MEN AND MOLECULES by John F. Henahan
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CHAPTER 5

THE WEB-BUILDING MACHINE

Seven days a week, at about 5:30 A.M., fifty female spiders in a Syracuse, New York, laboratory begin production of their own thirty-foot skeins of near-invisible thread. Each spider lives in a glass-enclosed aluminum frame about twenty inches square. By 6:00 A.M. she will do what she has to do, create a web that will serve as her home for the day.

Six out of seven days a scientist will remove the sliding glass windows from the aluminum frame, take the spider out and carry the web to a large black box. The web is sprayed carefully with white paint, then photographed. The scientist destroys the web, and the spider is replaced in her glass case to await the morning, when she will build another web.

The Syracuse spiders are sisters to thousands of others who have been weaving their compulsive webs day after day for more than fifteen years under the observant eyes of Dr. Peter N. Witt and his associates. Dr. Witt is an M.D. and pharmacologist at the Upstate Medical Center of the State University of New York. His scientific male cross spider as a screen for drugs, but since then her webs have sent their spokes and spirals into many unexpected fields, revealing valuable insights into the chemistry of the brain, synthesis of protein in the body, behavioral psychology and even the clicking, whirring world of computer technology.

ASSORTED SPIDER LORE

Early in his spider studies, Dr. Witt found that the female cross spider's web-building machinery is extremely susceptible to climate and season. (Male spiders are not good web builders at any time.) In the winter, when temperatures are low and days short, fewer webs are woven. To counteract these variables, Dr. Witt has programmed temperature and light conditions in his laboratory so that every day is a summer day for the lady *Araneus diadematus.*

As noted earlier, the spider unreels about thirty feet of silken thread for a web big enough to fill its roughly twenty-by-twenty-inch aluminum frame. The web thread is so fine that it weighs only about one ten-thousandth of a gram—six days out of seven, that is. For a long time Dr. Witt and his colleagues were puzzled by the webs woven on Monday morning; they were a little larger and heavier than webs woven on the six other days of the week. After considerable head-scratching, note-taking and careful observation of the spider's habits, the answer was obvious. The scientists worked six days a week, but the spider worked seven. At the end of their normal workday, Dr. Witt or one of his associates always destroyed the spider's web after it was spray-painted and

Fig. 13 Web built by a young cross spider. *Peter Witt*

Fig. 14 Web built by an old cross spider. *Peter Witt*

he placed small weights on the backs of young spiders. Slowed by the added weight, the young spiders soon fell into the energy-conserving habits of their elders; they wove webs with fewer, thicker strands.

The cross spider sits in the center of her web waiting patiently for an insect to blunder into her gauzelike trap. Because her eyesight is very poor, she must rely on other senses to tell her that her meal has arrived. When the fly thuds against the web, the spider is instantly alert. As the fly struggles to get free, the spider extends her two front legs and tugs at the radial threads to determine which part of the web is vibrating. Then she almost scampers toward the frantic fly, embraces it, and injects a lethal poison with her pincer jaws. In seconds, the fly is dead. With a few deft movements, like a clerk wrapping a package, the spider enshrouds the hapless fly with loops of silk, then carries it back to web center where she can feed at leisure.

So sensitive is the spider to any vibration that she

DRUG STUDIES

Soon after he began working with spiders, Dr. Witt realized that the web builders were uncovering subtle aspects of drug action that were not obvious when they were given to man. The drug studies included sedatives, tranquilizers, stimulants and so-called hallucinogenic drugs, among others.

In some cases, Dr. Witt compared normal webs with those built by the same spider when drugged. In others he compared webs built by a large number of drugged spiders. Although the effects were often gross enough to be seen by casual observation, Dr. Witt was not too interested in these qualitative effects. To probe the less obvious effects of drug action, he drew up a set of mathematical measurements which can be applied to enlarged photographs of the various spider webs. Carefully recorded on long data sheets are the angles between the threads that jut out from the hub of the web, thread length, distance between the spirals, overall web size, shape and regularity—the beginnings of a sophisticated computer program set up later on.

The hallucinogenic drugs have received considerable study inside pharmacological laboratories and great notoriety outside the lab walls because of their dramatically bizarre effects. These range from wild, almost psychotic hallucinations, through visions of monsters, pleasantly technicolored impressions of the surrounding world, new appreciation of paintings and music, to a feeling of being one with God. Otherwise little is known of their specific biochemical effects in the body.

