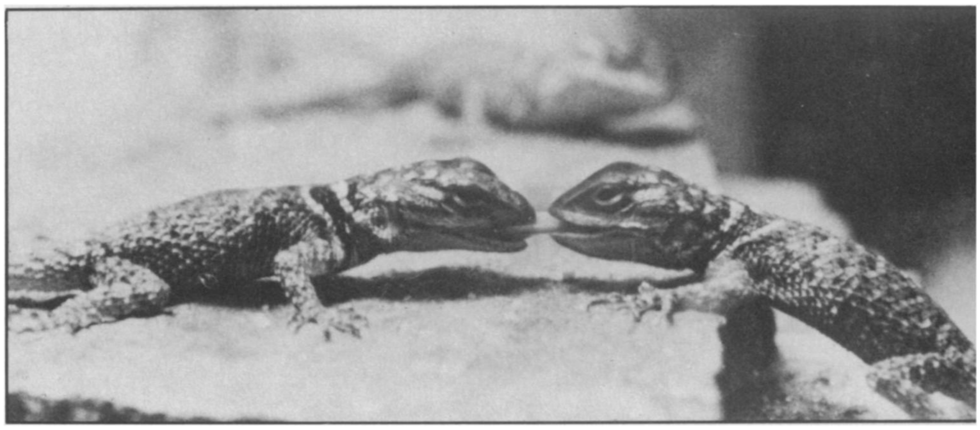
LIKE A LIZARD IN THE SUN



Neil Greenberg

Blue spiny lizards seek the sun's heat and tussle over food soon after hatching.

Reptiles have long been sold on the feasibility of solar heating

BY JULIE ANN MILLER

Reptiles have been successful users of solar energy for more than 200 million years. Until recently animals that relied on their environment for heat were considered second-class organisms, imperfect mammals. But now their thrifty approach to heating is gaining respect. "Reptiles don't make good mammals, but mammals don't make good reptiles," says James R. Spotila of New York State University College at Buffalo. "Each happens to be adapted to a particular niche."

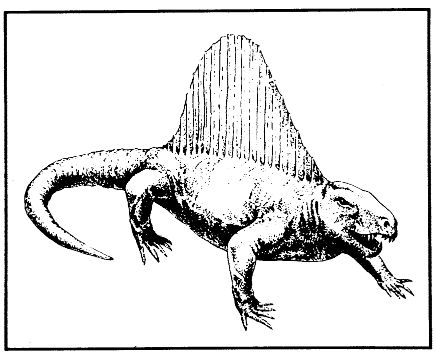
Some reptiles perform amazing feats of temperature control. The best regulation occurs among animals subjected to large daily environmental fluctuations. An example often cited is an iguanid found high in the mountains of Peru. As the air temperature gradually climbs from 0°C, the lizard maintains a body temperature of more than 30°C.

Sunlight is an important heat source for these and other day-active reptiles, as well as for some amphibia and even insects. Such sun-dependent animals are called heliotherms. Air, water and soil are other sources of reptilian heat. Some reptiles can supplement external sources with heat produced internally, for example by contracting their muscles. But internal heat is much less important for reptiles than for mammals and birds.

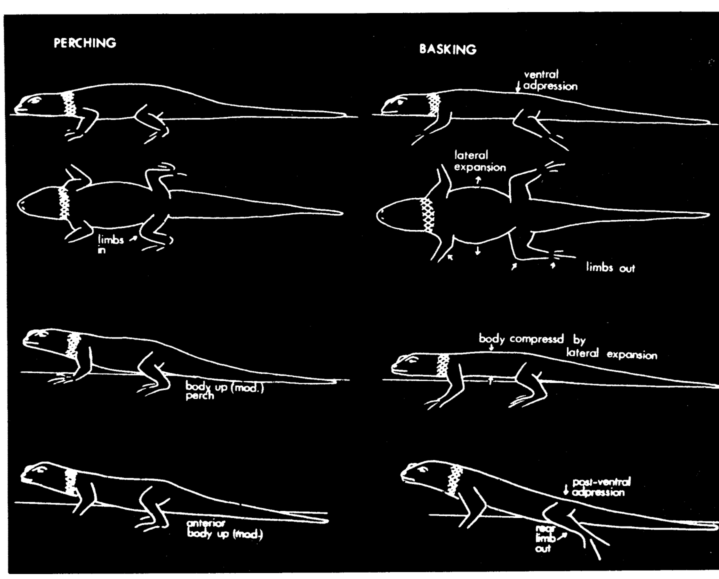
Biologists are learning to appreciate the economy of reptilian energetics. "Reptiles can survive where mammals cannot," says zoologist Neil Greenberg. "With one-fifth to one-third the resting metabolism of mammals and birds, they can get through a season and have young on very much less food."

