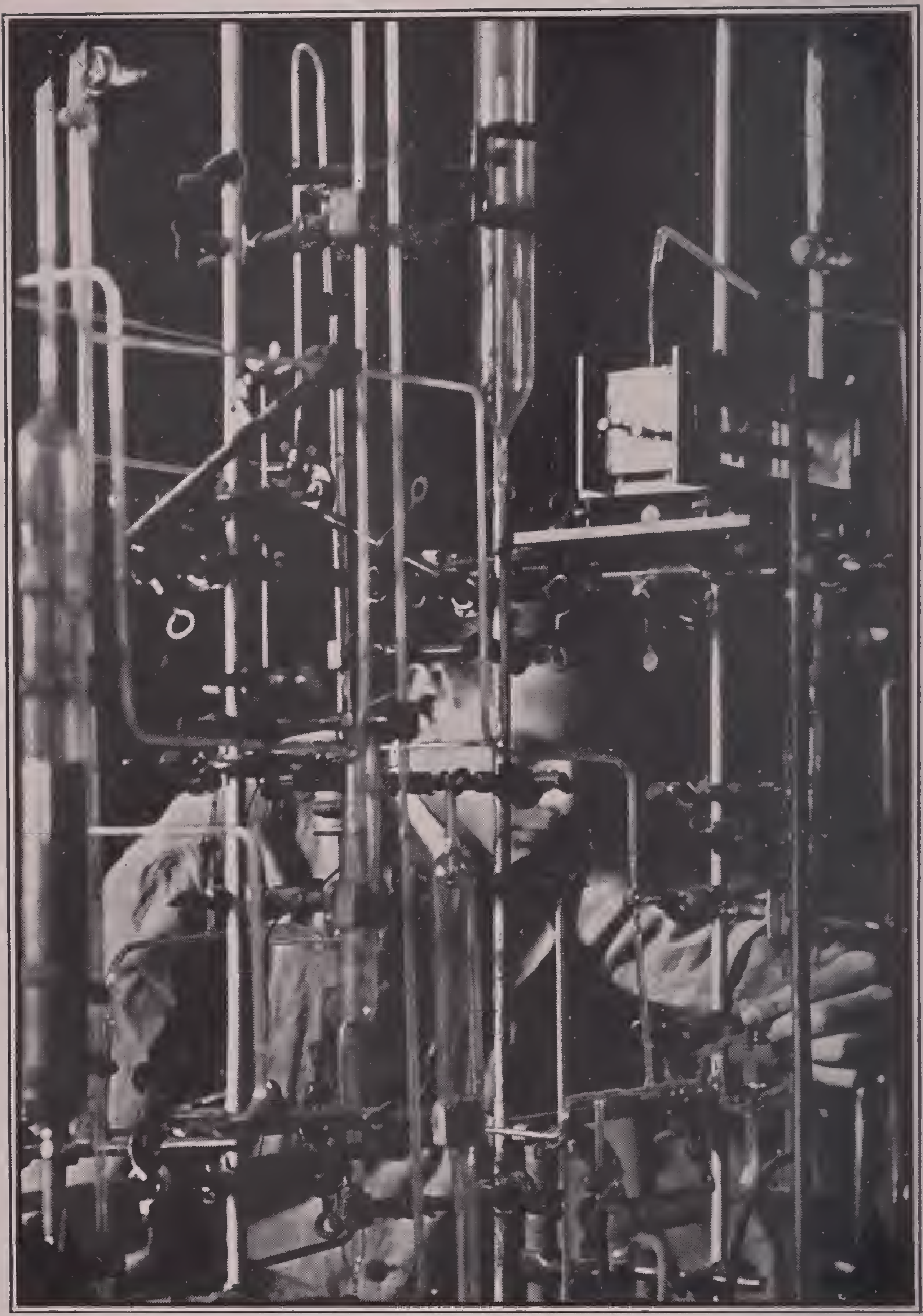
STEPS IN THE DARK

MILTON MAYER
AND
JOHN HOWE

STEPS IN THE DARK



"A day will come when science will turn upon its error and no longer hesitate to shorten our woes"
OUR ETERNITY—MATERLINCK

STEPS
IN THE
DARK

MILTON MAYER
AND
JOHN HOWE

THOMAS S. ROCKWELL COMPANY
CHICAGO
1931

Printed in United States of America

PREFACE

THE SCIENTIST is full of curiosity. He is forever asking questions about what he sees. He may be quieted for the moment, but he is determined upon getting an answer sometime. He is not satisfied; he is troubled in mind and spirit.

In laboratories, in dissecting rooms, in observatories, in the cold of the Arctic Circle, on the sands of the African desert, in fields of waving wheat, in cities buried beneath the debris of thirty centuries, in prisons, even in the humble family kitchen, the scientist is working away to find out the *why* and *what* and *when* and *how* of things.

How eyes are transplanted—What fasting does—Weighing human souls—Making wheat immune from disease—How to know when there is oil hundreds of feet under the earth—That new ninth planet that hid from us so long—Why the bus-driver did not hear the whistle when he drove into the path of the flier—Why it is best to do the dishes one particular way—When shady dealings in real estate began—What is happening in the so-called American home . . . . It is a fascinating chain of subjects which lures the eye on from page to page.

To read this book is to enter upon high adventure. And when we lay it down it is with genuine regret that we take leave of this dear, impossible person, this scientist, this fanatic, if you will, as, with test-tube and microscope in his hands and with fearless resolve in his heart, he steps forward boldly—on into the dark.

PHILIP SCHUYLER ALLEN

The University of Chicago

CONTENTS

PART I—In Politics and Human Nature

I The Lie Detector 13
II Psychoanalyzing Politics 25
III Weighing Human Souls 29

PART II—The New Past

I A Yankee Visits Our First People 37
II The First Scientist 44
III Americans Speak American 51
IV Bally-Hoo Among the Ancients 60
V Beating the Law in Babylonia 67
VI A Prehistoric Garbage Heap 72

PART III—In Commerce and Industry

I Listening for Oil 79
II The Robots are Coming 87
III Diagnosing a Railroad Whistle 93

PART IV—Man and His Ills

I Tracking Down the "Flu" Germ 103
II The Story of Ethylene 113
III Mice Tell Us About Cancer 123

IV HUNGER—FOR FOOD AND FOR FACTS 131
V THE ART OF DOING NOTHING 140

PART V—Families of Wheat and Men

I IS THE FAMILY DOOMED 149
II DISH-WASHING AS A FINE ART 157
III DISEASE-PROOF WHEAT 161

PART VI—Toward Understanding the Human Machine

I TRANSPLANTING EYES 173
II THINKING AS A CHEMICAL PROCESS 180
III AS A RAT THINKETH 186
IV IS WEATHER SENSE GOOD SENSE? 194
V HOW OLD WAS TOM? 197

PART VII—Into the Cosmos

I "SHOOTING" THE MOON 205
II NEW LIGHT ON THE WORLD'S BIRTH 213
III FINDING THE NINTH PLANET 219

STEPS IN THE DARK

PART I

In Politics and Human Nature

CHAPTER I

THE LIE DETECTOR

PUT me back on the machine. I won't resist it any longer. . . . I won't move. I'll let the machine find out what it can. I'll sit perfectly quiet and let the machine find out where the grave is. If the machine finds it out and you find the grave, then that will only be a circumstance against me and I may be able to beat the case so that you can't hang me. . . . Put the machine on me. . . . Put the machine on me. . . ."

* * *

It all began on September 3, 1928, when an advertisement appeared in the classified columns of a Seattle newspaper, describing an automobile offered for sale by James E. Bassett, of Annapolis, Maryland. The young man had driven across the country to Seattle, where he visited relatives, pending his departure for the Philippines on a government appointment.

The following day the advertisement was answered by a gaunt, unimpressively agreeable man. The owner and the prospective customer left in the car together.

Bassett was never seen again.

A description of the car—it was one of a few of its type on the Coast—was broadcast through Washington, Oregon, and California, together with some details of the "customer's" appearance. A week later an automobile broke through a traffic signal in Oakland, California, and a traffic policeman jumped on the running-board. The car, with its occupants, was taken to the police station.

At the station the car was recognized as Bassett's. Among the articles heaped in the tonneau were a tear-gas gun, a poison pistol, and some personal property, including a watch that was later identified as a trophy Bassett had won as a tennis star at Annapolis.

The circumstances were incriminating. The suspect—he gave the name of Earl Decasto Mayer—was held, as was his mother, who had accompanied him in the car. The Seattle authorities extradited Mayer for trial.

County Prosecutor Ewing D. Colvin wanted to indict the man for murder, but was thwarted by the problem of the *corpus delicti.* The victim's body, indispensable to the prosecution of murder charges in Oregon, was missing. He questioned the prisoner for days, utilizing every legal method practicable for the acquisition of information. But Mayer was wily; Colvin recognized in this man a cunning, experienced criminal, obdurate and alert.

The official investigator found that Earl Mayer was, as a matter of fact, a versatile desperado and a persistent one. He had "done time" in the penitentiaries of five States—Montana, Utah, Colorado, Kansas, and Washington. Automobile stealing was the chief charge, but there were other offenses. Only a short time before Bassett disappeared, Mayer had been released from the Federal prison at Leavenworth, Kansas.

Before this time, Mayer had been the sole suspect in three murders (murders by implication only, since the bodies were never found), and on all three occasions he had slipped free because of the failure of the State to establish the *corpus delicti*.

There was little doubt in the prosecutor's mind of the man's guilt—not of grand larceny alone, but of murder as well. The law, however, cannot convict on the mere ground of certainty in the minds of prosecutors; for the minds of prosecutors are, alas! not infallible. The law, however, can protect society against an individual who has trespassed repeatedly. There was no question about his possession of the stolen property. The upshot of the affair was that Mayer was condemned to prison for life as an habitual criminal. But the disappearance of the young government man was not forgotten.

A year passed. Mayer had been returned to the King County jail in Seattle, pending an appeal of his conviction as an habitual criminal.

Meanwhile, in Washington, D. C., young Bassett's father had met a man whose name he had frequently heard. This was Chief August Vollmer, of the Berkeley, California, police, known throughout the country as "the scientific policeman."

As a leading advocate of scientific methods for combatting crime and criminals, Vollmer had gained a reputation in his profession. He had joined the faculty of the University of

California, where he instructed interested members of the younger generation in the application of a new technique in police work.

Vollmer was conversant with the Bassett case. He was asked whether he could help find the missing man. He could help, he thought—and then he added, "perhaps." He had a machine, he explained, which had come to be called "the lie detector," invented by a youthful criminologist, one of his students.

Had they ever actually applied it? The scientific policeman admitted that they had—in about 10,000 cases, and subsequent developments had never contradicted the evidence given by the lie detector. In short, they had used it without a single failure. It was a simple machine, though it had a formidable name: it was called a *pneumo-cardio-sphygmograph.*

How did the lie detector work? Was it recognized in a court of law? Could you force a man to submit to it? No, you couldn't force people to submit to it. But you didn't have to. The innocent were eager to absolve themselves; the guilty were afraid to incriminate themselves by refusing.

And the courts? No, they didn't recognize the lie detector. And why should they? Courts are conservative. To them, this device was merely a scientific experiment. Courts were not interested in soul-searching; they recognized only facts, based on strictly interpreted rules of evidence.

How did the lie detector work? Like a simple device used by physicians for testing blood pressure—modified by a few embellishments.

The lie detector resorted to no "third degree" methods. It merely recorded the subject's blood pressure, together with his heart-beat and his breathing, while he answered questions. The subject sat in a comfortable chair and extended his arm as he would for a blood pressure test. Around it the operator wound a rubber tourniquet, and another over the chest.

The breathing, heart action, and blood pressure of the subject moved penlike needles on a slowly revolving cylinder covered with ruled paper. Under normal conditions, the needle marked steady zigzag lines on the paper, indicating that the bodily condition of the subject was relaxed.

Asked, "Do you enjoy cold weather?" or "Do you like candy?" the subject could answer, unhesitatingly, "Yes" or "No." And the needles would scratch their regular zigzag path across the paper, revealing no emotional disturbance in the subject.

But, "Did you murder this man?" Even an innocent person recoils from so brutal a question, fired point-blank on the heels of "Do you enjoy cold weather?" and "Do you like candy?" He is shocked by the naked suddenness of the question and the lie detector impartially records the shock.

The innocent person answers, with truth, "No." His voice may have been steady; he may have manifested no signs of perturbation. But the dancing needles of the lie detector have done their work by the time the answer is given. The chart tells the story. If it could speak, it could not more eloqently tell the scientist than it does by its record, "This person's blood pressure rose slightly—about five millimeters—when he was asked if he had committed murder. That is the normal reaction of any person at whom such a question is leveled. This person, although he himself may not have been conscious of loss of composure, is guilty of what the layman calls nervousness—a failing common in one degree or another to all men. He is not guilty of murder."

Again, to another, "Did you murder this man?"

"No," the suspect may answer glibly. He may look his interrogator in the eye, and smile; his voice may be steady. "This man looks honest to us," the court might say. "He is ready with his answers. He looks at us squarely, his eyes betoken his innocence. Let's give him another chance."

