mouse or vole holes.

Solitary wasps that live in the ground include the cicada killer, eumenid wasps, digger wasps, sand wasps, and spider wasps. Many of these wasps have to deal with parasitic wasps that will steal into their burrows and leave their own eggs to hatch and devour the original eggs or pupae, so many digging wasps disguise the entrances to their burrows, making them hard to find. For one, they disperse the excavated soil, so that predators or parasites won't be able to spot it as easily, and then they also plug the hole when they go out and often cover it with debris.

That leaves the worms.

Annelida: Earthworms.

I guess they're out there—it's just hard to remember that in the summertime. Charles Darwin calculated 53,767 earthworms per acre. That was England, of course, where it rains a lot. Darwin's last published book was on earthworms, called *The Formation of Vegetable Mould through the Action of Worms*. The book was surprisingly popular, selling more copies than the initial edition of *Origin of Species*.

Once he had an estimate of the number of worms per acre, Darwin went on to measure how much soil passed through each worm and how much soil there was in England, proving that all the topsoil in England had passed through the intestinal canal on an earthworm many times. He also calculated the rate at which earthworms bury ancient ruins, doing his fieldwork at Stonehenge. Darwin also performed extensive experiments with earthworms, establishing that though they could not hear they could detect vibrations and that they were intelligent and could learn. This last assertion is an embarrassment to those who still cling to the tenet that intelligence is a distinctly human characteristic and that whatever animals do, especially invertebrates, is something called "instinct." Myself, I think intelligence is still a good idea worth trying.

I could feel another whiteout coming on. Darwin had filled the dining room with jars of worms and it was creating a domestic crisis, Mrs. Darwin saying, at last, "You have to choose: it's me or the worms," and Charles inventing and calling in a "worm-mediation specialist" who brokered a compromise, the worms getting Mondays, Wednesdays, and Fridays and Mrs. Darwin getting Tuesdays, Thursdays, and Saturdays.

Laura was talking to me. "What?" I said.

"It's getting cold."

You have to dig to find earthworms here. Or wait for a rain. Laura grabbed an arm and we ambled on.

Dale Pendell combines science and poetry in his writing and is a long time student of ethnobotany. His publications include the *Pharmako Trilogy: Pharmako/Poeia* (1994), *Pharmako/Dynamis* (2002), and *Pharmako/Gnosis* (2005), all published by Mercury House.