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Dr Frank Craighead
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83012

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is "smarter" than humans; he circulates the high level of lipids attached to a blood protein which provides stable transport so ~~and~~ the lipids are not deposited in the blood vessel walls.

Humans ~~transport~~ who develope arteriosclerosis have transported their blood lipids on different blood proteins that result in an instable combination so that the lipids are deposited as ~~in~~ arteriosclerotic plaques in the coronary arteries.

in the entire vascular system,
including the coronary arteries.

Somewhere:
(if you wish)

chemical analyses of the blood showed high levels, by human standards, of circulating fats, including cholesterol. These levels would place a human in a very high risk category for the developement of arteriosclerosis and of coronary heart disease. Additional studies however showed that the bear

May 2

Dear Franck,

I seem still to do more and more of what I'd rather not do and less and less of what I'd rather — hence the months delay in this letter.

We still sympathize with your loss and marvel at the way you and Esther have managed it. Wish we could help.

All of us are well physically though I've not heard too recently from many of the children. Mary seems real happy; James is still struggling; and the rest managing. I see only Liz often; she works in a bank in Monument 20 miles north of the Springs

Finally received moisture as rain & snow; it was much needed. But it is so cold that life-giving water threatens the life of calves only 1-2 weeks old. Nature is harsh!

Enclosed are comments. I liked your chapter!

Best to all

Morgan

CHAPTER VII

HIBERNATION AND THE INNER BEAR

In January of 1963 we webbed through deep powdery snow that had sifted down through the lodgepoles until it covered the forest floor to a depth of 8 to 10 feet. We entered the timber where a small blaze high on a tree told us we should start our course, following a bearing of 240°. This would lead us back to the three-forked lodgepole that towered up over the den where grizzly No. 164 was sleeping. We sank deep in the fluffy snow as did the marten whose tracks occasionally crossed small openings then vanished as this arboreal predator took to the trees in search of red squirrels.

The north facing entrance to the den of the female grizzly was covered with snow except for a tiny opening through which some warm air escaped. It would have gone undetected had we not known just where to look. After compacting the snow, we removed our snowshoes and used them as shovels. Before long, a sleepy growl that could be interpreted as a groan, followed later by another with ominous overtones of a warning, made us desist, think the situation over and decide to leave No. 164 alone. We had returned with the hope of determining whether she had two year-olds ~~lings~~ with her and to evaluate the situation for later study of the sleeping bear and her winter den environment. We were not what might be called mobile should the aroused grizzly charge out of her den; in fact, we were quite helpless. Unable to run, our only alternative would be to shoot in self defense. An immobilizing dart would not take effect in time.

Not wishing to put either our own or the sow's life in jeopardy, we reluctantly buckled on our snowshoes, shouldered our packs and retraced our steps. Perhaps another year, I thought, we will find a den more amenable for studying, or a bear in a more dormant condition. We ~~needed~~ a situation where we could immobilize the grizzly at least once and instrument the den and bear for temperature recordings. This den quite obviously would not suffice and as we threaded our way through the trees, I was not at all sure that we would eventually find one that would meet our requirements.

In the meantime, we could perhaps study the winter sleep or hibernation of the black bear. This member, Ursus americanus, of the bear family was in no way so aggressive as the grizzly nor was he so powerful. Above all, his instinct when cornered was to flee rather than attack. He did not have the grizzly's trait of complete lack of fear for that awesome species, Homo sapiens. There were many things that we could learn about black bear dens that would apply to the grizzly. Why not, we thought, start our den studies with the black bear until we could safely work with a grizzly? Several years later when we returned to one of Marian's snow covered dens, we were still unable to immobilize a grizzly without risking her life and Marian was not an aggressive bear as grizzlies go.

The black bear has evolved curved claws that enable him to nimbly climb almost any tree whereas the grizzly is not adapted for climbing. Instead, his long front claws are ideally suited for digging. It may be that the ability of the black bear to climb and thus escape many dangers has made him less agressive than the grizzly who must face a challenge or turn and run. At any rate, there is a tremendous difference in the temperments of the two animals and as might be expected, the black bear is more at home in the timber and prefers this habitat while the grizzly is fond of and quite at home in open country---meadows, burns, sagebrush habitat and open expanses above timberline. Because of his facility at digging, the grizzly excavates, shapes and completely constructs his winter den. The black bear usually seeks out a natural cave or shelter which he may modify or use as is.

The black bear has two distinctive color phases - black and cinnamon,- but the term black applies to both colors. Many black bears sport a white V-shaped collar. Many young grizzlies also have collars but they are not V-shaped in front and they tend to disappear as the bear ages. Grizzlies have a distinctive shoulder hump, black bears do not. The grizzlies' face tends to be concave or saucer-like while the black bear's is the opposite, being convex.

In general, grizzlies are much larger than blacks. The average Yellowstone male will weigh 500-575 lbs, varying between spring and fall, the female 300-380lbs. and a large one will go as high as 500 lbs, a male 1000 to 1200 lbs. The largest we weighed was 1120 lbs. The average male black bear weighs about 200 lbs. and the female a quarter less. A few of the largest black bears on record have weighed over 600 lbs. but this is exceptional. Like the grizzlies, their weight varies from spring to fall reaching a maximum just prior to hibernation.