Among the best-known hallucinogenic drugs are mescaline (found in the sacred cactus raised by the Peyote

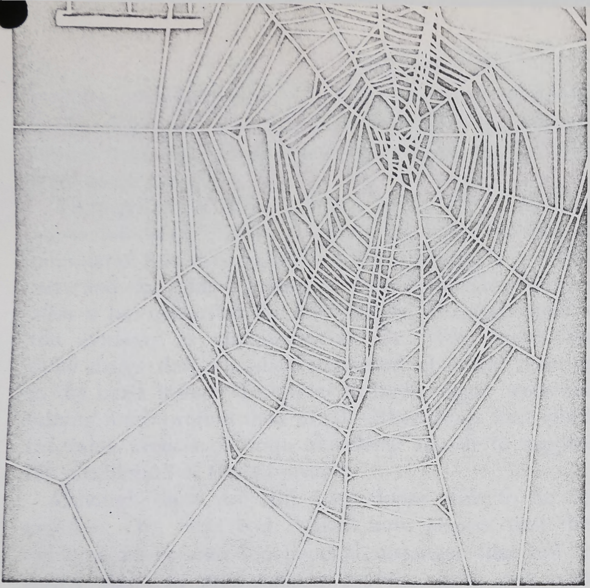

Fig. 15 Web of the female cross spider after a dose of the stimulant drug amphetamine. *Peter Witt*

so drastically that the usually delicately wrought web becomes a chaotic cross patch of misplaced spirals and gaping holes. As a food catcher, the web is utterly useless.

When the cross spider is fed one of the stronger barbiturate sedatives, she drowsily cuts down on web size. It becomes misshapen; spirals and radii are abnormally placed. The tranquilizer chlorpromazine, which normally calms a human being without causing sleepiness, appears to dull the spider's incentive to build webs. Some tranquilized days, when her usual instincts would prod her to build her web, she ignores the signal. Other days, on the same drug, she builds, and the web is completely normal.

the thread protein. Using a radiation detector on the silk of the final web, the chemist learned that it took only twelve hours for the alanine to make the complete route from meal to web.

Throughout Dr. Witt's studies on the effects of drugs on web-building behavior, abundant evidence has accumulated that there must be a link between brain chemistry and the spider's ability to make more thread protein after it has exhausted its daily supply. Although much of the evidence is circumstantial, Dr. Witt knows that some drugs that stimulate important chemical reactions in the brain induce the spider to build bigger webs containing more protein than usual. Other drugs that inhibit the same aspects of brain chemistry appear to suppress the production of thread protein.

Although there are still many loose ends to be tied together, Drs. Witt and Peakall now suspect that their work points to two biochemical messages that tell the empty gland to start making protein again: one signal probably emanates from the brain, and the other may be more localized, residing in the silk gland itself.

The spider's silk gland is a saclike cavity surrounded by a wall of tissue in which the thread protein is synthesized. After emptying the gland, which he can do quickly by reeling the thread onto a small spool, Dr. Peakall finds that tiny globules of protein begin to accumulate in the gland wall, then empty into the gland sac.

As mentioned above, this process can be speeded up or decelerated by certain mental drugs. However, when Dr. Peakall removed the gland from the spider and treated the dissected organ with the same drugs, it reacted as if it were still attached to the spider; some drugs faceted spider web into the language of the computer. As a model against which all other webs could be judged, Dr. Reed concocted a stripped-down, fictionalized master web that reflected the basic qualities of any real web that the computer would ever encounter.

With this master web lodged firmly in its electronic memory, the computer is ready to be confronted with the structural ingredients of real webs punched neatly on cards: about sixty cards for each web. Almost instantaneously, the machine can now riffle through its memory and spot differences in webs of the same spiders built before and after it has been fed a drug. It can also compare a large number of webs built by many different spiders on the same drug, or note structural abnormalities resulting from injuries to the spider, e.g., the loss of a leg.

As a remote and perhaps ultimate objective of their work, Drs. Witt and Reed hope that some day the computer's memory will hold a complete record of every variable—physiological, psychological, anatomical, etc.—that goes into the production of the ideal cross spider web. When that day arrives, the scientists expect that the machine will figuratively be in the same condition that a spider is each morning before she makes her first movement toward building a web. Primed with all the pertinent information that its memory can hold, the computer will then be asked to do electronically what *Araneus diadematus* does by instinct. With a push of a button, this properly programmed computer will begin to feed out a catalog of data, radial angles, thread length, distances between spirals, etc., until the dimensions of this machine-made web are all recorded. At that point, scientific, mathematical substance will be accorded an