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WHEN A man steals something from you, it may indicate anything from carelessness on your part to a faulty police system or the cussedness of human nature, but when nature steals something from you, you are pitted against the gods. May the best man win!

On the other hand, Dr. Douglass, like all scientists, was stealing from nature. Nature held a secret, and Dr. "D," as his co-workers have affectionately called him, wanted it. He plotted ways and means of obtaining data on sun spot occurrence in the distant past so that he could, perhaps, project it into the future. You can't picture a man plotting and planning some safe-cracker's technique for obtaining data on sun spots? It does sound like considerable work for a rather dull end, and you are right about the work but not about the end. Would you call a volcano dull? Well, the sun spot is what we can see of a volcano-like disturbance on the face of the sun. One does not deal with one sun spot but with many, the number increasing periodically and the band occurrence moving closer to the equator of the sun as the numbers increase. No one can say just what causes these disturbances or spots, but it is obvious that they do represent increased activity of some kind within the interior of the sun. The dark spot which we mortals see from such a distance is dark because the gases escaping in a whirl from the hot interior cool as they are released and hence look darker than the glowing surface around them. The bands might be compared to the Tropic of Cancer and the Tropic of Capricorn, as you see them drawn upon that globe which came with a year's subscription to something. Globes have their uses after all.

At the periods of sun spot maxima some areas upon the earth receive increased storms dependent upon the increased atmospheric disturbance, while other areas are affected in

the opposite manner and parch with drouth and choke with dust storms. Now do you see why Dr. "D" worried about stealing the secret? Records of sun spots extended back into the 1700's, but no self-respecting scientist would consider trying to work out cycles, periodic recurrences, on such a short period of data as that. Perhaps these cycles of sun spots, storms, and drouths were not periodic, although the short records suggested it. Nothing but safe-cracking nature could solve the question, and the question was too real an issue to be left unsolved. He cracked the safe.

And what does all this have to do with the secret of the missing rings? Plenty—but wait.

If sun spots affect the weather, what does the weather affect? A child could answer the question if put that way, but it took a man renowned as an astronomer to put it in this way and to answer it for himself. The weather affects plant growth, of course, and the plant which grows over the longest period of years is the tree. Some trees grow all the year around and hence would not show the effect of seasonal variations in precipitation, but trees which stop their growth in the winter and lay down a hard dark layer of protective woody cells in the fall thus mark the growth of the year. Trees growing in moderately dry, temperate area, where their annual increment is largely dependent upon annual precipitation, would reflect that annual precipitation in the width of their annual rings.

The study of modern trees in the region of Flagstaff, Arizona, convinced Dr. Douglass that his system of studying tree rings was workable. He found that the ring record of large and small rings marking certain years could be identified from one pine to another and that the record could be carried back as far as the tree ring records extending into the past. In checking trees from a large area against each other, he found that while their actual ring sizes for any given year varied from tree to tree, their pattern or record was consistent throughout an area in which the weather fluctuations were quite consistent and that this area could be

determined by identifying the record of one tree in terms of the main group until a periphery was reached where the new records did not match the old. This periphery would mark the boundary of another climatic area, for which a new chart of fluctuations through the past would have to be worked out. Trees which grew in bottom lands or near streams showed little fluctuation in growth from year to year, outside of age variations, but those which grew in the uplands and on slopes showed records sensitive to annual precipitation. Dr. Douglass was well on the way to wresting one of nature's most useful secrets from her.

Then came the mystery of the missing ring, perhaps a measure of vengeance for his success. When a tree grows on or just under a ridge, the storms sweeping up from below strike it with full force to do it injury. The soils of ridges are usually rocky and the slopes steep. Enter the missing ring,—or can a missing ring enter? Caesar's ghost entered; why not the missing ring.

When a tree grows in such a place that too little of the moisture of a dry season is available for growth, the tree does not grow, or it may grow only on one side where some moisture is available to the roots. The ring which grows on one side in such a case is usually microscopic in size, but the record on the other side is short one year's growth. When is a missing ring not missing? When it is present on one of the other sectors of the tree. One knows that the ring is missing from a specimen because the record of large and small rings of one tree matches those of a number of other trees, but with the exception that the records of the one is one year off from that of the others over part of its length. Perhaps the records match from 1936 back to 1905, but below that the small rings on the ridge tree are one year ahead of those of that group taken from the slopes.

The implication is that about 1905 one ring did not grow upon the ridge tree, and when one looks at the main group to locate a very small ring indicating a very dry year near that point, he finds that 1904 was, indeed, very dry in the South-

west. 1904 is very likely to be missing, but a good detective may be able to find a minute indication of its presence at some point in the cross section of a specimen.