The two species of bears inhabited most of the North American continent from the Atlantic Ocean to the Pacific from the Artic tundra to Mexico. Primitive man worshipped the bear and so did some American Indian tribes. In some instances the bear was hunted and killed as a token of courage and tribal status. In such encounters the bear frequently came off the victor. Other tribes would not kill a bear. Much of the awe and reverence that men held for the grizzly may have been due to the fact that the bear resembled man in many ways. Like men, the bear can rise to a standing position and like men, they walk on the soles of their feet. The track left by a hind foot though large, resembles man's. A skinned bear has an exceptionally human appearance. In physical feats, the bear could outdo his human competitors. He could run faster, swim better, his reflexes were faster and he could travel with uncanny silence and stealth. While man struggled to get food and keep warm during the long severe winter, the bear slept in comfort, living off his fat which supplies about 3500 calories per pound. The food that produced the fat was obtained by a hunter and forager even more efficient than the best of men The bear exhibits truly remarkable adaptations to life in his natural environment, ~~adaptations to life in his natural environment~~, adaptations far superior to many of man's.

When incorrigible grizzlies dangerous to visitors or nusiance black bears were killed, we performed autopsies on them. This work was done in collaboration with a life-long friend, Dr. Morgan Berthrong. It was he who from our samples first noticed the complete lack of arteriosclerosis in the coronary arteries. Then through microscopic studies he found the large, medium and small arteries to be totally free of arteriosclerosis. These findings led to blood chemistry studies to see if we could determine why the bear, unlike man, was not afflicted with arteriosclerosis. Perhaps it would provide us with a better understanding of this disease in man. In pursuit of this work we routinely collected blood samples from most of the grizzly and black bears that we captured. We had numerous samples taken in spring, summer and fall, but so far none in winter from hibernating bears.

In the high Yellowstone plateau country most black bears are in winter dens well before the grizzlies retire. First one goes in and does not appear, then another until even the tardiest sleeper is slumbering. The grizzlies tend to enter ~~to enter~~ winter dens pretty much at the same time and this unanimous urge to retire seems to be triggered at least in part by a snow storm or blizzard. Often black bear tracks led us to their winter dens. Never did we locate a grizzly den in this way.

Thus in the fall of 1967 with snow on the ground and geyser steam in the air, we followed black bear tracks to a cave opening near thermal pools in the vicinity of Old Faithful. The bear slumbered while the snow depth increased, elk and buffalo moved less freely and centered their activities around thermal areas relatively snow-free. While these animals west of the continental divide congregated in small resident herds where limited winter food was available, the elk herds of Hayden Valley migrated to the Lower Lamar Valley and left the lush forage to a few sturdy bison ready and capable of digging down through layers of snow to feed on it.

Winter had well advanced and a coldness and uniform whiteness, sometimes in deadly calm, at other times swept by chilling horizontal winds, characterized the environment. Solitude was both at hand and afar. Over this frozen whiteness, a raven flapped undisturbed by countless snow particles hitting his eyes, or were they protected in flight by the nictitating membrane? I wasn't sure. I only knew that while almost all other life quietly waited out the storms the raven often revelled in their presence, rolling, diving, banking in the winds as though it was just another balmy spring day. The approaching raven dipped low, apparently curious about the single human form beneath him. Instinctively the raven knew that life one day might be food for him the next. He continued on but with a piece of data stored in his memory bank.

Beneath and behind his disappearing form, a lone figure was sitting on snowshoes. The deep snow, unmarred except for a few human tracks, stretched beyond him to a dark green barrier of scattered spruce and fir. The man's attention was neither directed to the immobilizing gun beside him nor to the projectile syringes carefully arranged on a knapsack. Even the camera lay idle. Oblivious of his winter surroundings he was listening intently, picking up the sounds and muffled noises that seemed to emanate from the earth directly beneath him. The voices, though weak, were distinct.

"Let's roll her over."

"Do you think there's room."

"We can try."

"Good, now feel along the inside of her leg. Can you detect a pulse?"

"No, I can't feel a thing."

"John, how's she breathing?"

"A little rapid but steady. Now I feel a faint pulse. Hand me the vacuum bottle and the needle. Shine the light over here: I think I've got a vein. There comes the blood. I didn't get the femoral artery but we'll get enough."

"The vial is almost full. Let's get out of here."

"If the drug effects wear off, we'll have to scramble."

Three of us were packed in this small stifling den with a large black bear and all were profusely sweating.

"It's no wonder she hasn't built a bough bed", I thought. "The heat from this thermal area keeps the den amply warm throughout the winter."

John and Maurice were wriggling their way through the narrow entranceway toward the den opening, and just in time. The bear growled and raised her head as the flashlight disappeared. The effects of the drug were diminishing. Control of her jaws was returning. Propelling my way with elbows and knees, I followed John and caught a blast of light as he emerged into the blinding glare of light reflected from the wintery Yellowstone landscape. As we appeared, Charlie Ridenour commented, "I'd give a fortune to have had a tape recorder. You should have heard that conversation."

Charlie might not forget that conversation; the three of us would never forget the experience. Unique or unusual experiences are a form of enrichment that can be sought out and accumulated. In the course of a lifetime, you can lose wealth and possessions. Power, prestige and status may be fleeting. Almost anything one cherishes can be lost or taken away. An experience, unusual, pleasant, thrilling, awe-inspiring, impressionistic becomes a part of the individual. It can not be lost. It is something he and he alone keeps and relives unto death. In seeking a good life, greater emphasis might be placed on experience rather than material possessions.

We had successfully immobilized a black bear in its den and had obtained a blood sample, thus making our first intimate acquaintance with a hibernating bear. A blood sample from this hibernating black bear at a time when thyroid levels should be low might be revealing. Using a small centrifuge, we would soon separate the blood serum from the red blood cells and later ship it in ice to Morgan for chemical analysis.