In many respects the temperature control apparatus of reptiles resembles that of mammals, but in some cases the same means are used for opposing ends. For example, in mammals blood flow carries outward the energy-expensive heat generated by internal tissues. In a basking lizard the circulatory system distributes heat inward from the surface.

Both groups of animals sense temperature with receptors in the brain, and both can increase or reduce peripheral blood circulation. The Galapagos marine iguana



Did Dimetrodon's *sail collect radiation?*



Neil Greenberg

Perching lizards hold their limbs close, ready for action. Basking lizards sprawl with ribs expanded to expose the greatest surface to the sun.

is a supreme example of such temperature control. It shuts down peripheral circulation when it plunges into cold water to feed. Blood again flows to the skin when the animal returns to land to bask in the sun. This control of blood flow allows the iguana to heat twice as rapidly as it cools.

Various reptiles do have an assortment of special tricks for effectively gathering radiant energy. Color changes help some animals maximize light absorption. Desert geckos and iguanids, for example, are dark in the morning when they emerge from their burrows. As they warm to about 35° C, their color lightens. Light color is a better camouflage for a desert animal than is dark. So it appears that early in the day, gathering heat takes precedence over maximum concealment.

Presenting the sun with the widest surface is another heat-capturing strategy. Some lizards, such as the blue spiny lizard, expand their ribs to sun a 25 percent larger area. Paleontologists have proposed that the sail of prehistoric reptile *Dimetrodon grandis* was specialized for temperature regulation. C. D. Bramwell and P. B. Fellgett of the University of Reading in England calculate that the 1.15 square meters of sail would save two hours of the time it would take *Dimetrodon* to warm from 26°C to 32° C. Those two hours could give *Dimetrodon* a valuable advantage: In the morning it could attack while its prey was still sluggish with cold.

But it is predominately the behavior of reptiles, not their specialized equipment, that allows them to thrive without much internally generated heat. They must invest time daily in heat collection and generally forego other activities until their body temperatures are right.

"Time is energetic money," Greenberg explains. Therefore, effective warming behavior is good business. In studies at Rutgers University and now at the National Institute for Mental Health in Poolesville, Md., Greenberg has analyzed blue spiny lizard behavior (JOURNAL OF HERPETOLOGY, 11:177, 1977). He observes the lizards in a laboratory chamber designed to mimic nature — complete with a dawn-to-dusk moving light source.

"Most thermoregulation is accomplished by selection of microhabitats with thermally distinct microclimates," Greenberg says. The animals keep their temperatures in their active range by moving between light and shade, orienting their bodies parallel or perpendicular to the light rays and by seeking warmer or cooler surfaces. James Heath of the University of Illinois calculated that just the changes in a horned lizard's orientation to light increase the animal's active period by an hour.

While warming in the sun, the blue spiny lizards hold efficient light-gathering poses. They face away from the light source, exposing their wide backs. They keep their bodies elevated while the ground is colder than the air and relax to touch the ground when it warms. The lizards may even put their forelimbs on a rock to tip for more effective exposure. "They sometimes get into awkward postures when orienting to a photothermal source — clinging, for example, to rock prominences or shelves," Greenberg says. The lizards bask for 30 to 90 minutes to bring their temperatures from 22° C to 37° C.

When the lizards' temperatures reach about 38° C, they shift to a perching stance. The perching animal holds its limbs closer to its body. "The postures employed when perching are more suggestive of readiness for rapid action than those of basking," Greenberg says. He estimates a basking animal requires an extra half-second to jump for a cricket. Perching animals, better positioned to view and interact with their environment, are also more likely to attract predators.

Once warm, the blue spiny lizard remains active over a wide range of temperatures. Some other reptiles, more sensitive to temperature, shuttle between sun and shade, basking and perching, to maintain a more constant preferred temperature. Biologists have found that the muscle enzymes in these animals are more sensitive to temperature than those in blue spiny lizards.

The dependence on basking does limit reptiles' behavior, as well as their geographic distribution. The lizards can move rapidly only for a very short time when cold. But in rare situations, reptiles will abandon warming behavior to defend territory, hunt prey or avoid predators.

Greenberg reports that the blue spiny lizards are exquisitely cautious when they first emerge in the morning; a sound in the laboratory hallway can send them scurrying back into hiding. In those lizards, feeding has a wide temperature range. Greenberg has observed eating from 25.3° C to 38.5° C. However, the probability of eating an available insect increases from 8 percent when the animal basks to 56 percent when it is warm and perching. Foraging for food, a less common activity, is only observed in lizards with body temperatures of 34.3° C to 38.7° C., a much narrower range.

