# THE SECRET CLOCKS

## *Time Senses of Living Things*

SEYMOUR SIMON · Illustrated by Jan Brett

# THE SECRET CLOCKS

## *Time Senses of Living Things*

SEYMOUR SIMON · Illustrated by Jan Brett

Macmillan/McGraw-Hill School Publishing Company
New York ▪ Chicago ▪ Columbus

*To Joyce, Carmen, and the rest of the nice people at Equinox Travel*



Macmillan/McGraw-Hill School Division
10 Union Square East
New York, New York 10003

Printed in the United States of America

ISBN 0-02-179531-2 / 6, L.12A

2 3 4 5 6 7 8 9 WES 99 98 97 96 95 94 93

# *Contents*

# *The Mysteries of the Fish and the Worm*

It is a warm summer night. Thousands of people line the moonlit beaches of Southern California. They watch as the incoming tide pushes the waves high up on the sandy shore. The waters reach their highest point on the beach and then begin to recede.

Suddenly someone calls out, "Here come the grunion!"

As if by magic, the waves sweep wriggling masses of silvery fish onto the beach. Using their bare hands, men, women, and children scoop up one fish after another and toss them into pots, pans, bags, and other makeshift containers. Gulls compete with the people for the fish along the beach.

But there are plenty of grunion for all. In just a few minutes the pots and pans overflow with grunion. The gulls seem to be full, too. They eat more slowly, as if trying to find space for still another fish in their swollen stomachs.

As suddenly as the grunion run started, it is now ending. A few stragglers catch an outgoing wave and are gone. The sand is now empty of the slender fish. Some of the people on the beach set up fires to broil their catch right by the sea. Others head for home and backyard grills.

Everybody is talking about the grunion run and how it compared with the one two weeks ago and the one two weeks before that. Some wonder if there will be a second run tomorrow night or if the fish will disappear for another two weeks. Some of the old-timers talk about huge grunion runs of past years.

Slowly the beach empties as the campfires die down and people begin to leave. The beach is now deserted. The only sound is the regular boom of the breaking waves against the sand.

But the story of the mysterious grunion is not over. High up on the beach beneath the moist sand lie uncounted thousands of fertilized grunion eggs. They will be developed in about seven days. Even though the young grunion are ready to hatch, they will remain within the protective coverings of the eggs until two weeks have passed and the next half-monthly tides wet the sand around them.

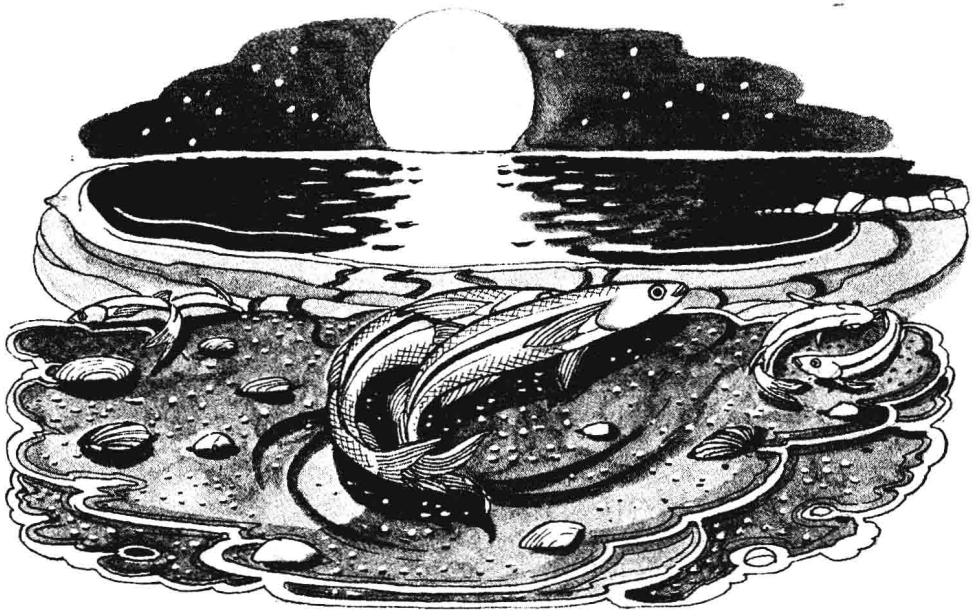
Grunion are small, silvery fish that live along the Pacific Coast, from Monterey to southern Baja California, and in the Gulf of California. They spend most of their lives in the waters near the sandy beaches. But during their spawning season, from February to September, the grunion come onto the beaches as regularly as clockwork. Local papers actually publish the times when the grunion are expected on the beach.

The highest tides of the month occur during full moon and new

moon, about every two weeks apart. Minutes before the night of the highest tide, the grunion swim in with the incoming waves.