But the lie detector testifies with the same impartiality as before: "This person's blood pressure rose forty millimeters. His reaction is clearly that of a criminal. That question carried him back to the crime he committed; that which, for want of a better term, you call the subconscious, broke through a carefully schooled exterior and sent a surge of horror and fear tearing through his physical being. His heart actually stopped beating for a fraction of a second, and then went on a rampage. He may not have felt these sudden changes; they staggered his whole constitution, without, perhaps, letting him know it, and certainly without any indication of it to you. Outwardly he showed never a twitch—never a shadow of 'nervousness.' He is guilty of murder."

The elder Bassett besought Vollmer to bring his machine to

Seattle. Vollmer could not go himself, but he sent one of his disciples, Leonarde Keeler, who had spent many of his high school days watching and wondering in the Vollmer laboratory, until he himself had become a budding criminologist.

The missing man's father wired Prosecutor Colvin. Colvin had small faith in magic contrivances. But he had tremendous respect for Vollmer. If Vollmer believed that the strange machine known as the lie-detector had the ability to catch criminals, there must be something in it.

"Lifer" Mayer found Scientist Keeler an affable fellow. A lie detector, they called it? Yes, that was what they called it. "Lifer" Mayer seemed faintly amused. "You should have tried that on me seventeen years ago," he observed. It had been seventeen years since Earl Decasto Mayer, habitual criminal, had fenced with the law for the first time—and lost.

In a barren, sunless chamber of the rickety courthouse of King County, Washington, science undertook the unraveling of a crime that had successfully baffled the law.

Prosecutor Colvin watched the needles.

Q. Did you steal Bassett's automobile?

A. No, sir. (The needles jumped. "A lie," said the machine.)

Q. Did you stab Bassett with a knife?

A. No, sir.

Q. Did you poison Bassett?

A. No, sir.

Q. Did you dope Bassett?

A. No, sir.

Q. Did you shoot Bassett?

A. No, sir. (The needles jumped, zigzagged. "His heart muscles contracted," said the machine. "He tried to control his respiration, but his blood pressure went up. He lied.")

Q. Did you strangle Bassett?

A. No, sir.

Q. Did you destroy the body?

A. No, sir.

Q. Did you burn the body?

A. No, sir.

Q. Did you cut up the body?

A. No, sir.

Q. Did you destroy the remains with a chemical?

A. No, sir.

Q. Did you bury the body?

A. No, sir. ("His heart action altered; his blood pressure started up; his respiration was affected. Hold on to that question," the machine told the prosecutor.)

Q. Did you leave the remains out in the open?

A. No, sir.

Q. Did you sink the remains in water?

A. No, sir.

Q. Did you bury the remains?

A. No, sir. (Again the needles fluttered, this time not as wildly as they had at the third question preceding. "He was 'set' for it this time," the machine said, "but he lied.")

For eight days, Mayer was questioned. Trapping experienced criminals by the more or less gentle procedure of interrogation is not easy. It is especially hard when the experienced criminal is at liberty to rise, bow with a gesture toward the door, and remark, "Gentlemen, the interview is ended." This was the prerogative of the prisoner undergoing this cross-examination. Mayer was rich in the sinister wisdom of the fox. But his cunning met its match in the youthful Keeler.

Above all things, Mayer had to be kept from knowing that the lie detector was seeking to pin him directly to the murder of Bassett. There were, consequently, hours of circumlocution and repetition.

Satisfied that they had learned the manner in which the body had been disposed of, Scientist Keeler and Prosecutor Colvin pursued a course calculated to find the grave of the missing man. That was more important than establishing the subject's guilt, of which the prosecutor was already certain. But such information was useless without the prosecution's ability to produce the corpse.

They evolved a simple procedure in which elimination was to solve the mystery. A map of the whole district between Oakland, California, and the Canadian border was split into ten segments. Then, with the needles of the lie detector etching their curious furrows across the revolving record, they pointed to each segment of the map, and asked:

"Did you bury the body here?"

Ten times they asked the question. Ten times the prisoner answered "No." Nine times the machine said, "He speaks the truth." The tenth segment included the Seattle district.

"Did you bury the body here?"

Mayer's heart action leaped like the mercury in a thermometer suddenly immersed in boiling water. The needles of the lie detector reeled off jagged streaks on the record. He had answered again, "No." Science said, "He lies."

The procedure was repeated. Sometimes the Seattle area was indicated first, sometimes fourth or fifth, sometimes tenth. Each time the man's emotions ran wild when he answered "No" to the prosecutor's query about the Seattle segment. The interrogators saw their subject's excitement mount as a glimmer of suspicion that he had unwittingly confessed crossed his mind. In a flash, they left the trail and plied him with decoy questions about specific areas in Oregon and California.

But after eight days they had peeled off the hundreds of square miles on which they were working; the small residuum, to which the lie detector now responded, was a mile and a half in area. There were three cemeteries in it. In this gloomy patch of land, also, there was "the little white house," one of several on which Mayer had obtained options some weeks before Bassett disappeared. In this little white house, the lie detector had told them, James E. Bassett was murdered.

According to Prosecutor Colvin, Mayer interrupted a ten-minute intermission during a session with the lie detector and asked to speak to Colvin alone. It was two hours before the dawn of November 19, 1929. Alone in the little room with the prosecutor, Colvin alleges, Mayer confessed having killed Bassett, and agreed to show where he had buried the body. Keeler and two others, listening at the door, heard the confession.

But here Mayer's attorney intervened; he protested that the use of the lie detector was "torture," and he invoked his client's "constitutional rights." The law upheld its precedents, and, with a wave of a robed arm, the lie detector was banished.

The dismissal did not symbolize the defeat of science. Science fights its battles with darkness, not with men. The law in this case thought it was ready for science—but it was not.

The lie detector, in thousands of cases, had proved its usefulness to society. In one of the most remarkable instances of modern criminal history, it found a man innocent of murder when the authorities "knew" they had the right prisoner.

A murder was committed in Salt Lake City, Utah. Three witnesses were alleged to have seen the killing. The murderer's description was broadcast throughout the country, and within a month a vagrant had been apprehended and identified by the three witnesses.

He was picked up in Richmond, California, where he admitted that he had arrived directly from the vicinity of the murder. His statements were contradictory, his behavior strangely evasive. In his bleary, confused testimony, he admitted having been in the Utah capital, admitted even that he "might have killed the guy."

The officers who had captured the fellow suggested that he be taken to Berkeley and tested by the lie detector. This was done. The scientists asked him the key question:

"Did you kill this man?"

"No," came the answer.

The needles did not jump. The lie detector delivered its verdict:

"This man speaks the truth. He is innocent."

But public opinion had been aroused against the man, and he was held. A month later it developed that he had been in jail for vagrancy on the day of the murder, in a town almost a thousand miles away from Salt Lake City! He was freed, and, with a magnificent display of nonchalance, he wandered shabbily, aimlessly, dustily out of town—a humble beneficiary of science.

Almost a year later the real murderer was found in Los Angeles and arrested.

CHAPTER II

PSYCHOANALYZING POLITICS

IS AN alderman a fat fool? Is he a fraud, a crook, a joke, a piker, another grafter? Is a mayor an ass, a bum, a half-wit, a hippo, a rotten egg, a monkey? Is a building-inspector a boodler, a no-good, a fake, a loafer?

Or do you feel more generous toward such institutions of public administration?

Or don't you care?

If a stranger came up to you on the street, with a pencil and a piece of paper, and asked you to write down the first word that came into your mind when he said "policeman," what would that word be?

Psychologists in recent years have been making an increasing use of the so-called "word association tests." These tests have enabled them to probe deeply into the subconscious mind, which is the seat of many personal ills and maladjustments. Especially significant inferences have been drawn when such tests are applied individually to a large group of persons, and their spontaneous, uncensored responses obtained and compared.

Not long ago this simple device of modern psychology was adopted by a political scientist in an attempt to ascertain in an effective way the intimate personal relationship between the members of a community and that community's civic administration—the attitude of the public toward municipal leaders and institutions.

The results of the test, which was conducted by Professor Leonard White, public administration expert of the University of Chicago and later civil service commissioner of Chicago, offer some amazing—and amusing—facts.

About seven hundred persons, representing a wide variety of social and intellectual levels, were questioned by Professor White. An analysis of the "word associations" which the inquiry elicited revealed a general distrust and a remarkably low opinion of politicians, their ethics, their aesthetics, their activities, and even their personal appearances.

In view of the fact that the test was carried out on the streets of Chicago only, it may be presumed that the reactions were conditioned by the state of affairs in that city. But this narrow viewpoint could not be avoided, because men and women are bound, by the limitations of experience, to form general judgments on the basis of the local situation.

The investigator chose as "stimulus words" *alderman, building inspector, city hall, civil service, elections, health department, mayor, policeman, politics,* and *school board.*

The test was conducted during the dramatic period immediately preceding the April, 1928, primary election in Chicago. The home of a candidate for State's attorney had just been bombed, and on the day of the election a candidate for ward committeeman was murdered. Recriminations among candidates had been more vicious than ever before.

The test, which was given to exactly 690 subjects, contained thirty words, twenty of which were inserted to disguise the true intent, which was to gain data for public administration study. These twenty "duds" also served as a barometer of the normality of the individuals.

The distribution of the responses into categories of "favorable," "neutral," and "unfavorable" was handled by a committee consisting of a business man, a housewife active in club work and politics, a labor manager, an employé of the Chicago Civic Opera Company, a professional stenographer, and an attorney.

Examination of the responses to the ten "key" words disclosed 1,159 unfavorable connotations and 761 favorable ones, out of 6,026 answers. The rest were neutral.

An extremely favorable reaction to the stimulus "health department" was obtained; 17.76 per cent of the reactions were favorable, against a mere 1.86 per cent unfavorable. In the cases of "civil service" and "policeman" excellent reactions, also, were noted.

"Alderman," with a 9.87 percentage of favorable reactions to 23.7 unfavorable, and "city hall," with a 3.45 to 23.56 per cent comparison, demonstrated the general distaste for the political sector of city government. "School board" (politically appointed) and "mayor" were also aligned with this group, the latter word calling forth the most antagonistic reaction.

Besides the epithets listed at the beginning of this chapter, there were numerous other interesting reactions to the "stimulus words." Some of the most piquant were:

To the word "mayor," *abuse of power, bah!, crazy, disgrace, impossible, dishonest, laughing-stock of the world*, and *ability, dignity, intelligence, order.*

To the word "policeman," *arrogant, bungler, dumb, grafter,* and *efficiency, fine, guardian, handsome, protection.*

To the word "alderman," *bay window, big cheese, corruption, useless,* and *city father, honest, leader, public service.*

Many persons might hesitate to express their real opinion, in reply to direct questions; they might even, for one reason or another, try to camouflage their reactions. But the subconscious mind reports the true attitude of the individual, often when he himself is unaware that he harbors such an attitude.

CHAPTER III

WEIGHING HUMAN SOULS

A FEW years ago Hinton G. Clabaugh wondered where to turn. He had devoted his life to the rehabilitation of criminals. For more than a score of years he had been hearing and sifting, adopting and discarding advice. He was chairman of the Parole Board of Illinois. He had restored—or refused—liberty to thousands of men, weighing them by such scales as were available for society's welfare and protection.

What were his standards? Had they proved to be sound and wise? He did not know. Should the present parole system continue? Or, what is an even more perplexing question, can it endure into the future? Must it go, and with it the indeterminate sentence? Is it simply inefficient in fact, although ideal in theory?

The man who had to—and could not—answer these questions for the People wondered if applied science could help. He took his case to the three leading educational institutions of his state: the Universities of Illinois and of Chicago, and Northwestern University. At his request, the president of each of these seats of learning appointed one of the ablest men on the faculty to see what could be done.

These three men were Andrew A. Bruce (Northwestern), Albert J. Harno (Illinois), and Ernest W. Burgess (Chicago). They constituted a committee which immediately went to work on the problem.

A year's survey of the five penal and reformatory institutions in Illinois, together with a thorough analysis of criminal records, penal records, and (when available) the life records of 3,000 men who had been paroled, convinced the committee that—

With the introduction of the parole system, the period of incarceration of criminals, instead of decreasing, increased. Crime had spread rapidly, but the parole system, properly administered, could keep pace with it. The prospect of parole and its realization had not hardened criminals, nor had it created them; on the contrary, parole had proved appreciably beneficial to society by transforming bad men into good.

The committee found the weakness of the parole system to lie chiefly in the heavy handicap put upon the Board by lack of useful and authentic information. The history of the petitioner for parole is put before the Board in a condition so befuddled and fragmentary as to be almost useless. The life record of the prisoner is often never mentioned. His reaction to conviction and imprisonment, his amenability to correction, and his prison-list of offenses are frequently omitted.

Statistical correlation—the major tool of the social sciences—was called into play by the committee, which chose to regard the situation as a "model problem." For each of the 3,000 paroled men who were studied, the scientists obtained data on twenty-one phases of the man's life history, his social background, his personality type, his criminal and prison career.

Against the matrix of these facts the scientists then aligned the records of the men subsequent to their paroles—what they had done with their new freedom. Comparing the pre-parole and post-parole records through an elaborate system of percentages, the committee worked out formula for predicting the probable behavior of men who are up for parole on the basis of each combination of twenty-one characteristics of their lives.

Here was the demonstration of science's method of attacking a problem—this time the problem of predicting human conduct, of weighing human souls.