An hour before we successfully obtained a blood sample from the hibernating bear, our movements and tramping around at the den entrance had aroused her. Her body temperature rose a few degrees, she became active and perhaps through curiosity looked out the den opening. We hit her with a drug-filled dart. She growled and returned to the blackness of her cave. A half hour later we thought the bear should be immobilized and helpless. We thought she should be: the problem was, we didn't know. Nevertheless, John, Maurice and I crawled into the narrow entrance and squirmed through the dark and confining tunnel guided only by a flashlight. The tunnel seemed to extend on and on. It turned out to be nearly fifteen feet long, terminating in a chamber only slightly wider than the tunnel itself. While propelled slowly by my worm-like movements, I heard John say that he'd reached the bear and she was out. Then I, too, was in the chamber--low roofed, the walls reddish in color, the air heavy and moist from the nearby thermal spring.

The inside of that den with the dark formless shape of the drugged female bear occupying most of the space is still vividly etched in my mind. Under similar circumstances, we could never have dared to push our way into a grizzly's sleeping chamber. We tried it with the grizzly we called Lucky, several times with Marian, with No. 101, and the pregnant female, No. 187. The response was always growls and activity within the den, an aroused alertness. This combined with deep snow that hampered fast movement and the aggressive nature of the grizzly, put a damper on our enthusiasm to immoblize and instrument the den occupants. Now and at least for awhile, we were compromising by working with the black bears. In the meantime, we were developing transmitters and techniques that would enable us to implant a temperature sensitive transmitter in a grizzly captured in fall, thus eliminiating the hazards to both bear and man of an attempted immobilization in a winter den.

With modification of the telemetry system, we were using to track grizzlies, we planned to monitor temperature conditions in the den of a hibernating black bear. At the same time, we proposed to obtain twenty-four hour or nychthermal body temperature patterns from the sleeping animal in an effort to learn more about his temperature regulating processes. Just as in humans these 24-hour temperature rhythms would give us insight into the winter physiology of the bear and inform us of the times when he was most lethargic or most active and alert. Would it be during daylight hours or late at night? Most but not all people are day oriented but bears are more active at night. Would the unbroken darkness of the cave tend to change the bear's pattern? How low would the bear's temperature drop from the 101° F. normal during summer activity?

The winter work ahead was of great interest to us, offered new experiences and a challenge. Our previous research had paved the way for the work to come. Joel Varney had improved our telemetry system so it had a capability of transmitting temperature data when we inserted tiny temperature probes (thermistors) under the skin and in the muscle tissue of free-roaming elk. In this way we had monitored their body temperature fluctuations in summer and during the winter months.

Now we were ready to employ the same technique on a black bear that in November we had tracked to a winter den. In January at the cliff den above the Gibbon River, we immobilized the bear by jabbing him with a drug-filled syringe at the end of a long stick. This was close quarter work and we were not sure how the bear would react. Would he ignore the needle injection and retreat further back in his den or would he charge? And how would we react if the bear rushed out of the den? The problem was definitely on our minds but we had not determined a course of action. Four of us, John, myself, Hank McCutchen and Klaus Nielsen were crowded on a tiny ledge leading to the den entrance. Each of us would have to make his own decision.

After we injected the bear with the drug, sernylan, there was a rustling movement, then all was quiet. Lying on my stomach, I flashed a light into the interior of the den to observe the bear's reaction to the drug. This first caused him to retreat into the far recesses of the cave where he moved restlessly about before making a fast break for the entrance. Our attempt to block the den opening with snowshoes failed He moved too quickly. Suddenly he had joined us on the narrow snowy ledge above the river.

The warning, "Watch out!" that John had shouted rang in our ears, but what to do? Our situation was precarious. Freedom of movement was drastically limited by deep snow, and a strong aversion to leaping off into space. Within the instant our crew individually, but in unison, moved in one direction--the bear, fortunately, and perhaps deliberately, in the other. He turned and began climbing a nearby perpendicular snow wall, pawing his way through snow 5 to 6 feet in depth. Carefully, and with difficulty, we followed on snowshoes. When we finally overtook him he was lying immobilized in the snow.

Pulling him like a toboggan, we dragged him back to the den entrance where we brushed off the snow and proceeded to instrument him with a collar-transmitter. While he was under sedation, we slipped the radio over his head and inserted a thermistor probe through a small incision in the skin which was then treated with an antiseptic and sutured. With this completed, I crawled into the den pulling the bear headfirst after me while outside John, Klaus and Hank pushed against his fat-layered buttocks. With our combined exertions, we replaced the bear in his bed but there was barely room for the two of us in the rocky den.

Nevertheless, I took time to look and marvel at this bear's beautifully constructed bed. I also recorded a few measurements. The insulated bed was eighteen inches deep by thirty inches in diameter, cup-like in shape with nearly perpendicular walls against which the bear's body fit quite snugly. Within the confines of the thick accumulation of bed material consisting of a porous mixture of dry pine needles and finely shredded twigs, the bear had been hibernating as though enveloped in a down sleeping bag. This particular bear, I thought, must be a master in the art of making beds. To exit I slid over the bear's body, carful not to disturb the bed, and wriggled head first out the narrow den opening.