The fish strand themselves as high up on the beach as possible. Wriggling about, the female digs into the wet sand, tail first. She lays her eggs about two inches below the surface. The male grunion curves his body around the female and spreads milt on the sand to fertilize the eggs.

The whole act of spawning takes only about thirty seconds. Then the grunion work their way back toward the water by flipping their bodies from side to side. The next wave carries the fish back down the beach. In two weeks the crashing waves of the next high tides will somehow signal the young, and they will hatch just in time to be carried out to sea.



Thousands of miles away from the grunion, the palolo worm lives in coral reefs around a few islands in the South Pacific. Palolo worms spawn only twice each year, in October and in November. The main spawning takes place during the last quarter of the moon in November. Scientists can predict the exact date each year. So, apparently, can the worms. Millions of them show up at the same time.

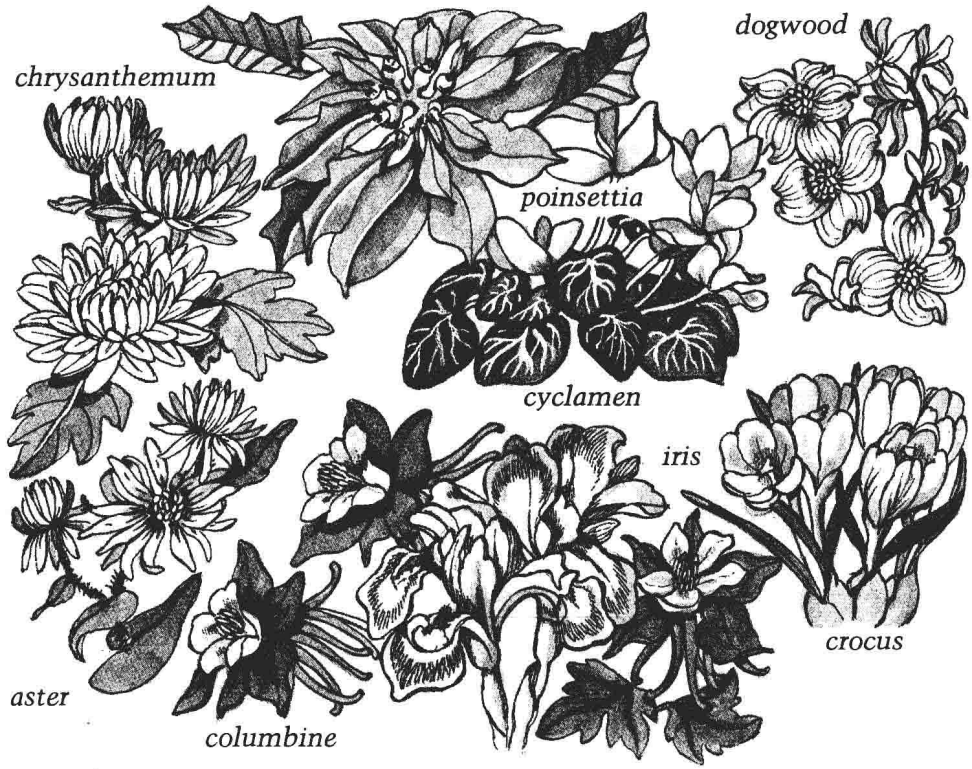
Adult palolo worms grow to be fifteen or sixteen inches long. They have two parts to their bodies. Just before they spawn, the hind part of the worm swells up with sex cells.

When the right day arrives, the hind parts of the worms soon shed their eggs and sperm, and fertilization takes place. Far below the surface the front parts of the palolo worms begin to grow new rear ends.

A year later the whole spawning act takes place again. At what is called "palolo time" by the islanders, the spawning worms are considered a food delight. They are scooped up by the bucketful, and great feasts are held. The spawning is so regular that the islanders date important events by it.

Many animals besides the grunion and the palolo seem to have some way of telling time within their bodies. Migrating animals start their journeys at the same time year after year. Most other animals follow a daily rhythm of activities.

Plants, too, have daily rhythms. Some flowering plants open only at night; other flowering plants open only during the day. Many plants show daily "sleep" movements; their leaves are erect during the day and droop at night. These sleep rhythms remain constant even if the plants are kept in constant darkness and at constant temperatures.




Plants also show seasonal rhythms, much the same as animals. For example, poinsettias, cyclamen, and freesias blossom during the winter, while forsythia, crocuses, and dogwood blossom during the spring. Summer brings blossoms to iris, rhododendron, and columbine, while in the fall chrysanthemums, asters, and dahlias flower.

Humans also seem to have internal rhythms. Some people even try to chart their own.