Farm boys and immigrants are the state's best "risks" for parole, and seem to make the most satisfactory adjustments after release, the committee told the Board. Hobos, ne'er-do-wells from the city, and older drug addicts, are all liable to violate parole.

"Those of inferior intelligence are as likely, perhaps more likely, to observe the parole rules than are those of superior or average intelligence," said Dr. Burgess. "Here, as in other situations, personality traits are more important than brightness. The man with the egocentric personality pattern faces the greatest difficulty in social readjustment. The emotionally unstable, however, seem to have the least difficulty in keeping a clean record under supervision.

"Most young offenders work in gangs. These are fairly good subjects for parole. The men who work alone, the 'lone wolves,' are among the least suitable. Men who have lived in residential neighborhoods, men who have had permanent employment, are better subjects than those who lived in hobohemia, rooming houses, and underworld districts and men who have had only occasional employment. Men punished in prison and men who have served long terms are poor subjects for parole. Men paroled on murder, manslaughter, and sex offenses show a low rate of violation, while men committted for fraud, forgery, and burglary have a high rate."

The committee submitted these and other findings to the Board, knowing full well that such a fact-finding procedure as they recommended was costly. Behind every obstacle to the efficient functioning of the Parole Board, they acknowledged, is the lack or the misappropriation of money.

There is lack of funds to hire intelligent, humane prison guards; to provide recreation, and physical and mental stimulation for the inmates; to assemble complete, authentic histories of convicts. There is lack of funds to free the prosecuting attorney's office and the judiciary from sinister "influence;" to double or treble the forces necessary for the real reform of the law-breaker and the ultimate protection of the community; to free the Parole Board from political obligations and to guarantee its complete isolation from partisan clutches.

They recommended that the Parole Board enjoy the status and independence of the State Supreme Court, with compensation on a par, so that men and women of highest qualifications may be attracted to its membership.

Will these air-castle funds make crime costlier to the state? No, not if they make possible the perfecting of the parole system. If this system is abandoned, or even curtailed, the cost of crime will increase enormously at once. If the average prison term be increased but one year—and with the elimination of parole it would be increased many years— the erection of new penitentiaries and reformatories, at a staggering expense to the taxpayers, will be imperative.

It is true that the perfection of the parole system demands the appropriation of a vast sum of money, but the committee felt justified in guaranteeing that within a few years it would result in enormous savings—in cold cash—to the state.

* * *

Ten men sit around a long table. We see that they are blindfolded. Blindfolded, they pass judgment on 3,000 men and grant them freedom, readmitting them into the society they had offended. How many of these men make good—justifying the ten blindfolded men who weighed their souls?

It is shown that 75 per cent of the 3,000 made good. This means that they did not violate their paroles during the three to six years that they had been at large when Bruce, Harno, and Burgess appeared upon the scene. The remaining 25 per cent violated the trust that society had reposed in them. Of these backsliders, 16 per cent were returned to penal institutions.

Out of the 75 per cent another 10 per cent later on were apprehended for new offenses, committed after their release from parole.

In other words, the blindfolded Parole Board did a 65 per cent successful job. It will be generally admitted that, in the face of existing conditions, this is a favorable record. But could not the 65 per cent be raised to 85 or 90 per cent, or even higher, if the parole system were reorganized upon a more efficient basis? The scientists think so.

The parole system is here; to abandon it would be to retrace the steps of progress in dealing with offenders against society. But it can be made a still more efficient instrument for salvaging human life. And Bruce, Harno, and Burgess, summoned from their laboratories, have shown how this can be done.

PART II

The New Past

CHAPTER I

A YANKEE VISITS OUR FIRST PEOPLE

ENOUGH moonlight, reflected from the snow, filters in through the entrance to light up the blurred scene inside. A group of figures, ten perhaps, squat in a rough circle. By their faces, seamed and seared and scorched like blasted cliffs, they are recognizable as men. They are clumsily clad in heavy furs. Either the furs are impenetrable or they themselves are oblivious to the cold—or both; for a thermometer from the white man's country would register 60 degrees below zero, Fahrenheit.

These are not white men. In their setting, they have the general appearance of Eskimos. But a cursory scrutiny of their faces and skins reveals them unmistakably as Indians.

They are not voluble, but from time to time one or another member of the group mumbles some strange syllables. His fellows do not hear him, it seems; for there is no reply. They understand him, of course, because they all speak the same language—a language in which one sound uttered at four different pitches has four different meanings. To an ordinary English-speaking white man, casually dropping in on the group, the language would sound less intelligible than Chinese.

It happens that there is an English-speaking white man in the party—and he is quite out of the ordinary. As a matter of fact, he is little more than a boy. He is the only member of his race, except local trappers and such folk, who has ever enjoyed the hospitality of these uncouth aborigines and has come back to tell about it.

His hosts are not entertaining him, and he sits cross-legged on the ground in a corner. Huddled there in the shadow, with white face and slight figure, he is alien to the goings-on in the center of the room.

He watches the men place and withdraw and replace certain sticks on a crazy pattern scraped into the ground around which they are grouped. Furs and other personal property from time to time change hands. To be sure, the back-room atmosphere of a cigar store is missing; so are the chewed cigars and the red and blue chips. But this strange performance in the depths of a desolate northern wilderness is nothing more nor less than a poker game. The players are Athabascan Indians. It isn't an all-night game, because it is transpiring north of the Arctic Circle, where night comes once every twelve months and outsits any poker game that ever lured mortal man.

About a week, as the white man reckons such matters, after the poker game, the splintered moonlight throwing its beams over the Great Bear Lake looks down on another spectacle.

The white youth's hand guides an ax. He is alone—unseen, unheard by the villagers. Against the walls of the frozen sky the crunch of his digging rebounds. But he has taken care to be out of hearing of the Indians. For he is exploring an aboriginal grave in the pursuit of his scientific research.

He had been lucky, so far. He had intruded alone upon the primeval privacy of the Hareskin Indians, about whom little more than their name was known to the outside world. He was the third white man from civilization who had attempted this, and the first scientist. The other two were missionaries; they had come, not to study these people, nor to take anything from them, but to teach them and help them. The presence of the priests had been resented; their bodies were customs, to learn their legends.

And then this youth had come—fifteen years later—to thrust himself into the midst of these unknown Indians—into their homes, their councils, their work and love and play, and their death. He had come to record their language, to study their skins, to inspect their skeletons, to scrutinize their customs, to learn their legends.

The youth was Cornelius Osgood. Twenty-three years old and an anthropology student—later an instructor at Yale University—he had undertaken this adventure for the National Museum of Canada. He had already seen something of the world, having traveled about 100,000 miles before he set out, in May, 1928, to live among this "key" tribe of American Indians, which covers more ground and is less understood than any other tribe still extant. The primitive Hareskins, numbering at present about 1,000 persons, are an important branch of the Athabascans who are spread over all of far northern Canada.

These Athabascans' ancestors are believed to have come from Asia over the Behring Strait, and are generally considered the earliest Indians inhabiting the North American Continent. Various branches of the great tribe are rapidly losing their identity and vigor along the Pacific coast in the United States. These representatives of the family are modernized and have been exhaustively studied.

But this northernmost branch was practically unknown previous to Osgood's fifteen months' research among them. And since the Hareskins had carried on their Arctic existence with almost no outside contacts, the characteristics of the first Athabascans—probably the first American Indians—are better preserved in this one sparse people than anywhere else.

The home of the Hareskins is in the vicinity of the Great Bear Lake, which straddles the Arctic Circle in northwest Canada—one of the most desolate regions on the North American Continent.

Osgood's equipment, when he left Chicago with the Great Bear Lake territory as his destination, consisted of two rifles, 400 rounds of ammunition, two cameras, twenty-four notebooks, fifty recording phonograph disks, an eider-down sleeping bag, and a minimum of personal effects.

His first stop was Ottawa, the Canadian capital, where he received further equipment and information from his subsidizers—the anthropology division of the Canadian Government's Department of Mines. The purpose of his trip was broad in its content but specific in its connotation. He was to "reconstruct the ethnology"—the science of the race—"of the northern Athabascan Indians."

Having piled up about 4,000 miles of travel since his departure, a thousand of them without guide or companion, Osgood reached Great Bear Lake, the base of his operations, early in the summer. The last segment of his railroad journey took him to the town of Waterways, and for a year his mode of travel was confined to foot, canoe, and dog sled. The lake is about the size of Lake Huron, but its remoteness has made it little more than a name to the civilized world.

Six months after he had last been seen, a letter from Osgood reached Chicago, establishing the fact that he was still alive. The letter, written from "The Fishery, Great Bear Lake," in January, was received about the middle of April.

"Bear Lake is my vantage spot," the communication read. "It is the battle-ground of the Northern Dene (the Athabascans), a desirable location which holds the one sure supply of fish; and fish are, and probably always have been, the chief food supply. Around a little space of land near the end of the north shore of Keith Bay gather the families of Dogribs, the Satuden, Katcodene, and sub-group Indians. It is from this place, known as the Fishery, that nearly all the trails and trap-lines for a hundred miles around have their commencement.

"After making nearly the complete circuit of the lake in a small sloop during the summer, I decided to pitch my tent at the Fishery. A little later I moved into an eight-by-twelve shack which, before it served me, was first a dog house and then a fish cache. By means of the removal of half a ton of boulders I lowered the floor about a foot, so that I could stand up. I enjoy my home, and when I see it in the distance as I come from a hard trip, I am willing to swear there was never a better."

Osgood found his vast laboratory populated by specimens "as deceitful, uncommunicative, and ungrateful, as a group, as any people I have so far been stimulated to imagine."

The problems he faced grew with each new day. The colossal barrier of the tribe's menacing attitude toward the white man who wanted to live among them was only one source of discouragement. An epidemic the preceding summer—an epidemic that the Indians would not or could not explain—had wiped out most of the old men and women, and the younger generation of natives stared glassily at the white youth when he tried to stir up their memories.

He would take his dogs and go off in search of old burials, or for the indelible traces of stone axes on ancient stumps. As summer drew on, the shore opened up and revealed old canoes, and drift objects of wood and bark. It was his job, with such odds and ends and smatterings of evidence almost torn from the Indians, to reconstruct a whole social order.

Osgood tried in every possible way to build up confidence. He had long evening sessions with the Indians. When they were tired and surfeited with food, he endeavored to give the leads that would start the stolid Hareskins on tales of their native folklore. But the winter was long and results were short. Nevertheless, a beginning was made.

When spring came, he found himself starting life again with the natives. After the experiences of the dreary winter, the memory of civilization waned. But he stuck doggedly to his work. He remained at Great Bear Lake through the summer of 1929, and in September of that year he was back in Chicago with the results of the year of study.

The Hareskins are dying. Within the last half century many have scattered and intermarried, and the tribe has decreased to an extent that presages the imminent extinction of this lingering vestige of America's first people.

Osgood brought back a fascinating story, patiently pieced together, of this vanishing people—their life, religion, work, play, strife, social standards—their physical measurements, their archaeology. Three hundred photographs, which he secured, form a unique contribution to the study of man by man, as do his fifty phonograph records of songs—ceremonial, gambling, love songs. With the aid of his friend and guide, who came up to his frozen camp and acted as interpreter and tutor, he learned the Hareskin language, which, like so many phenomena that antedate modern man, is inexplicably baffling.

Thus, amid freezing gales, a youth pursues a retreating race, that it may give up its secrets before it has disappeared forever. Beyond the farthest tip of civilization's reach, science finds an epoch and an epic; and a new chapter is added to the story of man.

Chapter II

THE FIRST SCIENTIST

THE complaint sometimes heard that the modern physician is "as independent as a hog on ice" probably emanates from the time, some thirty centuries before the birth of Christ, when the first surgeon of whom we have record resolutely divided his diagnoses into three categories: (1) an ailment which I will treat; (2) an ailment I will contend with; (3) an ailment not to be treated.

This intelligible, if arbitrary, stand is recorded, along with the experiments of the Egyptian medico, on a rolled papyrus fifteen feet in length. It is the oldest medical book in the world, as well as the earliest repudiation of quackery in human history. Previous to the work of this anonymous scientist the street-corner faker thrived in unmolested bliss, busily selling incantations against the demons who allegedly afflicted healthy citizens and transformed them overnight into the lame, the halt, and the blind.

It had evidently been the intention of our first surgeon to present a medical survey of the human body, beginning at the head and going on down to the feet. But, unfortunately, his discussion of the ills that flesh is heir to did not extend beyond the thorax and the top of the spine. Evidently he was rudely interrupted; for his dissertation, which is the most important scientific document surviving from the pre-Greek age, ends in the middle of a case, the middle of a line, and the middle of a sentence.

The aborted papyrus, recently translated from its hieroglyphics into English by the noted Egyptologist, Professor James Henry Breasted, remains, in spite of its fragmentary character, a milestone in the history of the development of medicine. It records the awakening of man to the connection between diseases and their natural, environmental causes.

Aside from this fundamental recognition, our Egyptian surgeon possessed a remarkable understanding of human anatomy—far superior to that of the medical students of the Middle Ages. His diagnoses reveal his belief that the heart and the brain are "key" organs in our physical make-up. He evidences knowledge of the circulatory system and the pulse, as well as a comprehension of bone structure—of fractures and their treatment. Although no knowledge of the nervous system appears to have been developed in this period, the prevalence of paralysis and the primitive treatment for it are indicated in prebiblical phraseology.