With the black bear again reposing in his pine scented bed, we descended the steep hillside to our tarp tent along the river. From this vantage point with a fire for warmth, we monitored by radio the gradual rise in the bear's body temperature as well as the temperature of the den and the outside air. This was accomplished by counting at definite intervals the pulses or "beeps' per minute from our radio receiver. A stopwatch was used and the greater the number of pulses, the higher the temperature. These totals were immediately converted to degrees F by means of a previously prepared pulse rate vs. temperature chart. A gradual drop in the bear's body temperature indicated that he was revertin to his previous lethargic condition of winter sleep.

After the bear had returned to a normal condition of winter sleep, we obtained body temperature patterns. Over one 24-hour period, the den temperature remained relatively constant at 26 to 28°F. while outside air temperature varied from 15 to 30°F. During the same period the bear's body temperature dropped to a minimum of 94°F. at night and reached a high of about 96°F. in the afternoon, suggesting a typical high day-low night rhythm even though the cave was relatively dark. In still darker dens, a diurnal rise in the bear's body temperature did not occur. The most significant changes in body temperature occurred in response to disturbance, the greater the disturbance, the more the temperature changed. When undisturbed the bear's body temperature drops as the den temperature declines. During an unusual cold spell, one bear's temperature reached a low of 89°F. after which it rose to over 90°F. even though the den temperature continued to drop. It appears that 89°F. is about the lower temperature limit the bear can safely tolerate after which a spontaneous arousal takes place in response to a metabolic increase.

While monitoring the bear in the cliff den, we remained awake to periodically count the radio pulses per minute, convert them to temperature and record in a notebook. In order to obtain a 24-hour temperature pattern, break camp and return to West Yellowstone, we went without sleep, other than an occasional nap, for 40 hours. This grueling grind was quite an incentive to develop equipment that would automatically record the changing temperatures. On the other hand, we did not want to eliminate our contact with the elements, the sound of boots crunching in cold snow, the brush of snowflakes on our face, the flickering fire, the warmth of a down sleeping bag, the friendly visit of Canda Jays or the infiltration of our camp by an audacious marten that stealthily cut the leather straps on my back pack and stole the steaks we were saving for our last meal.

While we were monitoring the body temperature of the Gibbon River black bear, Marian was giving birth to a litter of three cubs. In the fall of 1967 we felt certain that Marian was pregnant and we looked forward to visiting her winter den after parturition when hopefully we might see her tiny helpless young. In late September her radio transmitter had failed and we lost the chance to track her to a natal den. Our studies of the hibernating black bears were giving us some idea of winter conditions in the grizzly dens. We located Marian's den sheltering the sow and her three large cubs in the fall of 1968, but immobilizing four grizzlies simultaneously seemed only remotely possible and we had no intention of placing ourselves in a position where we might have to gun Marian down in self defense. Marian, as we shall see, did not dig a den in 1969 nor did she hibernate in 1970 when, electronically speaking, we took a big step forward and radio monitored a black bear and his den using the Nimbus satellite, a rapidly moving man-made star in the sky.

During October and November we had tracked black bear, No. 6 for 27 days using the radiotracking system we had developed for studying grizzly bears. Jay Sumner and Jim Clear followed and observed him while he selected and prepared his winter den. Now in February I was peering through the snow-choked entrance to verify that our bear was still sleeping--not in the torpor of true or deep hibernation but lethargic with a reduced heart rate and somewhat depressed body temperature. The black bear as we had learned could quickly awaken from his winter sleep and if disturbed would even rush out of his den. If unmolested, he would doze curled in his den with little movement. He'd go five months without drinking or eating. He would live off the thick layers of fat accumulated during the late summer and early fall months. Efficiently adapted for a long winter sleep, he would neither urinate nor excrete. The bear seen in the dim cave light was in a dormant condition and at my cautious peek did not move. We rarely looked in a bear den without having the animal open his eyes or growl, an indication that he detected our presence.

During the winter sleep, the bear is highly vulnerable to his main enemy, man. Nevertheless, the ability to sleep through adverse winter weather when food is not available is an advantage in the survival of this large species. Man has adapted to changing conditions and has freed himself, at least temporarily, from the vicissitude of cold, drought, food shortages, population pressures and a host of other disabling forces by altering his environment. The bear, more so than man, has himself adapted to changing environmental factors. He is a marvel of biological adaptation of physiological and chemical perfection developed to cope with existing natural environments. However, he is gradually losing out to the rapid changes man is now making in the environment and he cannot cope with man's highly developed and sophisticated technology of killing.

Hibernation in the bear is a complex adaptation to adverse environmental conditions that might, at times, well serve man. A capability of sleeping long periods of time could be an asset on extended space flights. Physiologically, bear and man have much in common and the chemical composition of the blood is much the same. But the bear has attributes we lack such as the ability to handle metabolic products whose accumulation in man would be toxic. This may be related to the unusual lobulation of the kidneys. It is not inconceivable that if scientists can learn how the bear hibernates, we might, with modern technology, duplicate the process ourselves. The purpose of this inital winter excursion was to reconnoiter and to cache gear for a feasibility experiment in monitoring a black bear den by satellite-part of our long range objectives of learning more about the bear, particularly those secluded and isolated during winter sleep.