Many of the daily, monthly, and yearly rhythms of living things have been known about for hundreds of years. But it was only when scientists such as Gustav Kramer of Germany began to study and

experiment with animals and plants that these rhythms began to make sense.

Kramer was able to show that birds migrate in certain directions by using the position of the sun. He also showed that birds adjust for the sun's movement by using an internal rhythm that works much like a clock. Following Kramer's experiments, most scientists now use the term biological or internal clock when they refer to regularly timed rhythms in living things.

Each kind of living thing has its own ways of surviving and continuing its species. Each species relies upon some special features that help it to live and reproduce.

The giraffe's long neck and legs allow it to reach up to feed from the tops of trees where few other animals feed. The mouse escapes from many a close call with its enemies by being small and quick. The spines of a cactus protect it from animals that might feed upon it.

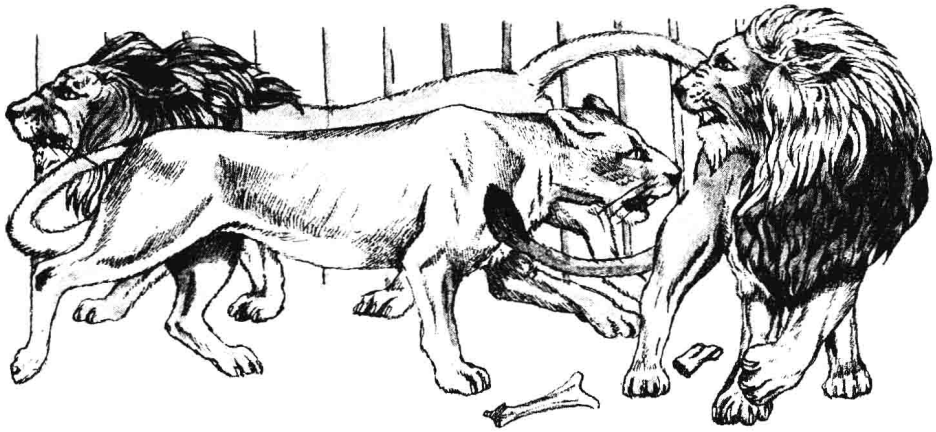
In much the same way the internal clocks of living things help them to survive. Birds migrate in just those seasons that help to insure them a plentiful supply of food. The internal clock of honeybees helps them to go in the right direction at the best time for nectar. Many plants open their leaves during the day and close them at night. In that way they receive extra sunlight and lose little water by evaporation.

Of course, the animal or plant does not *know* that its internal clock is helping it to survive. It simply continues to behave in the same way as others of its kind. By surviving, a living thing has a chance to reproduce and give rise to the next generation. Nature rewards survivors by allowing the continuation of the species.

What makes the clock of an animal or plant run so accurately? What sets these biological clocks and keeps them going? Do animals somehow learn how to keep time, or do they depend upon changes in their surroundings? What factors work to keep a plant on time?

In this book we'll look at some of the ways that scientists and nature observers have studied these questions. We'll examine some of their discoveries and some of the new questions the discoveries have raised. Later on you'll have a chance to try out your own experiments with biological clocks in animals and plants and even with the clock inside yourself.

# *Living Time*



If you ever visit the lion house at the Bronx Zoo in New Yōrk, or any other zoo, in the early afternoon, you'll see something very strange. On a hot summer day most of the big cats are sleeping in their cages or moving around very slowly. But as it gets closer and closer to three o'clock, the animals start to pace restlessly back and forth.

There seems to be no reason for this activity unless you notice the sign on one of the cages. It says, "Feeding Time 3:00 P.M." Then the reason becomes clear. In some way the animals can tell when their feeding time is near and they become active. They do this long before they have seen their keeper approaching with their food.

Many people who have pet dogs tell a similar story. If they come home from work regularly at the same time, their dogs seem to be restlessly active and ready to greet them. But if one day they come home from work unexpectedly early, they may find their dogs

resting or even asleep. The dogs' internal clocks are not set for their masters' coming home at that time. The dogs may even bark for a moment or two, as if a stranger were entering the house.