The surgical student for whom the book apparently was intended is given "instructions in regard to treatment of the perforation of the temporal bone." (The temporal bone contains the organ of hearing in mammals and is situated in the side of the head.) We read:

If thou findest that man to be silent and he does not speak, thou shouldst soften his head with grease; pour (an unidentified medicant) *into his ears. He may put his hand to his eyes but not realize that he is doing it.*

The test for paralysis strikes us as a simpler and more effective procedure:

Tell thy patient to look over his right and over his left shoulder and at his breast, if he is able to do so.

To be sure, Professor Breasted points out that this first scientific physician had not entirely escaped the current superstitions of his age. In the instance of a case lying between the categories of "ailments I will contend with" and "ailments not to be treated," the surgeon recommends the application of a magical formula. This extra-surgical treatment is invoked in the case of a compound, crushed fracture of the frontal, or forehead, bone.

Fifty-six physical examinations are recorded in the papyrus, most of them dealing with sword-cuts in the skull and with injuries sustained in the erection of the great temples and monuments that gave ancient Egypt its preëminence in architecture. Since most of these injuries were caused by tangible physical agencies, with attendant tangible pain, they were not to be attributed to malignant spirits whose expulsion could be effected by magic.

Our Egyptian surgeon not only scoffs at the notion of illness caused by non-natural forces, but he adopts a scientific approach that was extraordinary for his era. He will not suggest treatment for sixteen of the fifty-six cases he discusses; in fact, he includes twelve of these sixteen cases in the category of "ailments not to be treated." In other words, he frankly admits his ignorance of the proper procedure.

The author begins with simple cases of skin fractures and superficial injuries; then he proceeds to surgical problems of increasing gravity and complexity. The first case he describes involves a scalp wound. Case No. 2 is a severe cut that does not injure the bone. The third patient, and those following, are victims of injuries that affect the skull. The fourth case, for example, is a compound fracture; the fifth is a compound, comminuted—or pulverized—fracture; and the sixth is a compound, comminuted fracture in which the membranes encasing the brain are ruptured.

For the first time in the history of medicine this papyrus records the application of surgical bandages and the use of antiseptic measures. There is mention of cauterization, of lint manufactured from vegetable tissue and used externally and as an absorptive, of linen bandages, adhesive plaster (two pieces of which were always applied transversely), and of supports designed to keep the patient upright in bed.

Probing the wound is recommended, with the suggestion that the fingers or a swab of linen be used in the process. Surgical stitching also is discussed, as well as the possibility of setting dislocated bones through experimental probing.

There is a reasonable likelihood that the payrus was used as a text-book as recently as the sixth century before Christ, when Uzahor-resenet, a high priest in the temple of a goddess in the Nile Delta city of Sais, restored the first medical school in the world—the "Hall of the House of Life"—under the patronage of King Darius I of Persia, whom Professor Breasted describes as "the greatest and most enlightened administrator of the early world before the rise of the Romans."

An inscription from the statue of Uzahor-resenet, now in the Vatican Museum in Rome, reads:

"His Majesty, King Darius, commanded me to come to Egypt while His Majesty was in Elam as Great King of every country and Chief Prince of Egypt, in order to establish the Hall of the House of Life.

"I did as His Majesty commanded me. I equipped them with all their students from among men of consequence. No sons of the poor were among them. I placed them under the hand of every wise man for all their work. I equipped them with all their needs, with all their instruments, which were in the writing, according to what was in them aforetime.

"His Majesty did this because he knew the value of this art in order to save the life of everyone having sickness."

"In this remarkable inscription," writes Professor Breasted, in his introduction to the translation of the papyrus, "we find the earliest known mention of a medical school as a royal foundation. It is important to note that this Egyptian medical school at Sais was not being founded for the first time, but was being restored, as the surviving old writings in Uzahor-resenet's hands showed him it had been 'aforetime.'

"We note with interest that the medical students of the sixth century B. C. in Egypt were selected from families of good social station, and that, as the last lines show, these young physicians were evidently also priests in the temple of the Goddess. (The Goddess Neith, at whose temple Uzahorresenet was a priest.) Indeed, the High Priest himself, Uzahorresenet, bore the title 'Chief Physician.' Among the branches of instruction, the reference to 'instruments' shows us that surgery was included.

"Among these highly civilized cities of the Nile Delta, the first large cities the Greeks had ever seen, the Macedonian kings of Egypt set up their enlightened scientific foundations at Alexandria. We see now that in medicine at least Darius anticipated them. The important point to note is the fact that the support of old Egyptian medical instruction was continued by the Persians after their conquest of Egypt (525 B. C.).

"When, two centuries later, the Alexandrian physicians began to enjoy the princely support of the Ptolemies, they found themselves among the surviving native Egyptian medical schools and medical libraries of the Delta, when such contacts and influences as we have suggested could hardly have been escaped."

The vicissitudes to which the roll had been subjected, together with the wear and tear of daily perusal, have frayed the outermost flap, upon which the writing began. As a result, the name of the book, the name of its pioneering author (if it was there), and the opening discussion of the first case were lost.

The precise beginning of science, like the precise beginning of life, is unknown and perhaps unknowable. Physical as well as spiritual evolution has covered up its trail like a fugitive. The hieroglyphics of five thousand years ago are, on infinity's date-book, only a few hours old. Some day the man who inscribed the hieroglyphics and the man who translated them may be classed as practically contemporaries.

In the meantime, there has been restored to mankind the work of the first of those daring scientists who, defying superstition and crusted tradition, blazed the trail which unborn generations were to follow.

Chapter III

AMERICANS SPEAK AMERICAN

IF YOU talk in the vernacular of the United States, you do not speak English, according to the man who has been called "the greatest living dictionary maker." You speak American, a language that is indigenously and inalienably yours, that was born on the day the Pilgrim Fathers set foot on American soil at Plymouth in 1620. On that day, the hardy pioneers drew lots for the division of land. Each man's portion of ground came to be referred to as his "lot." Today a piece of ground in America is known as a lot. But in England—and in English—the word *lot* has never meant anything but "share."

Sir William A. Craigie, Professor of Anglo-Saxon at Oxford, Professor of Lexicography at the University of Chicago, and, most recently, Knight of the British Empire, has been in Chicago for the last five years, engaged in compiling *An Historical Dictionary of American English.* Besides recording the meaning and background of all imported words, his monumental work is to include the history of every expression that is truly American, from its origin as early as the seventeenth century down to the present day.

This diminutive, gray-bearded Scot, who just before his departure for the United States had completed thirty years' work as editor of the *S, T, U, V, W, X, Y,* and *Z* sections of the ten-volume Oxford English Dictionary, is now devoting his genius to the study of a phenomenon that the American lexicographers, such as Webster and his successors, deprecated and evaded. He is going to present America with a dictionary of its own language, representing a compendium of the evolution and meaning of those distinctively American words that have caused modern scholars to recognize the idiom of the United States as a separate and individual tongue, no longer the same as English.

The famous dictionary maker has come to the rescue of our much-maligned American slang. He declares that the "man in the street" is enabled, by its use, to express himself more pointedly and forcefully in thousands of situations than would otherwise be possible.

"Consider, for instance," he says, "the phrase, 'It's up to you.' There is no other group of English words to convey so concisely this exact shade of meaning. Slang expressions of this kind are destined to be permanent additions to the American language, and obviously must be included in our *Dictionary of American English.*"

Slang is often carried to excess, Professor Craigie admits; but it is plain that the real test of slang lies in that determinant which is the real test of any human tool, mental or physical—its utility. If a slang word or phrase fills a long-felt want and is generally adopted throughout the country, it will take its rightful place in the language.

But the American Dictionary is not to be a hodge-podge collection of slang, in spite of the attention that will be demanded by such Americanisms as *bunk, small potatoes, boss, simoleon, square meal,* and *tight place.*

It has two other primary functions, both of which surpass in importance the systematized compilation of "vulgar" speech. In the first place it will trace, through the delineation of each word and phrase that made its first recorded appearance in America, the history of the nation itself. The hundreds of persons who are now voluntarily culling newspapers, hand-bills, circus-posters, war orders, personal letters, bills of sale, inventories, and the more literary records of our native speech, are charged with furnishing the history of each Americanism, showing the locale of its origin and the diffusion of its popular use.

The second purpose of Professor Craigie's lexicon will correct the error of former American dictionary makers who attributed distinctly American creations to the English authors by whom they were later adopted.

Such an authority as Webster not only failed to present a complete picture of the American language at the time, but ignored many perfectly acceptable native expressions simply because they did not have an English background. Webster attributed the word *fall,* meaning autumn, to English sources, although the word had survived only as a part of American speech. Again, he sweepingly omitted from consideration words like *prairie*, in his first work, although that word had appeared in the title of a novel by James Fenimore Cooper.

Webster, completing his dictionary in 1828, regarded the language of the United States as the language of England; he ignored, without a qualm, such pure Americanisms as *pale-face, pecan, platform* (in its political use), *pone, powwow,* and *punk* (touchwood).

The rigors and novelties of the new country profoundly influenced the spoken language of America early in colonial history, inspiring all sorts of new locutions. Elements both physical and mental appeared on this side of the Atlantic that were unknown in Great Britain. Life began here again under new conditions.

Before the white man had fully explored the reaches of his recently acquired home in the Western Hemisphere he had fathered the beginnings of the American language in a large aggregation of expressions which he had coined from the immediate expression of novel situations and from his efforts to reach a verbal understanding with neighbors from other nations of the Old World.

Among the earliest Americanisms are *blizzard, camp-meeting, cave in, kick* (in the sense of "object"), *take back* (a statement), *stump* (as an informal platform for a political speaker), *backwoods, bee-line, bluff, clearing, diggings, Indian file, log-rolling, to tree* (in the sense of cutting off escape), *gouge, bundle, boost, prospect, swap, bogus,* and *spook.*

In a letter written on April 2, 1775, George Washington used the compound word *back-country,* an expression never found in England and one which rapidly intrenched itself in the body of the national speech. At about Washington's time, too, Americans assigned the word *corn* to the plant and its fruit, known for centuries in the mother country by no other term than *maize. Corn,* in England, has always referred to grain in general; or, in some cases to wheat, oats, or barley. But never does it connote maize to the Britisher.

The lore of early America, in all its quaint and odd aspects, is pouring into the office in which the lexicographer sits studying the raw material out of which his great work is to be shaped.

Bunk—one of the most forceful and expressive expletives in the national vocabulary, is not only pure American, but is traceable in its origin to the legislative halls of the country. Col. Edward Buncombe, a Southern congressman, addressing his fellow legislators on one occasion in 1827, began to reel off an interminable declamation on a subject that was extraneous to the business before the session. Agonized cries of "Down with Buncombe!" eventually convinced the gentleman of the advisability of concluding his oration. But whenever, thereafter, an honorable representative appeared to be heading off on a long-winded or irrelevant tack, there were mumblings of "Buncombe." This gave way to the throatier roll of *bunkum,* and eventually to *bunk.*

But why should an Englishman be called to this country to compile a dictionary of the American language? What background, one might ask, has he in American life, in "English as she is spoke" on this side of the Atlantic?

Professor Craigie's qualification for the undertaking is paradoxical, and yet it is entirely congruous with the demands of the enterprise. Americans, he points out, refuse to admit the drifting apart of the English and the American languages, but the separation has long been patent to the Britisher, who has learned that when he crosses the big water he must go so many *blocks* from one place to another, rather than *turnings,* that he must order *dessert* when he wishes a *sweet,* that a *bowler* is a *derby,* that the *bug* of his homeland is the objectionable *bedbug* in the United States, and that insects pervade the American landscape under the general denomination of *bugs.*

After the Civil War, Englishmen were puzzled by strange words in news dispatches from the United States. They began to read of *carpet-bagger, caucus, electioneering, governmental, on the fence, indignation meeting, lynch law, wire-pulling, almighty dollar, colored people, Uncle Sam, run* (a candidate), *stump* (the country), and so on. What language was this?

Especially curious, in the light of the American's reputation for efficiency and businesslike methods, is the tendency to develop more elaborate words in place of the brittle English equivalents. Instances of this kind are the American *elevator* for *lift, automobile* for *motor car, gasoline* for *petrol,* and *locomotive* for *engine.*

These and a large percentage of intrinsically American expressions are easily traceable to their sources. But many of the words that will be discussed in the forthcoming dictionary are riddles, their origins being lost in the mists of history and legend.

Notable among these is *Yankee*, the origin of which has been heatedly disputed for two centuries without any final settlement. Its use is clearly established from 1765 onward. Another word which has a very definite start, so far as the printed record is concerned, is *bogus,* appearing first in the Painesville (Ohio) *Telegraph* of July 6, 1827, and there used as the name of a machine that produced counterfeit coins.

To the influence of such American groups as the Dutch are attributed the origins of several everyday words, including *boss* (from the Dutch *baas*) adopted in New York in 1806, and *spook,* in 1801.

Rowdy turns up a little later, and the earliest evidence (1819) identifies rowdies with backwoodsmen, and speaks of "the hunters, or Illinois Rowdies, as they are called." *Dander,* in such phrases as "to get one's dander up," is in common use from about 1835, while *cocktail* has been traced back to 1806, when it was described as "a stimulating liquor, vulgarly called bitter sling."