Our expedition members terminated a three-mile trek on snowshoes at the base of a steep slope that defied further travel except on all fours. Struggling upward slightly more than we slipped back, we had gained the halfway mark. We were on a level with the bear den. Here we stopped to catch our breath and zip open our parkas. Before climbing higher John and I looked for a rocky outcrop where we might position an antenna that would transmit to and receive signals from the orbiting Nimbus satellite. On up the hill was a site with a relatively unobstructed view of the sky. With the aid of ropes, Harry hauled up the cable spool, Joel and I each backpacked a battery, John and Derek the antenna tripod and transmitting equipment. By the time we assembled the gear it was noon and the satellite was passing by unseen high above us. It would complete another orbit of the earth about every hour and three quarters and it would pass over us again at midnight. On some orbits it would be overhead, on others close to the horizon. When low and to the west the hill might interfere with data transfer. Our plans to monitor the bear and his den by satellite were progressing. On our next ascent, we would haul up a loop antenna for the den, recording equipment, more batteries, temperature and light probes, cameras, camping gear, and equipment for instrumenting and immobilizing the bear. We were embarking on a rather fantastic project -- the culmination to numerous winters of studying sleeping bears using bio-telemetry methods. In collaboration with NASA engineers, we were committed to a project to test the feasibility of satellite monitoring of temperatures and light conditions in the den of a hibernating black bear. At the same time we planned to obtain body temperature patterns from the sleeping animal.

Through NASA we had obtained the loan of an IRLS (interrogation, recording and location system) platform used for collecting and transmitting information from ocean bouys and weather balloons to satellites. Platform is the engineers' jargon for the remote sensing, transmitting and receiving equipment. It was the electronic gear that we were setting up to leave unattended at our bear den. Sensors within the den would gather information for transmittal to the overhead Nimbus 3 satellite in a polar orbit 700 miles above us. Twice every 24 hours the satellite would pass by and interrogate the instrumented bear den. We could thus obtain data from light and temperature sensors at 12-hour intervals. We would also continuously chart the bear's body temperature on a nearby recorder. Prior to each orbit, a ground station at Fairbanks, Alaska, would transmit commands to the satellite indicating the precise time when the den platform was to be interrogated. When the satellite was within radio view of the equipment at the den, there would be an exchange of signals and the IRLS platform would transmit the sensor required information on temperature and light conditions to the satellite. Here it would be stored until later readout over Fairbanks, Alaska. The satellite would also measure the time required for the signal to travel to the platform and return: information later used to determine location of the station on the earth's surface. When the satellite completes the orbit by passing over Fairbanks tracking station, the accumulated data are transmitted to the ground station and new sets of commands are radioed to the satellite for the following orbit. The collected data is next sent by telephone lines and micro-wave to the Nimbus data processing center at NASA's Goddard Space Flight Center near Washington D.C. In the course of processing, the data is printed out by computer and then mailed to the experimeter. In our efforts to test the feasibility of using satellites for wildlife research by remote recording of data from a "hibernating" bear and his den, we were taking a space-age leap from our earlier campfire monitoring.

If we had visions of satellites removing the backbreaking work of monitoring bear dens while we sat back and waited complacently for the data to pour in, we were quickly disillusioned. Soon after assembling our field equipment and electronic gear in the little town of West Yellowstone, we took off on snowmobiles pulling sleds laden with skis, snowshoes, camping equipment, food and the electronic equipment needed for our experiments.

Five miles out of West Yellowstone, we left our snowmobiles and trekked cross country carrying our gear in backpacks. Harnessed like dogs, we pulled the heavily laden sleds. Some of our crew pushed while others pulled as we threaded our way through very dense stands of young lodgepole pine. Vince Yanonne, with the bulky plate-shaped antenna strapped to his back, often had to step sideways in order to pass between closely spaced trees. Joel Varney took off his heavy parka and tied it on his sled. As he stepped into the harness again I heard him mutter, "And I thought this was going to be the easy way to monitor a bear den."

Two miles later we dropped some of our gear beside a huge rock where we would camp. We then continued until our progress was interrupted by the steep, snow-covered ascent leading to the bear den. Again stashing the now useless snowshoes and skis, we struggled and crawled up the steep slope with our heavy burdens. We grasped every protruding bush or tree to keep from slipping backwards. On the uphill side of a large spruce trunk I dropped my pack; then traversed across to the den entrance. Accumulating snows had closed it since our former visit until only a slit remained.

After my eyes adjusted I could detect the dark form of a bear, motionless and curled in repose. My silent approach through powder snow had not awakened him. But would not the struggles and deep breathing of the others still bringing gear up the steep slope do so? I had no doubt that the bear would soon arouse. When we were finally assembled we went quickly to work. It was a procedure we had performed at other dens and we knew just what steps to take and when. While John and Vince and Jay measured out a dose of the drug sernylan and attached a hypodermic syringe to a long jab stick, Joel and I unpacked the elctronic equipment. John's son, Derek, set up the movie camera at a vantage point, and his daughter, Karen, got ready to take still pictures. Pat moved to a tree that she could climb and Harry started unwinding cable that would lead from sensors placed in the den to the ledge above, where we had placed the satellite antenna.

Though our preparations had been made as quietly as possible, our presence had alerted the bear. A black nose and one ear soon protruded from the narrow snow opening. The bear raised his nose and sniffed, turned his head from side to side and then backed into the den. Seconds later he poked his head out again, nervously sniffing the still air.

Derek was taking movies, Karen was taking stills and I was taking pictures of Karen taking pictures. We were all apprehensive lest the bear should suddenly lunge out of the den before we could immobilize him, leaving us only tracks in the deep snow. As he retreated into the den, John quickly peered inside, poised the jab stick and struck the bear in the shoulder. With the momentum of withdrawing the syringe he backed off fast. Momentarily surprised, the bear retreated but seconds later burst out of the entrance and plunged down the snowy slope, stopping in a patch of brush.