Checking in these missing rings is simpler in explanation than in execution. Beneath a desk light, hour after hour, sat Dr. "D" peering through a magnifying glass at a bit of wood held so close that it rubbed his nose. Night after night his white hair reflected back a halo of light, glowing like a moon from dusk until dawn. Men laughed at him and he began to question his own idea of seeing the weather through tree rings, but still he shaved the wood surfaces clean with a razor blade, oiled them, and painstakingly checked the records of specimen to specimen and hunted the missing rings. Year after year his charts collected; his measurements of individual ring widths grew to fill filing cases and his specimens collected in boxes on shelves, boxes beneath tables, boxes lost but not forgotten in dusty corners, filled with the skeletons of old pieces of apparatus devised for ring measurements and for mechanical studies of cycles. He matched the records of modern trees against those of beams long ago cut for house roofs in the Hopi villages, some of these Hopi beams having been cut in the 16th century and used again and again in new houses built when old ones collapsed. The outer rings of the old trees duplicated the records of the inner rings of the more modern and younger group; the two together offered a record of dry and wet seasons back to the early 1300's, A. D.

During the historic period of the Southwest, the Spaniards recorded at least two bad drouth periods and their effects upon the Indians. In 1668, '69, and '70, the pueblo of the Jumanos, one of the group east of the Manzano mountains in New Mexico, suffered drouth and famine almost to the point of extinction, and while slightly over a century later, between 1778 and '80, the Hopis of northern Arizona were struck by drouth, famine, and disease. The cattle which they had acquired from the Spaniards all died; the people themselves were starved to skeletons. Many died;

some joined the Navajo; some tried to get to Zuñi where conditions were slightly better. The Spaniards tried to make of their hardships a wedge by which to persuade them to come over into the Rio Grande and give themselves up as Spanish subjects, but the unconquered tribe answered that they preferred death to subjection. De Anza reported that if rains did not come the next season the entire group would have had that choice of death and extinction; their food was gone; their animals were gone; the desert produced too little food to sustain life except for a roving people accustomed to traveling long distances.

These were the effects on the pueblos of three year drouths for which the tree records showed very small rings, missing in some cases. What, then, of longer drouths and of their effect upon people and trees?

The chart was back to the early 1300's, and there it stopped at a period so difficult to read that certainty was impossible. The midnight oil burned out; the razor blades fell one after another into the waste basket, but the missing ring, in its absence, was lord of the day.

The scent of the tree ring struggles had been set in Arizona up to this time. Now the scene shifts to northwestern New Mexico, where Neil Judd and Earl Morris, archaeologists of national repute, were excavating Pueblo Bonito in Chaco Canyon and Aztec Ruin, north of there, near Farmington.

The historians and the tourists of the country have always asked for dates on the ruins excavated. The archaeologists were more concerned with culture sequences, variations, developments, and diffusion than they were with exact time, but they tried to oblige, and the dates which they suggested varied from man to man as much as their hat sizes. I do not mean to say that they gave out whatever date first came into their minds; they manfully tried to evaluate what data they had on chronology, but that data actually gave no more than relative chronologies of culture sequences. Hundreds of years in one man's estimate became thousands

to another. Judd and Morris decided that if they could persuade their astronomical friend, Dr. "D", to study the specimens of roof beams which they were taking from their ruins, he might be able to construct a master chart from them. If, eventually, very old Hopi beams or beams from late prehistoric ruins could be found, their records might fit onto the inner record of the long modern master chart and onto the outer record of the prehistoric pieces, and so fill in the gap and date the ancient roof beams and, hence, the ruins, at the same time that it carried the record of weather fluctuations several hundred years farther into the past for sun spot and meteorological studies.

The beams were collected and Dr. Douglass began their study. The dry climate of New Mexico is proverbial; these old beams had been so well preserved that when they were cut the center was golden with pitch and the odor of resin was strong. A master chart was made to represent the beams as a group from each ruin; the charts were matched against each other and two ruins were found to be very close to the same age. But what the age was remained a mystery; there was a definite gap between the ancient and the modern charts. How to fill it?

Dr. Douglass came to the rescue again, with the same straightforward thinking which characterized his decision to begin tree ring work. Certain pottery types were known to represent the general period of the old specimens. Certain types were known to approximate the period of the interior of the modern chart. Between these types of pottery others were known to come in a general sequence. If a ruin with the types in between could be located, it might produce logs which would fill in the gap in the chart. At the same time, these new logs might clarify the faulty record at the inner end of the modern chart, that faulty record on which some trees indicated so many missing rings that the accuracy of all for that period was in question.