The fate of such innovations has been varied. Some have been short-lived and some have never risen above the level of vulgarisms, while others have made their way not only into standard American but into English speech as well.

"The search for early instances of such words and phrases is usually an interesting one," we are told by Professor Craigie, "because the types of literature in which they occur are truly American in character, and frequently of an entertaining nature. There is more to be learned about the history of American speech from a close study of Neal's *Brother Jonathan* or Paulding's *John Bull in America* than from the more solid and solemn works of their contemporaries."

In other words, most of our sturdiest idioms were first recorded in the informal publications that flourished as freely as they do now. The following are a few examples of newly-invented words that first found printed expression in the popular literature of their generation:

Ahead of (in figurative sense), 1825.
Allow (admit), 1843.
Anxious seat (in religious use), 1888.
At that (in such phrases as "and slow at that"), 1830.
Awful ("an awful bother"), 1814.
Back number (figurative), 1810.
Back seat (in "to take a back seat"), 1863.
Bark up the wrong tree, 1833.
Big bug, 1831.
Blowout (feast), 1825.
Boss (as a verb), 1856.
Britisher, 1829.
Bully (excellent, capital), 1855.
Bury the hatchet, 1824.

Bust (burst), 1850.
Take the cake, 1886.
Calculate (think, believe), 1812.
Carry on (frolic, riot), 1834.
Catch on, 1884.
Caution ("a caution"), 1834.
Chalk ("to walk the chalk-mark"), 1835.
Chore, 1820.
Clear out (leave), 1824.

Completion of the letter *S* section of the Oxford English Dictionary required ten years of intensive work. This will not, of course, be the length of time required for work under the letter *S* in the American Dictionary, since the scope of the latter covers only a mere three centuries.

But Professor Craigie does not venture to estimate the date when the present formidable undertaking will be completed. In the prosecution of his immense task, he has issued a call for coöperation on the part of many Americans. He himself, seated in his quiet little office, is diligently organizing the vast stores of material that he is thus accumulating.

It's an awful job—no bunk about that.

CHAPTER IV

BALLY-HOO AMONG THE ANCIENTS

THE digger into ancient civilizations is a genial, tolerant fellow under ordinary conditions. But when he comes across an Assyrian ruler of 700 B. C. who roller-coasted into the office of Head Man of the then known universe by means of much the same publicity stunts that politicians today employ, he is likely to become even more tolerant toward his twentieth century compatriots.

Sargon II usurped the throne of Assyria many centuries ago—to be exact, a matter of 721 years before the birth of Christ. There is only one fact that identifies him as a usurper, but that fact is conclusive: He boasts of everything but his ancestors. His predecessors and successors vaunted every factor in their own make-up, disposition, and achievements; but more brazenly than anything else, they memorialized their royal line.

According to Professor Edward Chiera, who led an archaeological expedition into Assyria to dig into the ancient tyrant's great palace, Sargon II took the name of a powerful ruler of earlier times—Sargon I—when he acceded to the throne of the empire, but he studiously avoided allusion to his progenitors as long as he lived.

The second Sargon, in fact, did not live unduly long; he met his death in a minor skirmish in the mountains near Khorsabad, after a reign of seventeen war-torn years. But while he lived he fought and conquered every nation of sufficient size to threaten any segment of his domain. The tribes—including the Hebrews of Palestine—that fell before his relentless lust for power were made tributary to him, and thousands of their members were taken prisoners of war and reduced to slavery.

When Sargon II looked around the horizon, as Alexander the Great was to do four centuries later, and found no more worlds to conquer, he sat with his head in his hands, pondering new schemes for immortalizing his name and his prowess. Warfare had yielded him its richest fruits. What should he do with his myriad slaves? What should he do with his time?

"I have it!" Sargon II must have exclaimed to himself, his eyes shining with joy. "I'll kill two birds with one stone; I'll build a palace that will make history's eyes pop. It will be the biggest and most beautiful palace ever built. My 27,000 Hebrew prisoners of war will do the work; it will keep them out of mischief. To be sure, my little project will cost the state a tidy sum, but it will relieve the unemployment situation, and the name of Sargon II will endure forever."

Sargon set out at once to realize his ambition. His palace became the grandest memorial that had ever been erected to god or man. Solomon's temple could have been moved about in its courtyard. The doors of the palace were guarded by ten stone bulls, the four largest of which weighed forty tons each. The walls and ceilings of the structure were embellished with six thousand square yards of frieze work and carving, nearly all of it depicting the intelligence and benevolence of the emperor.

Many of the friezes are still intact. They depict docile emissaries coming from Palestine and Syria, from all the inconsequential kingdoms between the Persian Gulf and Kurdistan, from the realms of Asia Minor and Egypt—all of them bearing conciliatory gifts of horses, thrones, statues, and money. The king's personal valor and military genius are eulogized from one end of the palace to the other, and all men are advised of the terror and splendor of this monarch's name, and of the wisdom of the gods who chose him to rule the world.

Palace of Sargon, the Great King, King of the Universe, King of Assyria, Viceroy of Babylon, King of Sumer and Akkad, King of the Four Regions of the World, Favorite of the Great Gods. Assur, Nabu, and Marduk Have Intrusted to Me an Unrivaled Kingdom and Have Caused My Gracious Name to Attain Unto the Highest Renown. I Bring Great Good to the Cities. I Have Delivered the People from Taxation.

This audacious self-eulogy, with variations, appears at least once in every chamber of the palace. Was it purposeful beyond sheer boasting? At any rate, the Orientalists say that it was 100 per cent effective propaganda.

Statistics, enumerating the enemies killed, wounded, and captured, obviously in excess of any ancient army's voraciousness, screamed from the walls of magnificent reception halls in which, it is likely, indignant representatives of tributary nations awaited admission to the throne-room for an audience with Sargon regarding the burdens of taxation imposed on their people.

While Sargon lay dozing amid his purple and gold these emissaries found plenty of opportunity to acquaint themselves with the fates of other nations, whose complaints were silenced by the "divine infallibility" of the Emperor's swordsmen. Somewhat chastened, they were ushered into the royal presence, where they announced that they had come to advise the King of his just and generous attitude toward his vassals, and to announce the preparation of a priceless gift, for which each and every citizen had considered it a privilege to contribute a tithe of his wealth. In this fashion the war-weary ruler spread smoldering peace and groaning culture throughout his realm.

It may seem, then, that the massive temple erected by the Emperor in eulogy of the Emperor was simply a matter of national diplomacy. But recent discovery refutes that supposition and indicts Sargon II as the most pompous blowhard that the world has ever known.

Inscriptions describing the monarch's prowess and benignity were discovered by Professor Chiera on the backs of slabs, where they could not be seen until the walls crumbled to ruin and every side of each stone could be exposed. Besides these, he recovered boxes, such as are sealed in the corner-stones of modern structures, imbedded five feet deep in the masonry of the palace, crammed with plaques of bronze, silver, and gold, all proclaiming the glory that was Sargon's.

Here was a man who felt the pressure of the future, who tried to reach ahead of time and life. He was taking no chances with legend's uncertain perpetuity or with carved inscriptions exposed to the elements. He had his ineffable virtues recorded and put away in safety-deposit boxes for the wonder and enlightenment of curious minds twenty-seven hundred years later.

So the name of Sargon II did not perish, though his body, which was mortal, did. He was killed in 704 B. C., not in one of the epochal battles that elevated him to a position among the world's greatest military leaders, but—as we have seen—in a distinctly minor skirmish almost within sight of his unfinished palace at Khorsabad.

The report of a small mutiny under way in the mountains outside the city awoke the battle-lust of the autocrat, and he elected to try his hand again at the pastime that had made him Emperor of the earth. But the relaxation born of worldly success had taken its toll, as it usually does in the case of those who have lived active lives. Thus the man who had dazzled his generation was ingloriously shuffled off the terrestrial scene.

The palace of Sargon II was never completed. His son, Sennacherib, had plans of his own for a cozy little place. Moreover, he and his father had never hit it off as well as fathers and sons should. Sennacherib perhaps thought that it would be a delightful joke on the old gentleman if his dream castle was deserted and left as a wind-swept sanctuary for homeless animals.

An added incentive to this decision was probably the insufficiency of blank wall space for laudatory inscriptions of the incomparable wisdom and munificence of the new ruler. At any rate, Sennacherib packed up his laundry, gathered together his slaves, and moved to a choice subdivision ten miles away. There, on a site close to the Tigris River, he had plenty of elbow-room for demonstrating his own technique in palace building.

In the spring of 1929, while engaged in excavating 125 tons of relief carvings from the palace of Sargon, the Chiera expedition stumbled upon young Sennacherib's structure. Although the excavation of the junior ruler's palace cannot be effected for many years Professor Chiera and his associates know that the story of Sennacherib's construction project will, in many respects, rival that of his father's achievement.

According to Old Testament records, Sennacherib was the more distinguished of the two men. But they surely had much in common. An inscription has already been recovered that indicates a propensity to self-adulation which in its matchless egotism suggests a direct inheritance from the father.

Included in the collection from Sargon's palace which was sent to America are all the fragments of frieze work that covered a corridor one hundred feet long. Three of the colossal slabs depict foreign emissaries appearing before Sargon laden with gifts. There are figures of horses and men from the courtyard walls, and a heroic-sized carving of Sargon himself, accompanied by his prime minister. One of the forty-ton bulls, when the pieces are assembled, is eighteen feet high and seventeen feet long.

The activities of the excavators were confined largely to the palace courtyard, the edifice itself being reserved for future work by the expedition. Between the palace of Sargon and that of Sennacherib lies a walled city, still untouched. It is believed that the Assyrian plain covers hundreds of town-sites of that era. The expedition was housed directly above the royal quarters of Sargon, near the present city of Khorsabad. Professor Chiera made overtures for the purchase of the site, in order to raze it for the furtherance of his excavation plans.

Naturally, the expedition encountered almost insuperable difficulties in crating and moving the immense fragments of the great stone carvings. Sections of the colossal bull weighed as much as twenty tons. The priceless sculptures were transported on motor trucks across the waste-lands to the Tigris.

After the prizes had been safely landed in America the expedition again set out for the Far East, early in 1931, to resume work on these two rulers of twenty-five hundred years ago whose capacity for slipping a "fast one" over on the gullible public has yet to be surpassed by modern politicians.

CHAPTER V

BEATING THE LAW IN BABYLONIA

IN THE course of an achaeological expedition carried on jointly by Harvard University and the University of Pennsylvania a number of clay tablets have been uncovered in ancient Near Eastern ruins baring the business transactions of the first shyster lawyers ever known.

The inscriptions, baked into the clay, indicate that modern specialists in sharp practice have scarcely advanced beyond their colleagues who flourished 3,000 years before Christ.

In the ancient city of Nuzi, in Mesopotamia, which the expedition dug up in job lots, it was against the law to sell land. The date of this blow to the real estate busines was 1500 B. C. The law-givers decreed that land might be transferred from one relative to another, but that it must not leave the hands of the original owner's family.

This apparently unreasonable statute had its justification in the fact that Nuzi was a pugnacious community whose gentry were conscripted for military purposes at frequent intervals; and, since the army was raised from among the landowners who were bound to do yeoman service under the Nuzian flag, it was a matter of imperial policy to prevent one citizen from owning too many tracts of land, because such a condition would appreciably reduce the army eligibility list.

The good people of Nuzi were not slackers; nevertheless, they had a penchant for dabbling in real estate, and were determined to carry on traffic in land in spite of the law.

Here was soil for the roots of the shyster, and he flourished. One particularly tricky barrister—unidentified here and forever—opened the way. He suggested that the prospective customer get himself legally adopted by the prospective seller.

The rest was easy. The newly acquired son received the tract of land he wanted, as a token of "father's" filial affection. The "son," in turn (he was frequently older than his fictitious father), presented his "dad" with a handsome cash present in honor of his birthday or of some national holiday. Within half an hour of the consummation of the transaction, the adoption was informally annulled, to the mutual satisfaction of both parties.

The plan was so air-tight that it was adopted widely and effectively, bringing prosperity and prestige to the legal trickster who conceived the coup.

Two hundred years previous to this particular piece of legal legerdemain, the Babylonians were having trouble with contracts for home-sites. A Babylonian, whom we may call the party of the first part, would negotiate a piece of land, improved or otherwise, into the possession of a brother-Babylonian (the party of the second part), extracting, in accordance with the recognized theory of marketing, as healthy a profit as possible.

About a week later, the party of the first part would appear on the premises involved in the transaction, and take said premises away from the duly installed owner. This little business was accomplished boldly on the basis of the "might is right" theory. However, if the injured party of the second part had two or three muscular brothers, he dispatched them to the residence of the nefarious party of the first part, and a good deal of sling-shooting followed. The ultimate disposal of the real estate was determined by the superior accuracy and agility of one party's or the other's representatives.

The Babylonians—a simple but energetic people in the main—regarded such an adjustment of difficulties as "fundamentally sound"—even ethical. For them it was the democratic way of life, even if it did sometimes result in the democratic way of death.

One fateful afternoon, however, it occurred to a certain king—or to his legal advisers—that a really worth-while amount of property could be detached from the simple country folk by the employment of a group of thugs called an army. The Babylonians, accordingly, were brushed off their property without any formalities on the part of these hired highwaymen, and retribution by the agency of big brothers was out of the question.