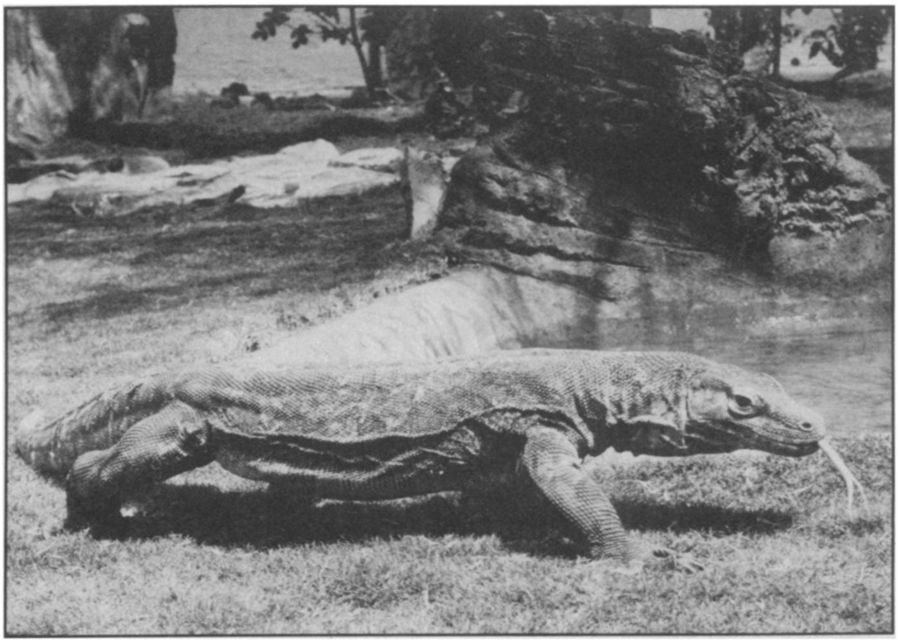
Basking, although different in exact posture, spans the range of reptiles. Size appears an important variable in some aspects of thermal regulation. Most experiments have used conveniently small species, which conduct heat much more rapidly than do small mammals. On the other hand, mammals and reptiles between 10 and 100 kilograms have similar, low heat conductances.

Komodo dragons, for example, wake up with a head start over other lizards. Because of their bulk (they are the largest of living lizards), body temperature does not drop to the air temperature overnight. Even so, Brian K. McNab and Walter Auffenberg of the University of Florida found that Komodo dragons, ranging from 3 to 48 kilograms, bask in the early morning sun. The researchers found skin temperatures to be greater than muscle temperatures during basking, but to fall when the animals entered the shade.

Spotila has developed mathematical models of heat flow in large reptiles. He maps out all the ways heat can get into and out of their bodies. He also observes different sized animals in environmental chambers that simulate sunlight.

Spotila's calculations show that, even with a low metabolic rate, a large reptile could have a relatively constant, high body temperature when exposed to warm daily fluctuating conditions. "You warm up tissue and it takes a long time for the heat to leave," Spotila says. Spotila, McNab and Auffenberg all support the argument that dinosaurs did not need to generate heat metabolically in order to maintain a constant temperature (SN: 4/8/78, p. 218). Their size alone could do it.

Heat collection is only one aspect of thermal regulation. Avoidance of the sun, and of overheating, is also crucial. Spotila suggests that desert reptiles may win over mammals for the daytime niche because they can stay reasonably cool. Mammals cannot turn off their metabolic furnaces even when air temperature is greater than their body temperature. This problem has two consequences. First, the animal is burdened with the extra heat. Second, the mammal cannot lurk in the shade much of the day because it must find food to stoke its continually running furnace.


San Diego Zoo Photo

The Komodo dragon's bulk allows it to start the day with yesterday's leftover heat.

Many of the mechanisms for collecting heat are reversible for heat expulsion. Behaviorally, the animals move into the shade or position themselves to expose less surface to the sun. In the shade, an overheated lizard increases blood flow to its surface to radiate energy. Bramwell and Fellgett suggest that a hot *Dimetrodon*, by presenting a minimum of sail surface to the sun, could emit 0.6 kilowatt of heat to the sky.

While reptiles still often face problems of under- or overheating, many effective behaviors and physiological mechanisms for temperature control have been well documented. Researchers are now turning to the nerve pathways that instruct reptiles in how to make the best of their places in and out of the sun. □