We waited for the drug to take effect before we cautiously closed in on the motionless bear. We wrapped him in a tarp and with the entire crew either pulling on ropes or pushing we hauled him back up to the den entrance. Here we swaddled the anesthetized bear in a blanket so that his body temperature, effected both by the drug and the cold, would not drop too low. The first bear that we had immobilized in his den had a body temperature of 96°F. soon after we anesthetized him. By the time we had replaced him in his den, his temperature had dropped to 83.5°F. We hoped to prevent this hypothermia produced by the combination of drug and cold.

While other members of the team were inserting a tiny body temperature transmitter rectally into the bear and positioning the chart recording equipment, I crawled headfirst into the cramped quarters of the rocky den. Vince managed to squeeze part way in to help me place the tiny light and temperature probes and numerous wires each terminating in either a photodiode or a thermistor sensor. He fed these to me through a small opening in the side of the den and I fastened them in place with spikes pushed into cracks in the rocks. I distributed the temperature sensors so as to measure temperature at the front, rear and sides of the den. I placed sensor Number 2 under the shallow fir-bough bed, along with a large loop antenna which would pick up the emmissions from the transmitter in the bear, thus enabling us to continuously and automatically record the bear's body temperature on a nearby chart recorder.

The body temperature system that Joel had devised consisted of a temperature sensitive transmitter inserted in the bear and a wire loop antenna located under the animal. This particular transmitter was patterned after a model designed by Dr. Stuart McKay. It was supposed to be swallowed but in this case we reversed the procedure. The function of the antenna was to pick up the signals from the transmitter inside the bear and transmi them to a receiver outside the den. The body temperature of the bear would affect the transmitter with resulting changes in the rate of pulses broadcast. The receiving equipment was a broadcast band radio receiver with a pulse rate converter wired to a chart recorder. The demodulated pulses would be counted automatically and converted to a direct current voltage by the pulse rate converter thus making it possible to continually record the temperatures on a chart.

As I backed out of the den quarters, I placed the light sensor on the den wall and pointed it at the entrance so it would monitor the amount of light entering the den. It could thus be used to tell us when the den entrance was closed by snow or opened by the bear moving out. I diagrammed the position of each numbered sensor and then Joel and I placed similar sensors on stakes and on trees outside of the den - some high, some at snow level, some pointing skyward, others toward the snow cover. Because the satellite would only be able to monitor the sensors twice every twenty-four hours, we placed small clockwork driven chart recorders, inside and outside the den where they would continuously record the air temperatures. With the exterior and interior den sensors finally in place, the rectal transmitter lodged within the anesthetized bear and a chart recorder operating to obtain continuous body temperature, we pushed the bear back into his den, closed the opening with snow and climbed on up the slope to secure the transmitting antenna and connect the cable from the den sensors.

For the next seventeen days our visions of working in heated rooms at other tasks while the data poured in actually transpired. We even did some downhill skiing instead of cross country touring and winter camping. Our chart recorder powered by nickel cadmium batteries was accumulating on-site body temperature information, and the capsule-like Ryan temperature recorders were providing a continuous record of the den and outside temperatures for comparision with satellite monitoring results. However, much of the work burden had only been shifted to Chuck Cote and his engineers at NASA's Goodard Space Flight Center near Baltimore, Md Here Nimbus satellite data was processed, printed out by computer and mailed to us for analysis and interpretation.

Sensor No. 2 under the bear's bed informed us via satellite that the bed temperature rose from 33°F. to a high of 85°F. over a ten-day period. Warmth from the bear's body maintained an average bed temperature of 70°F. for the same ten-day period. The temperature in the rear of the den averaged 29°F. compared to 26°F. near the entrance and 20oF. outside the den. The bear was acting as a heater to modify his winter environment. The warming effect of his body on den temperature was revealed when he later left the den. Temperatures from all inside sensors dropped to coincide with outside air temperatures. In the earlier Gibbon River den experiment, the bed temperature rose much higher than that recorded by satellite. In the micro-climate between a very well constructed and insulated dry pine needle bed and the bear, we recorded a maximum temperature of 97°F., just slightly lower than the body temperature of the active and aroused bear. It was clearly evident from our accumulated bed temperatures that the black bears were "hibernating" in a localized environment and micro-climate considerably altered by their presence. The average temperature in the bed of our satellite bear was 77°F. above outside air temperatures. However, peripheral den temperatures were not greatly altered suggesting that little heat is radiated from the bear's body and that the heat lost by conduction is minimized when a good insulated bed has been prepared.

Voltage readings from the light sensors placed outside the den varied from about 5 volts during the day to zero at night. For about a month we obtained zero readings from the light sensor inside the den pointed toward the entrance, an entrance which was sealed with snow. On March 14, the reading indicated that the entrance was probably open. This coincided with a sharp drop in bed temperature. We suspected and then verified that the bear had left the den. The relay of data from den to satellite to us had immediately informed us of this movement of a bear isolated in a wilderness area of Yellowstone. It was just one example of how a satellite system could provide an unusual capability for studying animals and their environment in remote locations.