The problem was acute. Craft, clearly, was in order; and craft was supplied by Babylonia's legal wits.

Why not, some genius of the profession (perhaps the great-grandfather of the gentleman who conceived the Nuzian adoption scheme) suggested to his associates, invoke the curse of the gods on any man who overtly violates a contract? The three or more wise men of the period, assembled in council, conceded that the gods were omnipotent. They might favor the king by winking at international manslaughter. But here was unrighteousness at its worst and depravity at its deepest, in time of domestic peace.

The curse of the gods in those days made even the boldest tremble. It struck swiftly and surely. The plain people knew it, and the king knew it. What is more, the plain people knew that the king knew. Therefore, the wily suggestion was seized upon by the long-suffering Babylonian people.

The upshot of it was that not long afterwards the following blood-curdling warning was broadcast on clay bricks—one of those recovered by the Harvard-Pennsylvania expedition—up and down the country:

"Whensoever in later days an agent, a governor, or a prefect, or a superintendent, or an inspector, or any official whatsoever who shall rise up and be set over Bit-Khanbi, shall direct his mind to take away these lands or shall lay claim to them, or cause a claim to be made to them, or shall take them away, or cause them to be taken away, or shall side with evil, and shall return these lands to their province, or shall present them to a god or to the king, or to any other man, or because of the curse shall cause another to remove this memorial-stone or shall cast it into a river or put it in a well, or destroy it with a stone, or hide it where it cannot be seen—upon that

man may Anu, Enlil, and Nin-Makh, the great gods, look with anger, and may they curse him with an evil curse that cannot be loosened!

"May Sin, the light of the bright heaven, with leprosy that never departs, clothe his whole body, so that he may not be clean until the day of his death, but must roam about like a wild ass outside the wall of his city! May Gula, the mighty physician, the great lady, put a grievous sickness in his body! May Adad, the ruler of heaven and earth, overwhelm his fields, so that there may spring up abundantly weeds in place of green herbs, and thorns in place of grain! May Nabu, the exalted minister, appoint him days of scarcity and drought as his destiny! His name, his seed, his offspring, his posterity —may they be destroyed in the mouth of widespread people!"

Here, in truth, was "a horse on the king." The phraseology was befuddling, as legal phraseology so ingeniously is to this day. But the point was clear. The king was completely boxed in, and his own legal talent dared not offer the suggestion that he ignore the invocation of the gods, since even the suggestion would be sacrilege.

The king had to dismiss his jolly robbers and content himself with the plunder that had already accrued to him. Normal conditions soon obtained over the land of Babylonia. For the clever lawyer, this time on the side of the downtrodden, had ruined—until the advent of modern man—the old-fashioned delights of contract-jumping and land-snatching.

CHAPTER VI

A PREHISTORIC GARBAGE HEAP

EVEN a garbage heap may yield treasure-trove to science. Not long ago there was discovered in northern Africa the skeletal remains of a 25,000-year-old race of people—a strange snail-eating folk—embalmed in their garbage. This particular garbage heap has provided anthropology with a new chapter in mankind's history and the most complete frame of a prehistoric human being ever discovered.

Buried under and preserved by a ponderous layer of discarded snail shells five to twelve feet deep, the mound man of Mechta-El-Arbie, Algeria, lay in obscure sleep through the ages. Now, at the beck of science, he arises to tell us the sort of life that he and his relatives lived in those far days.

Clustered around tribal fires between the Sahara Desert and the Mediterranean Sea, these humble ancestors of ours nightly munched on the meat scraped from thousands of tiny shells, presumably with as keen enjoyment as a modern epicure with a bowl of delectable shrimps before him. Occasionally—perhaps in honor of special guests—the *pièce de résistance* was a barbecued human neighbor, for his charred bones have been found in the host's fireplace.

But week in and week out, the African mound man, a person of simple tastes in the main, ate snails and created his tomb that way, instead of digging his grave with his teeth, as his descendants are often accused of doing. For five or ten thousand years he blandly disregarded the lack of sanitation and plumbing, and lived heartily, if somewhat squalidly, on snails.

The shells piled up. They took on the proportions of hillocks budding over the level countryside. When death—possibly the result of acute indigestion—overtook a member of the tribe, he was tenderly laid away in a tomb that might forever bespeak his life's most intimate delight. There he awaited the coming of his god—and, as it turned out, the coming of man.

Man came in the spring of 1928. An expedition sponsored by Beloit College and Frank G. Logan, vice president of the Art Institute of Chicago, had made its way through Algeria to the borders of Tunisia, just north of the bleached Sahara. The group, headed by Paul Nesbitt and under the general direction of Dr. George L. Collie, director of the Logan Museum at Beloit, was in its third year of field work.

But work is slow and discouraging in the Mechta country; for the region, which once supported a bountiful life, now lies desolate and baked. The temperature sometimes ranges between 115 and 150 degrees, Fahrenheit, and it is only between five and ten o'clock in the morning that white men can work.

The winds and heat and torrents of the ages had transformed the surface shells of the mounds into a thick crust.

From three to six feet below the surface were exhumed four skeletons of a hitherto unknown type of man, splendidly preserved by the calcium carbonate formation that had once been the refuse of the tribe's repasts. Besides the skeletons, thousands of bone and flint instruments were unearthed and brought back to America.

The Mechta mound man's tableware was not elaborate. Bone points, evidently used for toasting snails over fires, and small flints, presumably employed in the delicate business of extracting the meat from its casing, served the race in the stead of the countless types of knives, forks, spoons, and divers odd-shaped utensils from which the twentieth century diner has to choose before he can negotiate his way from soup to dessert. Rudely engraved shells of ostrich eggs, and the burned human bones in fireplaces, pointing to cannibalistic tendencies, completed the culinary ensemble.

The man whose refuse preserved his bones through thousands of years of nature's caprices resembled physically the modern European more thoroughly than did any other race, primitive or modern. He was not racially "pure," however; so his descendants who vaunt their racial purity must withdraw their claims or repudiate their unsanitary ancestors.

Comprehensive measurements of the four skeletons disinterred from the shell heaps show relationships with the Cro-Magnons (a fine physical type of man in Stone Age Europe), with the Negroids, and with the ancient, brutish, anthropoid-like Neanderthal men.

Anthropologists have come to the conclusion that this African was not originally related to the Cro-Magnon or the Neanderthaler, but that members of these races entered Africa over the land-bridges which then connected Africa and Europe at Gibraltar and in the region of Sicily, and underwent intermixture with the mound man. Then, too, it is believed that about 12,000 years ago these mound men moved into Europe by the same routes.

One of the skeletons recovered from the mounds reveals characteristics of the Alpine group of twentieth century Europeans. Another is of a mixed type with Negroid affinities. The other two might be termed primitive Mediterranean.

Here we have the earliest known evidence of racial intermixture.

The Mechta man was clearly erect and heavily muscled; and his brain case was, according to the prevailing standards, well developed. His forehead retreated only slightly, his prognathism (mouth projection) was slight, his chin strong, and the development of the ridges over his eyes almost imperceptible. This contrasts strikingly with the anthropoid, and with the Neanderthal man who dominated the terrestrial scene 50,000 years ago. The latter had a narrow, slanting forehead, a pronounced prognathism, a weak chin, and heavy supraorbital ridges.

The strain of the north African citizen of 15,000 years ago is probably found, in one degree or another, in fifty per cent of all European-Americans.

Professor Fay-Cooper Cole, a world-famed anthropologist, ventures the opinion that this ancient race originally came into Africa from the region between the Nile and Turkestan, which is believed by many authorities to be the actual "cradle of mankind."

Coming into Africa between 50,000 and 25,000 years ago, these primitive folk worked out their destinies in the homely fashion that we have seen, dotting the landscape with the snail-shell mausoleums in which many of them were to be preserved for the benefit of modern science.

Their disappearance, which took place about 11,000 B. C., is a mystery. They vanished, just as did the Neanderthalers, the Cro-Magnons, and many another vigorous people of bygone ages.

PART III

IN COMMERCE AND INDUSTRY

CHAPTER I

LISTENING FOR OIL

A CARAVAN of lusty youths rumbled into a somnolescent village of western Texas. Gaping natives watched the procession move down the main stem of the hamlet. The members of the party—a dozen, all told—were strangers to the community. They were dressed in khaki; their shoes were high without being boots. Clearly they were neither cattlemen nor farmers. They piloted half a dozen small trucks and four passenger cars to the local garage, where one of the intruders mounted guard; the rest made their way to the building which bore the sign *Hotel* on its façade.

It did not take the townspeople long to decide that the intruders had come to look for oil. But while this theory was the most likely one, it did not satisfy the citizens' curiosity. For West Texans know oil people and oil-well machinery when they see them. There was a lucrative field twenty miles away—its derricks danced in the dreams of the townsfolk. The strangers might be oil seekers, yes, even though there were only a dozen of them, but the trucks were weighted with contrivances that obviously could not be fitted together to drill a well.

The visitors were courteous and well behaved, but strangely uncommunicative regarding the nature of their business. So the townsfolk watched warily.

The activities of the strangers soon laid their motives open to some suspicion. They hired, at wages too generous for any righteous business, five or ten of the town's malcontents whom offers of employment had previously failed to lure. The leader of the party apparently knew the country. He approached several landowners in the environs and paid them from ten to fifty dollars apiece for the privilege of excavating on their waste land.

Within a few days the excavating began, and the natives learned that one of the trucks was loaded with dynamite. Charges of explosive, varying from fifty to five hundred pounds, were placed in holes dug about twenty feet deep. One truck carried the machinery for detonating the dynamite, while three others were maneuvered to positions about two miles apart and five miles from the prospective explosion.

At first, the town laid off work almost to a man. All looked hard and hopefully after each explosion. But there was never a gush of oil. Stranger still, the natives soon learned that the visitors had no expectation of unleashing a gush of oil.

The three trucks that had been moved about five miles from the dynamite cache were laden with dials and inscrutable equipment. From each a small instrument was led about twenty inches into the ground. There were no connections, the onlookers noted, among the trucks.

The performance was sometimes repeated in the same vicinity, sometimes on another side of the town. Standing at what is popularly regarded as a respectful distance, the onlookers were baffled in their attempts to unravel the mystery.

Soon the cannonading lost its novelty, and the citizenry returned to more interesting pursuits, leaving the newcomers to blow up waste land to their hearts' content. Then one night, as suddenly as it had come, the troupe packed its cabalistic outfit and departed. The men had shot one final charge of dynamite in the bed of a stream the day before, but when the townsfolk went out to investigate, there was no sign of oil. The townsfolk never saw the strange visitors again. Sometimes, when a bolt of spring thunder cracks open the sky, they remember, and ask one another, "Who were those guys, anyway? What was their game?"

As a matter of fact, the interlopers had been looking, not for oil, but for salt domes in the earth—salt domes that had been pushed up from inside the earth to within a few hundred feet of its surface, and around which oil had been lying in giant pools for two-score million years or so.

The men were commercial scientists, applying the new science of geophysics. It is a combination of the science that treats of the constitution and structure of the earth and the operation of its physical forces—geology—and the science that treats of the activities of matter and the laws of energy—physics.

This application of geophysics to the search for oil resulted from the discovery that many of the richest oil fields had their greatest pools in a circle around a sort of pillar of salt—a dome of actual sodium chloride in the earth.

The top of the dome, which is blunted or mushroom-shaped and almost cylindrical in plane, is sometimes as near the surface of the earth as two hundred feet, sometimes several hundred feet farther down. The dome may be about a mile thick, or high, and from one to three miles in diameter.

The wells are sunk above the salt dome, around its edges, and in the territory extending out from the periphery. But the petroleum industry has in the past had to sink the wells first—at a cost of about $50,000 per well—and often no oil has been found. Now, if the salt domes could be located first, countless millions of dollars in drilling could be saved.

In the ancient strata of sand and shale which flanked the dome, when it was newly risen, there was a certain amount of oil, but the oil was so diffused it could scarcely be tapped. As time passed, however, the oil was forced upward by the downward pressure of the water—heavier than oil—that was also in the deposits. Thus the oil formed in pools or pockets around the salt dome, concentrated so that when a pipe is forced down, the pressure shoots the oil up. As the oil goes up through the well, more oil seeps toward the pipe intake until the region is fairly well drained. Then the oil is pumped.

The problem, then, was to locate the presence of the salt domes, and thus know where oil might be found in goodly quantities, without the necessity of expensive preliminary drilling. Who would have suspected that an instrument used for recording earthquakes would come to man's aid in his search for the precious oil that turns the wheels of a world's industry?

The study of sound waves in the earth has long been conducted in connection with seismology—the science of earthquake phenomena. Delicate instruments called seismographs, located all over the world, record minute tremors caused by earthquakes thousands of miles away. Involved mechanisms locate the distance of the quake from the point of record and measure the severity of the shock.

It was not until recently, however, that scientists were able to apply the principles of seismology to the detection of the salt domes, the structures which have been discovered to be the core of countless teeming oil pools.

About twenty-five of these domes have been found thus far, all in the region of the Gulf of Mexico—in Texas and Louisiana. The wells have not been sunk as yet, nor will they be for several years to come, when new supplies of oil are needed. But the industry is satisfied that salt domes mean oil, and thus it keeps searching parties in the field at a cost of $1,000 a day for each party's work—as insurance for the future.