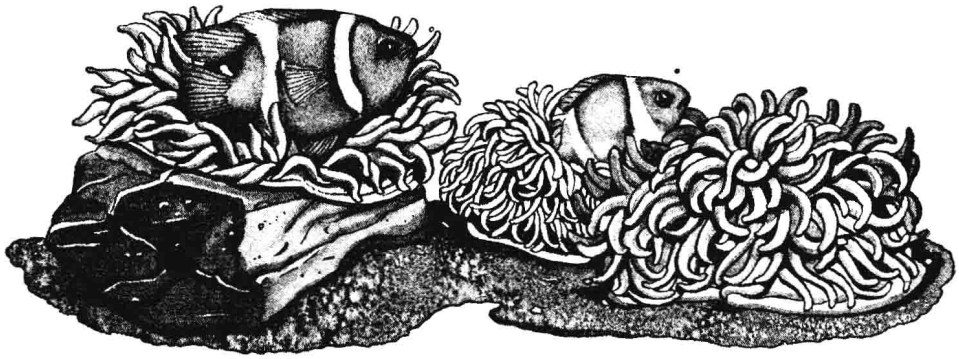
British naturalist Maurice Burton tells a story of the time sense shown by some stray cats in London. It seems that every Tuesday at noon a pet-food salesman would arrive with his wagon at a particular street corner in London. He would start to carve up meat for delivery to the cat owners in the nearby houses. While carving the meat, he would throw scraps and unwanted pieces to the ground for the stray cats which were around.

Soon cats would start arriving at the street corner every Tuesday just before noon for the handout. They would not come on any other day except Tuesday.

There are many other stories about what seem to be time senses in animals. Some of these observations date back hundreds of years. For example, the great Greek thinker Aristotle in the fourth century B.C. noticed that the reproductive organs of animals called sea urchins grew in size only during the period of the full moon.

Many sea animals seem to show changes that are closely connected with the phases of the moon. The half-monthly highest tides occur about fourteen days apart at full moon and at new moon. The palolo worm and the grunion are only two examples of many sea animals that breed during the time of the full moon.

Some animals, such as the robin, are early-morning risers and are active during daytime hours. Other animals, such as most bats, do the reverse. They get up at dusk and go to sleep at dawn. This helps each kind of animal find the food it eats — worms for the robin, flying insects for the bat.



Still other animals have clocks that seem to run on their own rhythms. For example, one kind of sea anemone opens and closes its many small tentacles over and over again in a kind of rhythmic slow-motion dance.

Many insects show different kinds of rhythms in their activities. In the tropics some kinds of insects bite only at particular hours. So if you are bitten at noon, you can assume it's probably one kind of insect; if you are bitten at three in the afternoon, it's probably another. This knowledge could help to prevent malaria or yellow fever if you knew when to protect yourself against the insects carrying the disease.

Even some microscopic-size living things seem to have time senses. There is a kind of alga, a tiny one-celled plant, that is phosphorescent — it gives off light. These algae are bright for twelve hours at night and much dimmer for twelve hours during the day.

At first it was thought that the algae were timing their phosphorescence to the light of the sun or to something else in their surroundings — temperature, for example. But the algae were brought into a laboratory and bred in aquariums in total darkness

and under constant temperatures. Four hundred generations were raised under these conditions, so that they had never experienced daylight. Still they went on as before — twelve hours of bright light, followed by twelve hours of dim light. No one is sure of the survival value of this behavior.

Sometimes, however, it is easy to see how the secret clocks of animals and plants are of help in survival. For example, the males and females of birds that sit on eggs to hatch them will take over their duties on a fairly strict timetable. Female pigeons always sit on the eggs overnight until about eleven o'clock in the morning. Then the male takes over until about four or five o'clock in the afternoon.

Many other kinds of birds have remarkable time senses. One kind of bird called the tinamou lives in Panama, where it is called the three-hour bird. It breaks out into a song every three hours, day or night. It is said that Panamanians can set their watches by a particular tinamou's singing.

Birds will often gather at a specific time at a place where they are fed regularly. The birds do not wait for the appearance of the person who feeds them, but will gather before he comes. Starlings also come back to roost at the same time each evening.

Domestic animals seem to have time senses that fit in with human activities. Frank Lane, in his book *Animal Wonder World*, reports on several of these stories. One of Lane's friends had charge of a small herd of cows during a summer. He would feed them salt every Sunday morning. They seemed to like the salt, because every Sunday morning they would turn up at the right spot for the salt, but they would not come on any other morning.

In another story, a farmer, plowing a field with a team of ten

mules, found that exactly at twelve o'clock, lunchtime, the mules would stop dead and begin to bray. It was useless to try to get them to move until they had been fed. At six o'clock in the evening the same kind of thing would happen. The mules would stop, begin to bray, and head in the direction of home. Talk about punching a time clock!

Farm dogs used for herding cattle or sheep are also very prompt. One such dog is reported to have gone off at seven in the morning and four-thirty in the afternoon to bring in the cows from the pasture to be milked. When daylight saving time came around, it took the dog a few days to adjust to a new schedule.

A chacma baboon kept in a Washington, D.C., zoo for twenty years followed its own work schedule. It would show itself in its cage until four o'clock in the afternoon and then enter its small room and close the door. It was finished for the day. Late visitors to the zoo would just have to come back the next day if they wanted to see the chacma.