While den and bed temperatures were being monitored twice every twenty-four hours by Nimbus 3, the bear's body temperature was continously recorded by the chart recorder in an insulated box near the den site. The bear's body temperature levelled off around 95°F., comparable to that of the Gibbon River bear whose temperature ranged between 94°F. and 96°F. This temperature we recorded during winter sleep is only four to five degrees lower than the temperature of an active bear in summer. This was expected as the bear is not a deep "hibernator"; that is, one whose body temperature drops so low it approaches ambient temperatures and where respiration and metabolic functions are greatly reduced. The bear, though in a lethargic condition, can as we repeatedly experienced, be quickly awakened to action. A deep hibernator, such as a ground squirrel, is in a torpid condition and cannot be quickly aroused. This is not to say that the bear is not an efficient winter sleeper. Because of his large size, he enters his den with an immense supply of food. This potential energy reserve in animals is proportional to the animal's size and weight but the metabolic rate is weight dependent. The large bear thus has a low metabolic rate and can fast for long periods without a reduction in metabolic level necessary in other smaller animals with a high metabolic rate. Our den temperature measurements also verified that the bear has a low thermal conductance and cannot like smaller hibernators reach and maintain a body temperature near the ambient air temperature. In other experiments we found that the bear's body temperature dropped as outside and den temperature declined. In one case it reached a low of 89°F. but after this, even though den temperature continued to drop, body temperature did not but instead rose abruptly to 91.4°F. It appeared as though this temperature was the lower limit that the bear could tolerate in safety. On reaching this thermal point, a spontaneous arousal mechanism went into operation and metabolic processes automatically increased, thus warming the bear. A colleague, Dr. Edgar Folk has found that in contrast, small mammalian deep hibernators such as door mice or ground squirrels remain dormant with a body temperature of about 41°F. but awaken periodically and eat, urinate and defecate. They become active about every four days and body temperature rises. Thus deep hibernators awaken regularly over short periods of time during which body temp- atures quickly rise. The bear hibernates at a considerably higher body temperature and sleeps in a curled position with little movement for long periods but can be quickly aroused. It appears as though the bear cannot reduce his body temperature more than about 10°F. below normal but does not need to. Other investigations have found that the bear's summer sleeping heart rate of 40-50 beats per minute drops as low as 10 beats during winter sleep and ozygen consumption is reduced by 50 per cent. These are only a few of the amazing adaptations of the bear to winter sleep. There is no doubt that he is a highly efficient hibernator.

The use of an earth-orbiting satellite to monitor a bear den provided interesting data on hibernation and revelaed the feasibility of applying this data-gathering system to studying numerous animals in their immediate environments located in remote and inaccesible areas of the globe. Even their physiological functions could be simultaneously monitored. Also, it enables information to be gathered almost simultaneously from numerous instrumented animals distributed over an extensive area.

The full application of satellite gathering systems or a combination of these and ground monitoring techniques implies far more cooperation and coordination of effort by ecologists and engineers, by private and governmental agencies, by foreign scientists and our respective governments than has existed in the past. Had there been even a semblance of cooperation from Yellowstone Park officials after 1968, our space age grizzly, Marian, might have been the first grizzly to be tracked and monitored by satellite. She had been groomed for a role she would never play.

The development of an economical and efficient satellite-wildlife technology will demand an integration of effort that could tend to unite diverse cultures and widely separated peoples, resulting in increased understanding of basic human problems and aspirations. Such understanding is usually accompanied by tolerance, a virtue the world urgently needs if the human race, and our partners in evolution, are to survive with a quality life for all. It would be nice to see this start and spread our from Yellowstone. It is well within the Park Service mission if not its present competence.

Black Bear No. 6, whose den was monitored by satellite, moved out to a Yellowstone highway in spring. According to a concerned ranger, he was given an overdose of nausea pills as an experiment. The purpose was to discourage bears from begging food from tourists. His radio collar was removed while unconscious from the drug and he was hauled away. This black bear that had made history vanished like so many others in Yellowstone and was never seen again. What happed to the Yellowstone black bears is perhaps best summed up in a statement written by a ranger in the Yellowstone Park Lake Bear Logs, July 8, 1970, after seeing a black bear -"1408- ranger reports a real live black bear at Sand Pt." - MG. A few years prior to the Park Service change in attitude and policy toward black bears and independent research, it was not uncommon to see 40 to 50 bears in a single day.

CHAMPION CLASP NO. 90
9 x 12

Diurnal changes in body temp. were not pronounced p 366

The largest & most significant changes in bear body temp. occurred in response to disturbances, and varied relative to duration & intensity of the disturbance

on three occassions when bear was immobilized his temp. rose 2° in a period of 2 hrs.

89.2 F

Bear's temp. dropped as the den temp. declined – reached a low of 31.8°C

Then though den temperatures continued to drop, body temp. rose abruptly to 33° c. (91.4°F).

Suspect that a spontaneous arousal mechanism was operating, with 32°C being the lower limit the bear could safely tolerate, a metabolic (89.6°F)

increase ensued when this limit was approached

If this behavior is typical of all black bears & grizzlies, it may serve as an alternative to the regular periodic awakening that occurs

in other mammalian hibernators, but which has not been demonstrated in the bear

In general, long-term temperature trends followed variations in ambient temperature

Bear did not urinate or defecate during period of 96 days – p 369 add page 3 - chapt. VIII

walks on sole of feet

Bear walks like man
Worshipped by man
Similar in many ways to man
} transition

✓ Track left by hind foot is similar to man's
✓ Can outrun man
Can outswim av. man

✓ Can rotate forearm and grasp and hold objects with their long dexterous claws

Morphology
Blood studies

Dictate ~~chapter~~ paragraph on remarkable nature of bear, emphasizing hibernation & bring in small adrenals. If bears were as large as man & he was proportionally as aggressive, man would not be here. With bear's size & strength he would, if truly aggressive have eliminated man. Over much of his range the bear is primarily a vegetarian