The search for salt domes goes on persistently. The privilege of exploding charges of dynamite on a piece of waste land is quietly purchased from the farmer or rancher in possession. Then the trucks containing the dynamite and the firing apparatus proceed to a strategic spot. A hole is dug and the charge of dynamite is deposited. Three more trucks—each carrying a seismograph to determine the speed of sound waves through the air, on the surface, and under the ground—go on to points about five miles from the impending explosion and about two miles from each other.

The men attending the seismographs proceed to plant their geophones in the ground at a distance of about twenty yards from the trucks, to which the instruments are attached by cables. The geophone is like a telephone receiver, except that it is much more sensitive. Now the stage is set for the fireworks.

By the use of radio broadcasting and receiving sets, the seismograph men are told to prepare for the explosion. This means that every person in the party stands stock still and holds his breath, so there will be no extraneous tremor recorded on the instruments in the ground.

At the moment of the explosion a radio wave, traveling at the speed of light, 186,000 miles a second, is released and recorded automatically at the seismographs five miles away. Then a sound wave through the air is recorded for the purpose of determining the exact distance between the firing point and the seismographs. The difference in the time of sending and the time of receiving (recorded by the radio wave) is multiplied by the known speed of sound waves, with allowance for the influence of temperature and wind, and the distance between the two points is computed.

The significant thing is the speed of the ground waves. The disturbance caused by the detonation releases these waves in every direction. They move comparatively slowly when they pass through loose material like sand or shale, but they are known to move more rapidly through salt domes, which are more solid and conducive to speed. Having determined the distance between the two points, the chief of the party knows how much time a ground wave traveling through sand or shale requires to traverse that distance.

If, as the chief studies the records later, he finds that the waves came faster than they should come through sand and shale, he decides to move to another point and "cross-fan;" that is, repeat the experiment from a point that is probably at another side of the dome.

In this manner the existence of the dome is determined (if the results of the "cross-fanning" concur with the results of the original "fanning"), and its boundaries are established.

How do the waves get down to the top of the salt dome, if it is at least two hundred feet below the ground, and how do they get up to the surface again? This question the geophysicist answers with the explanation that when the waves are "broadcast" on the ground they travel in every direction, some of them going down.

If there is a salt dome, they strike it and pick up speed, moving very rapidly over the two- or three-mile surface of the dome, and thus outracing the waves which are going slowly through the sand and the shale. As the waves that have been speeding through the salt dome reach the end of the dome, they are imparted to the sand and shale, where they lose speed. But, even though they lose speed and have to travel upward more slowly before they are recorded on the geophone, they arrive at their destination ahead of the waves which have been ambling in leisurely fashion through the sand and shale near the surface.

If the speed through sand and shale over the established distance should be one full second, say, and the chief finds that a wave has been recorded in one-half or two-thirds of a second, he knows that somewhere along the road was a mile or two-mile stretch of speedway. That speedway is salt. And deep around the edges of that salt are black lakes. Those lakes are oil.

We have enough oil on tap right now to last us a long while—maybe ten years, maybe fifty. But some day the cry will go up for more oil. Then the dozen youngsters who bowled into that Texas town with their new-fangled science will stand trial.

CHAPTER II

THE ROBOTS ARE COMING

MAN has never yet created life. That is one formula that is just beyond his reach; he recognizes it as a manifestation of some sub-atomic process that eludes his grasp. But if he could not create life, could he not perhaps construct a mechanism to function like a living being? The scientist sets out to manufacture an artificial man—a man who will toil day and night but never suffer from an aching back or tired feet.

Literature has long toyed with the idea. In 1818 Mrs. Shelley published *Frankenstein,* a novel about a student who created a man out of odds and ends gathered from graveyard and dissecting-room. In the present century the mechanical man has made two notable appearances: in the Yiddish play *The Golem,* based on an ancient legend, and in the recent drama, *R. U. R.,* which has given world-currency to the word *robot* as a servant machine. But in every fanciful case the mechanical man has turned against his creator, causing disaster and death until his own eventual extermination.

Within the last few years the General Electric Company has produced in its research laboratories at Schenectady four signally useful mechanical servants, each of which does at least a significant share of a man's work.

Unfailing and untiring, an electrical "man" is now counting, hour after hour, month after month, the number of vehicles passing through one of the the two tubes forming the Holland tunnel, the two-mile boulevard under the Hudson River, which connects New York with New Jersey. This traffic checker is an experimental unit of a proposed system that engineers envision as a revolutionary step in the control and protection of traffic.

The experimental unit is located at the exit end of the New York-New Jersey tunnel, or "tube." The apparatus consists of a small flood-light mounted in an inclined position upon the overhead iron-work of the tunnel, its slender beam of light falling upon a little circular window in a box located just beneath the sidewalk at the opposite end of the roadway. The box contains a photo-electric tube (the electrical "eye"), an amplifying tube, and an electrical relay.

Every time a vehicle passes the spot, the beam of light falling upon the photo-electric tube through the little window is interrupted, affecting the photo-electric tube so that a slight electrical impulse is created. This is amplified by the vacuum tube and fed to the relay, which energizes a transmission circuit ending in the administration building of the Tunnel Commission. There a registering dial is actuated by the electrical current so that it turns, registering one more figure in response to each impulse from the relay.

The plan, or rather the dream, of the engineers visualizes each of the tunnels divided into sections, with one of these units at the beginning of each section and one at each end of both tunnels. The count will be registered upon an indicator board in the administration buildings on each side of the river. By watching the dials, one will be able to tell instantly the exact volume of traffic passing through each tunnel at all times.

A sudden large increase in the number of vehicles in one section, with a concomitant slight decrease in the number in the section ahead, will indicate a congestion, resulting, perhaps, from an accident. The trouble point will be more quickly located and the ventilation more effectively regulated than by any existing method. In the event of a complete tie-up in either tunnel, the engineers will know at once the number and distribution of vehicles penned in, and they will be enabled to adjust the vital matter of ventilation without delay.

It has been estimated that fifteen million vehicles pass through the Holland tunnel every year. An electric eye—infallible, unwinking—will check this estimate with an exactitude that cannot be achieved by a corps of men. Thus the builders of the future will know better how to distribute strength and elasticity in the construction of bridges and tunnels.

This is only one function of the electric eye. In a still newer capacity this robot watchman detects the clearness of the atmosphere and furnishes the tunnel engineers with an instantaneous alarm when haze, fog, or dust impairs the vision of drivers beyond the limits of safety.

As now experimentally used in the tunnel, the electric eye is directly connected with a recording device a quarter of a mile from the mouth of the tunnel. Impulses from the photoelectric tube guide a pencil-point over a sheet of paper ruled graphically to indicate time and volume. At any instant, by glancing at the record, the supervisor of the tunnel can inform himself of the amount of haze permeating the subterranean traffic arteries, and if the visibility decreases from any cause whatsoever he can relieve the situation by speeding up the fans or by putting extra fans into service.

Here is a job that the mechanical man can do infinitely better than his creator. The falling fog in the open country is not perceptible to the human eye until it has congealed heavily. In the unnatural confines of this pipe-like structure, the obstruction of light is even less easily discernible. But the man-made eye sees it and records it, transmitting a warning to the supervisor that the visibility has been dimmed and that the lives of the motorists in the tunnel are endangered by collision or by panic.

The electric eye depends for its operation upon a principle discovered by Hertz in 1888, for which Einstein gave the first equations, a principle which is vital in television and talking pictures.

Light falling upon certain alkali metals will generate a feeble flow of electricity. Tiny chunks of light, or quanta, will displace tiny chunks of electricity, or electrons, from the metal, and the brighter the light is, the bigger will be the electrical flow. In General Electric's photo-electric cell any change in the amount of light falling upon the potassium hydride within is detected in one one-hundred-millionth of a second.

The projected use of the photo-electric tube as a detector may presage the development of a mechanical watchman for houses and stores—one that will sound an alarm at the first appearance of smoke on the premises. In the not-too-distant future this electrical watchman may be installed in cellars, in attics, and in warehouses filled with combustible goods. Connected with a bell or a siren, this apparatus will announce that the path of ever-wakeful light has been crossed by the tiny wisps of smoke that indicate the presence of fire.

The electric eye in the Holland tunnel is successful as a guardian against the wafted, inanimate smoke and fog. But the General Electric engineers have gone further—they have connected the eye with a voice and produced a policeman!

Should a burglar force his way at night into the Museum of Peaceful Arts in New York City—should he sheathe his gun after ascertaining that no watchman or policeman apparently is in the vicinity—should he be crowding a gunny-sack full of priceless art treasures—should he be making his way to freedom and criminal luxury—then—halloo!—he might hear a distinctly menacing voice behind him command:

"Stick 'em up—all the way! I've got you covered!"

Should all this happen, some murky midnight in this sanctuary of beauty, the chances are that the intruder would hurriedly "stick 'em up" as requested, and keep them up until a squad of police, which had started for the scene when the burglar crossed the mere slit of light, arrived at the place of action. And the chances are that the miscreant would be speedily rolled away to temporal punishment by the People and his loot safely restored to the museum.

The foregoing snack of melodrama is imaginary; but the situation is only mildly hypothetical. Today, when a visitor to the Museum steps from the elevator into the great room housing a valuable exhibit, he hears, not the command to "stick 'em up," but a courteous invitation to register. There is no human owner of that voice—the speaker is in a little box, and the speech—recorded on a disk—never varies. The victrola starts when anyone passes through a beam of light.

The electric eye has been conscripted for still a newer function—that of watchman over the precious human eye. A mechanism has been developed that turns on the lights in a schoolroom when the failing light of late afternoon or of cloud-clotted skies passes the imperceptible line at which it becomes a menace to the delicate sight of the children.

The daylight filters through a lens on to a photo-electric tube which is set for a certain degree of daylight intensity. Whenever the light outside falls below this mark, the photo-electric tube causes a small relay to switch on the lights in the schoolroom. If the skies clear and the intensity of daylight again reaches the proper mark, off go the lights. In the meantime, many pairs of human eyes have been protected.

Eyes are important. Science has created a super-eye.

Chapter III

DIAGNOSING A RAILROAD WHISTLE.

THE "Limited" gives no quarter. It is another of man's servants that at any moment may become like Frankenstein's monster. Its piercing clarion clears the way for the dazzling streak of steel. Men and beasts that do not hear and heed the shrieking steam quickly find themselves, or rather they are found by others, dismembered beyond the possibility of successful reassembly of their parts.

Mishaps at railroad crossings have increased appallingly year by year. Whole families are exterminated; automobiles—the most common party of the second part in these unfortunate encounters—are pulverized. Sometimes the driver, or some other member of the mangled group, survives long enough to moan, "I didn't hear the whistle," or "I didn't know it was so close," or "I didn't know it was a train."

All too often it is a case of "I didn't hear the whistle." And yet the Casey Joneses of today blow their whistles at every bend, at every crossing. The man in the cab, knowing that it is almost always too late to stop his mile-a-minute Juggernaut, once he has seen the carload of frightened blunderers in his path, does not forget to "give 'er a toot" at any and every junction, ranging from a country cow-path to a transcontinental speedway.

The number of railroad-crossing deaths traceable to ignorance of the approach of a train continues, notwithstanding the insistent tooting of whistles, to set new "highs." The railroads cannot maintain watchmen and gatemen at the thousands of intersections along their tracks. They plead with the car-driver and the pedestrian, by means of large, conspicuous signs, to STOP, LOOK, LISTEN! Their engineers begin sounding the siren of warning a mile before the crossing is reached. Then the responsibility shifts to the human caterpillars to avoid being crushed to a jelly.

Only the drunkard and the fool still persist in trying to beat the train to the crossing. And only a negligible fraction of drivers suffer from seriously impaired hearing. Yet the accidents continue.

A few years ago, a "Limited" operated by one of the greatest trunk lines in the United States demolished a school-bus filled with children, at a crossing just outside a small Ohio town. Seventeen children were killed, but the driver of the bus recovered.

Why didn't he hear the whistle?

He was a trusted, competent resident of the town. He had negotiated the crossing, with his precious burden, hundreds of times, many of them in fogs heavier than the one out of which the train had plunged its living tonnage into the bus. He testified that he had stopped before crossing the tracks, had walked on to the crossing, and listened for approaching trains; then had resumed his seat and driven into the path of the locomotive.

The engineer and fireman of the train were veterans in the railroad's employ; they had made this "crack" run hundreds of times. Their records as railroad men were punctuated with rewards for character and service. They testified that the headlight was burning, that the bell was ringing, and that the whistle was sounding, as they pounded through the heavy murk that shrouded the region.

The railroad officials, nonplussed, persuaded Professor A. L. Foley, head of the Department of Physics and director of the Waterman Institute for Scientific Research at Indiana University, to study the problem. Professor Foley had experimented with various phases of acoustics for fifteen years. The results of the application of his specialized knowledge to the problem of the locomotive whistle then explained the likelihood of the engineer's integrity in seventy-five per cent of the cases in which the engineer testified that he blew his whistle and the victim testified he listened for a signal and heard none.

The equipment of the locomotive that figured in the Ohio disaster was brought to Dr. Foley's laboratory and tested under all sorts of weather conditions.