Once again Dr. "D" solved the problem. In the summer of 1927 a beam expedition was sent out, a ruin answering

to the proper description was located at Showlow, in the White Mountains of Arizona, and the logs taken from it proved to be of the right period, crossed the gap, linked the two charts, dated the ruins, and carried the main chart, with its new additions, back to about 700 A. D. The missing rings of the late 1200's were found to be part of what is now known as the Great Drouth, lasting from 1276 to 1299. It was the longest and driest drouth known in the total period of the master chart, which has now been carried back to 11 A. D. for the area of Arizona and northwestern New Mexico. The latest dates to be found on the logs used in many southwestern pueblos fall within this period, and archaeologists can picture large districts of formerly populated area being crossed by famished bands of people seeking new homes, food, and water. Their own pueblos were deserted, and the fact that hordes of the people must have died at this time is indicated in the limited areas of occupation in the succeeding period. The peak of pueblo extension had been reached; the peak of pueblo culture had passed, and the missing rings spoke as clearly as the deserted villages of the tragedy of that passing. The land was so dry that even the trees could not grow; a curse from the water spirits, the clouds, the spirits of their ancestors, was upon the people, and they left, dying.

The Rio Grande area of New Mexico was populated more heavily from this period onward than it had been previously. Apparently some of the people who were forced by drouth from their old homes and their garden farms came east of this Mecca of flowing water and fertile river terraces. Here we can trace their moves and their relative periods of cultural developments, but so far they have been dated back only into the 13th century. W. S. Stallings, a student of Dr. Douglass, came into the Rio Grande to work out its record of weather fluctuations and to date its ruins, but the task so difficult in Arizona was even more difficult here. Aided by the experience Dr. Douglass could pass on to those he trained, Stallings was still held in the strong clutch of that

demon of nature,—our old acquaintance, the missing ring. In the Rio Grande the areas in which the weather fluctuations are consistent are small; these areas can be compared with other areas in which the records may be almost alike or on the other hand, far from alike. Districts next to each other may be less alike in their records than some far removed from each other. The patience and care of Stallings were not second to that of Dr. Douglass when he worked out separate charts for the districts of the Rio Grande and of the surrounding mountains and valleys. At present there is a tentative Rio Grande master chart which covers all of the smaller charts, but the variations within the large area make the composition of such a master chart hazardous and difficult. From some of the valley ruins around Albuquerque, the juniper beams of the old roofs cannot even be cross dated upon themselves, the record of one identified in the record of another. Juniper, it must be admitted, is infinitely more difficult than pine or piñon or Douglas fir for tree ring work, as its growing habits make the rings of uneven widths and tenuous. But the missing rings,—well, you understand by now what we would say about them, and, probably, what we privately say to them!

Tree ring work in New Mexico has not been entirely limited to the wood of prehistoric or of historic ruins. In the eastern slopes of the Manzano mountains drowses a small Spanish village named for those mountains. In the spring, the traveler sees a pink glow of apple blossoms long before he sees the houses of the brown adobe town, and these blossoms are on trees in orchards reputed to date back to the period when the Franciscan brothers worked for the souls of pueblo people living in large villages in the district. Bandelier said he could find no record of the planting of these orchards in the memory of the modern inhabitants, and it is he, probably, who started the story of the great age of the gnarled trees. The trees do not bear fruit today, but early American soldiers coming to Manzano found girls selling local apples as refreshments at dances, much as our cigarette girls do today.

Perhaps science is harsh on romance, but those apple orchards, laid out in rows, suggested themselves as excellent material for tree ring studies. One of the old trees in the north orchard had died during the year; its last leaves were still shriveling upon it. Its trunk was as large as any there, and the fact that the trees stood in rows suggested that they all had been set out at one time. While the villagers gathered to watch from the stone wall around the orchard, this recently dead tree was cut and sawed down, and in scientific glee I carried the stump back to my laboratory. I had little idea from the trees themselves whether they were young or old, but I was going to prove their age from a count of the rings in my specimen.

I suppose it is a wonder that some chamber of commerce in the state did not hurry me into solitary confinement and burn my log; the date which I published for its interior was no earlier than 1800 A. D. Such a rejuvenation and face lifting of antiques has been paralleled in practically everything dated by the Douglass method of tree ring analysis; man proposes but the wood disposes the great age of the Southwest. We know that the pueblo cultures and their progenitors, the Basket Makers, extend back at least to the time of Christ and probably further. We can give definite dates on ruins back into the sixth century, and we know of many earlier ones yet to be dated. But before these people were here, the much-discussed post-Pleistocene people camped and flaked their handsome Folson and Yuma points and hunted the bison and the mammoth. How long ago did these people live? Geologists offer estimates varying from 2000 to 20,000 years and only geologists can settle the problem.

The Southwest is old enough; it needs no romantic fibs to establish its right to vote. As for the exact age of its many old cultures, we shall continue to consult the trees, our most accurate time pieces, as far back as they will go. Then gird yourselves for battle and take up the razor blade; be onward and after the Missing Ring.