Gross autopsies

✓ striking lobulation of kidneys
✓ coronary arteries free of arteriosclerosis
adrenals small for size of animal
man 12-16 gms, bear 6-8 gms

rugal folds of the stomach and villi of the small intestine were extremely prominent as compared with man ... p. 48 1959-61 Report

thyroid regulator of metabolism
Bear thyroid small and thin-wt. 5-10 gms, adult human 30-40 gms

Fat pale yellow - paler than in man - man an orange yellow

Eyes small compared to man - 2/3 size of man

Microscopic studies

Large, medium and small arteries totally free of intimal or medial arteriosclerosis

The multilobular kidneys have a peculiar projection of the renal papillas into the calyces further than that in man. This suggests an ability to concentrate urine by greater water reabsorption in long loops of Henle. (Desert animals have extraordinary long renal papillas projecting into calyces). Perhaps in bear an adaptation for hibernation

The stomach has tremendously thick ~~mucosa~~ mucosa in which the parietal cells are especially prominent (HCL). Small intestine shows extremely long and numerous villi. These are concerned with absorption of food in man. Bears must have an absolutely fantastic absorption capacity as far as the gut mucosa is concerned.

60
45
105

45
4) 180
16
20

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add to Hibernation Chart

more on black bear — p. 2&3 + 4

more on blood — p. 3

add blood chem p. 6 top

add black bear experiment p. 7 (mid)

add temp. results of B. Bear (missoula) exp. — p. 10
after was dark.
line 7

Chemical studies

The bears are, not surprisingly, similar to man in most respects. The protein bound iodine is definitely low and with the small thyroids suggests a metabolic difference from man. This may be related with high cholesterol levels - P.B.I in bear - range 1.3 to 3.2 mcgm. percent in man 3.5 to 7.5

1963 cont Serum cholesterol values are consistently higher in grizzly bears than is normal in man - range 325 to 425 mgm. per cent compared to normal ~~human~~ values of from 150 to 250 mgm per cent.

It appears that grizzlies with high cholesterol levels and low levels of circulating thyroid are not susceptible to arteriosclerosis as in man.

Physiology & Hibernation
Winter Sleep & The Inner Bear

Visit to Marian's winter den - start den work with Black bear
Comparison Black bear & grizzly

Autopsies, blood chemistry studies - desire for blood samples
No samples in winter - following black bear
Old Faithful bear den
Conversation in den
Coming out of den
Blood sample obtained - centrifuging etc.
Entering den (flashback)
Plans to use telemetry to get 24 hr B. Temp. patterns
Gibbon River den
Immobilizing bear
Inside den
Converting pulses to temp. - example of data
Long hours to get data
Marian giving birth to cubs winter of Gibbon River work
Tracking black bear for satellite work
Discussion of hibernation
Possible use of hibernation info. in space flight
Trek to bear den with Satellite equipment
Use of NASA equipment
Satellite info. general - how operates
Leaving W. Yellowstone, hauling gear
Preparing den & instrumenting animal
Bear leaves den
Instrumenting den - how equipment worked
Data for next 17 days
Data received
Bear hibernation info. general
Experiments - info. satellite + capd. bear
Loss of black bear to Park policy

add
Philosophy on experiences
Grizzly changing W.Y.

$$\begin{array}{r} 21 \\ \underline{6} \\ 126 \end{array}$$

12

Black Bear

N.C. mean estimated wt. of male 281 lbs
female 287

Wts. p. 19 N.Y. – Miller

Teeth Cementum – Peggy Sauer – Black Bear Conference Delmar 1972

Wts. – Jonkel p. 48

adult ♀ 141 lbs } montana
adult ♂ 196

Large record male 665 field-dressed – 800 lbs – colo
620, 680 lbs. calif.
599 lb male N.Y.
633 lb " Penna.

Yellowstone Park
♀ blacks 233 lbs

Disturbed bear
champ jaws and click teeth
Hurt moaning

Sedation

Mortality

death of grizzly # 75, 1963 (Sept).

Old Mose # 179, died Aug. 5, 1964

overdose of drugs — 445 lbs

176 died July 1964, drugs

Intestines 51 ft. 11 in.

29, 1965 – drugs

196 ♀ – Aug. 1965 – ranger overdosed

205 ♂ – Sept. 1965 "

6, 1965 – drowned – overdose "

198 ♂, overdose (NPS)

Intestines of # 176 – 51' 11" long

others about 48'

148 owl-faced sow killed ramming car

Her adrenals were larger than others observed

about 4 times as large – very aggressive animal

1963 annual report

5 yr. total of marked bears. 165, of these 87 were theoretically in the population

in 1973 – 74 of these 87 were observed during 1963

Survival rate of cubs from 1962 to 1963 was 81%. It was 50% for the three preceding years. It was 100% for both cubs & yearlings from 1963 to 1964

1964 report – White-bark pine nuts, so abundant in the fall of 1962 are non-existent in 1963 & only moderate amounts in 1964.

Plants mentioned

Chapt. 4

melica or onion grass -
Fri
aster
Sagebrush
Rye grass
Sedge
Snowbank buttercup (Ranunculus glaberrimus)
sagebrush "
elk sedge

Turning over buffalo chips

ground sq.
Pocket gophers
Kestral
R.T. Hawk
Coyote
Canada jay
G.G. owl
marten
Ermine
field mice
raven
bison

9

8 90 lb cub #26, littermate #95 - tested 1st prototype radio on #95

Ht. of orbit 700 mi. ? chart VII

Check

Two color phases of Black bear – ch. 6

adrenals of no. 148 were 4 times as large as av. grizzly adrenals
very aggressive animal

add
Joel's present title – p. 16 ch 6