Not satisfied that fogs, winds, and other atmospheric conditions are alone responsible for the failure of warning signals to reach the ears of persons about to cross railroad tracks, the scientist delved more extensively into the problem. He installed a regulation locomotive whistle at the power-house of the University, and tested its sounding qualities for distances up to five miles.

He then arranged for a more realistic series of investigations by obtaining for study the use of several "big eight-wheelers of a mighty frame," as the Casey Jones saga describes them, from the Chicago, Indianapolis & Louisville Railway, operating through the University town.

His earliest tests proved that locomotive whistles, located, as they are, on the "roof" of the frame, behind the smokestack and steam-dome, and often behind the generator, are in a poor position to give warning signals down the track ahead of them. This location, Dr. Foley found, resulted in the blast's being fended off at right angles to the track, instead of down the track where it is needed.

Not only does this deflection of sound by the smokestack and steam-dome impede the efficiency of the whistle; the hot gases from the engine, in front of the whistle, act as a dispersive lens. The result is that when the locomotive is running at a good speed a blanket of these hot gases is formed which tends to absorb and refract the sound waves, so that the intensity of the whistle's sound in front of the locomotive is much less than it is at right angles to the track.

To eliminate the effect of wind and other conditions, tests were conducted with a locomotive in different positions on a turntable.

Confirming Dr. Foley's theories, the measurements revealed that the sound of the whistle was twice as intense at the side of the locomotive, where the sound is not only superfluous but actually a nuisance to persons living along the right of way, as it is in front of the locomotive, where the warning signal is essential.

To remedy this defect, Dr. Foley placed the whistle in front of the locomotive and inside a reflector somewhat similar to that in which the headlight of the locomotive is placed. The reflector served a double purpose: it reflected the reverberations ahead of the train, and acted as a resonator to intensify the sound.

The use of a simple reflector resulted in the production of sound intensity three times as great down the track as it was at right angles to the rails. This meant a sixfold increase of intensity over the whistle used without a reflector and in the customary location behind the smokestack, steam-dome, and generator.

Another important consideration when the warning signal is atop the structure instead of in front, Dr. Foley found, is the interference with the functioning of the whistle by the heavy air pressure resulting from the tremendous speed with which the locomotive cleaves the atmosphere.

When a train is traveling sixty miles an hour, one-third of the whistle area is rendered ineffective by the "boxing" of the column of air pressure. Consequently, there follows a "swishing" sound when the whistle is in operation. This sound, which is sufficiently familiar to travelers, provides an inadequate warning signal. The use of the reflector would, of course, eliminate this defect, since the reflector carries with it its own body of air, and all parts of the signal will function regardless of the speed of the locomotive.

Dr. Foley points out that all railroad whistles should be standardized. Whistles producing a note of high, shrill pitch, such as he recommends, should be restricted to the use of railroad locomotives. This would result in the public's subconscious identification of the warning shriek of the locomotive whenever it is heard. The instant reaction would be caution. Just as the motorist turns his car in to the curb as soon as there strikes upon his ear the sound of the siren horn that he knows is restricted to the use of fire apparatus, so would the motorist, the pedestrian, and even perhaps the cow, learn to react automatically to the specialized note of a train whistle.

Aside from the humanitarian aspect of the problem, there is an important economic factor involved. Professor Foley appends to the report of his investigation a summary of a bit of economic research that reveals an immense sum of money wasted annually under the régime of ineffective whistles. The steam required per hour to blow a locomotive whistle of the standard type is 8,352 pounds, necessitating the evaporation of more than four tons of water and the attendant consumption of 1,190 pounds of coal.

The locomotives of the nation whistle, it is estimated, 11,200 hours a day, at a cost of 6,664 tons of coal daily, or 2,434,026 tons a year. Figuring the cost of coal at $3.00 a ton, Dr.

Foley arrived at the total expenditure of more than $7,000,000 a year for the blowing of our locomotive whistles.

By taking advantage of the improvements his investigation has suggested Dr. Foley believes that the railroads can reduce their coal bill for whistle blowing two-thirds, with a resultant saving of human lives, which, unlike coal, cannot be translated into dollars.

Seven thousand men, women, and children are killed in railroad accidents every year. More than one hundred thousand are injured and maimed. The great railroad executive is helpless; so he turns to the scientist. The scientist focuses his quiet insight on the locomotive whistle. A year or so, and the job—the scientist's job—is finished. He presents his diagnosis and his prescription to the industrialist. Then he withdraws—to tackle another problem.

PART IV

Man and His Ills

Chapter I

TRACKING DOWN THE "FLU" GERM

IN THE early winter of 1918-'19, a "new" infectious disease ran like wildfire over the United States. Its toll of lives was terrific. "Spanish influenza" was the name of the strange malady, abbreviated in everyday speech to "the flu." Some authorities attributed the scourge—which first appeared in Europe—to war conditions.

Oddly enough, the ailment was not fatal in itself. But it destroyed the tissues and broke down resistance; then deadly pneumonia rushed in and swept away lives by the tens of thousands.

Awaking of a morning, during that grievous winter, many a man or a woman who the day or the week before had been cited as "the picture of health," felt languid and prostrated—"low," it came to be called. Medical examination revealed a sharp decrease from normal in the number of white corpuscles in the blood. The throat was red and sore, the nostrils irritated, the mucous membrane in the air passages inflamed.

Rales—a sort of rattle in the lungs—could be detected with a stethoscope. Headache, backache, loss of appetite—all these pressed into the dispirited frame overnight.

Physicians were bewildered. They prescribed rest, and the ordinary treatment for severe colds and bronchitis. But lives continued to slip through their fingers in a week or ten days. Practitioners, with all their skill, with all their untiring service and sacrifice, could neither arrest nor parry the assaults of the storm. Many themselves fell victims. The undertakers worked hardest.

Today, in the cemeteries of the nation's greatest cities, where the "flu" flourished like Kansas sunflowers, there remain tragic memorials of the plague in the form of countless thousands of headstones with dates in the months of December, 1918, and January, 1919.

Before spring, the epidemic had spent itself. Man as an individual was slow to shake the mantle of despair from his shoulders; but man in the mass discarded his sackcloth and ashes and turned his face toward the summer's sunlight.

It was science, however, that recoiled first from the blow. Before the last dead were buried, scientists were at work in their laboratories, seeking to unravel the mystery of this elusive distemper.

It was patent that the disease must be due to a germ—one that had never as yet been isolated and identified. Now the discovery and capture of the germ—the living, microscopic organism that carried and transmitted the specific poison—had proved to be the key to victory in the conquest of many infectious diseases.

From the dead germ, a vaccine might be made. Or the morbid essence that communicates the malady might be made the basis of an antitoxin. This, injected into the body which nurtured the noxious bacteria, neutralizes the living germ, thus effecting a cure. Bacteriologists all over the world took up the search. The results were discouraging.

Finally, ten years later (after several minor epidemics, and one that approached in virulence the first, had come and gone), "42x" was discovered and isolated by a thirty-year-old scientist who had worked at the job for six years in an obscure laboratory at the University of Chicago.

On December 12, 1929, Dr. Isidore S. Falk announced that with the assistance of fourteen research associates, all of whom had developed the disease that they had at last succeeded in solving, influenza of mild and violent types had been produced in monkeys by the injection of a certain one of the 3,800 different microbes that were being studied.

Announcements had previously been made, from time to time, all over the world, of the discovery of the guilty germ, but confirmation had failed to follow. Bacteriologists of every country had undertaken a race—a race that promised no reward to the winner. But they were handicapped by the failure of the "flu" to appear on a large scale until November, 1928.

Then an epidemic broke out on the Pacific coast, reaching heights that approached the affliction of a decade earlier. Like Hannibal's army, it lost much of its strength in its march over the mountains. But it reached the Middle West with a reserve force potent enough to double the death rate in the city of Chicago that winter. Somewhere between one-half and one-tenth of Chicago's three million inhabitants were stricken.

Once more a helpless humanity wondered and prayed and died. December 12 marked the peak of the epidemic. On that day, the institution which Dr. Falk served closed its doors in an effort to check the spread of the infection. Within five days, half the educational establishments in the surrounding region had dismissed their students.

On the day that the University closed its doors, Dr. Falk mobilized his resources for an intensive campaign. He called for volunteers; four responded. Informed of the bacteriologist's intention to work eighteen hours a day, so long as the epidemic furnished virulent material for study, three men and one woman signified their willingness to trade blows with the "flu" germ until they had won or were definitely beaten.

The first move was the acquisition of several dozen Rhesus monkeys, a type of simian known to be susceptible to influenza but not to pneumonia. These were escorted to the student infirmary, which was crowded beyond its capacity—as was every hospital in the city—with sufferers. From influenza-stricken volunteers samples of blood were taken, as well as throat swabs. Some of the animals were inoculated with blood, some with mucus samples from human throats, and some with both. The workers then made cultures from each volunteer's blood and throat.

Blood and mucus samples were taken from a total of twenty-three persons, including laboratory assistants who had manifested symptoms of the disease. There were, in all, 125 monkeys inoculated with the blood or mucus that contained somewhere in its substance the virus that caused the disease.

Skillfully plying their fine platinum wires, the investigators streaked thousands of specimens of blood and mucus from all the men and all the monkeys on culture dishes. They streaked each sample until the wire was ostensibly clean and its line became invisible. And they knew that the invisible lines contained individual microbes.

When they came back 24 hours later the invisible individual bacteria had each grown by self-multiplication into visible colonies containing millions of cells. With each colony the process of streaking was repeated until the investigators were certain of the absolute isolation of one organism.

But there were 3,800 different microbes obtained, through the culture process, from the animals and the human beings. Which one of the 3,800 suspects was guilty? That was the problem which confronted the investigators. The task before them was Herculean, but their enthusiasm carried them along on its buoyant crest. Ten additional members of the bacteriology department, inspired by the devotion of the little company, swelled the number of workers to fifteen.

All but 100 of the nearly 4,000 suspects were disposed of in quick order. Then the 100, each representing a unique clan of microscopic criminals, were installed in healthy monkeys. After that came the unrelenting surveillance of the animals for symptoms of the dread “flu.” But the results were not at all spectacular.

As the epidemic showed signs of waning, the searchers grew desperate. The germ had to be caught before the epidemic ran its course—not to return, perhaps, for years, when it might suddenly descend upon humanity again in redoubled force. The workers gave up going to their homes to sleep; they slept on their desks. Dr. Falk had an alarm clock at his elbow that awakened him every half-hour, after long sessions with the microscope had numbed his brain.

December 21, 1928, had been a cruel day. By this time almost half of the little group were in the hospital.

After midnight light-heartedness is not as fluent in a laboratory as it is in a cabaret. The workers had agreed to speak at the first signs of “flu” sickness in any of them. But the men in the hospital had hesitated to report—they thought it was fatigue and not the oncoming of influenza that had overtaken them. Miss Ruth McKinney, one of the four original volunteers, felt ill. Remembering the promise, she ventured to speak.

A colleague mechanically took a sample of blood from her arm. The blood was streaked on a culture plate, and the culture—numbered 42—was put in the incubator for twenty-four hours. Then it was removed, stained with aniline dye (bacteria are normally transparent, but they absorb the colors of certain dyes), and lo! there were colonies—blue and pink clumps of microbes—all of one type.

It was a streptococcus type; that is, the colonies were arranged in chains, or links; they were pleomorphic—many-shaped—and grouped irregularly, like beads restrung by a child. It was referred to then as the "pleomorphic streptococcus."

Was this the mysterious influenza germ? The investigators had no special reason to suspect it was anything more than just another germ successfully isolated.

Later, two types of germs were found living in this culture 42. One was labeled "x," the other "y." The "y" germ was proved to have resulted from contamination in handling the culture. Falk and his assistants then prepared for the inoculation of 42x into a monkey.

By this time the germs being studied had been reduced to eight general types; 42x was merely one of the many specific bacteria that could be classified into these eight groups.

On December 29, 1928, monkey No. 14b, an animal that had been enjoying perfect health, and had not previously been subjected to experiment, was inoculated. A large dose, consisting of millions of germs grown from 42x, was administered.

Things began to happen. On New Year's Day, 1929, the members of the group who were still able to walk were congregated in the laboratory. The count of 14b's white corpuscles had increased soon after the inoculation, but had decreased sharply and significantly by the second day following. Other symptoms soon appeared. Within a week, 14b was clearly suffering from influenza.

The germ was given to other healthy monkeys. They lost vigor, their throats were inflamed, their dispositions became muggy, they curled up, blinked abnormally, shrank from light flashed in their eyes. Science was seeking mercy for millions of human beings, so these monkeys had to die—in as painless a manner as death can be imposed.

Post-mortem examination clinched the proof. Mucus was found to have accumulated in their windpipes and respiratory tubes. The early symptoms of bronchial pneumonia—also characteristic of full-blown influenza—were revealed.

The eighteen-hour day which had been kept up without interruption ended for all the workers but Dr. Falk about January 10, 1929. The epidemic was practically over.

But the job was not finished. They had yet to keep that 42x germ alive—flourishing and deadly—before they could prove conclusively that it was responsible for the "flu." Possibly monkey No. 14b might have become infected in some manner other than from this germ, although every person involved in the inoculation on that fateful December 29 had subsequently fallen ill, despite the wearing of masks and the utilization of all possible precautions.

Repetition of the experiment, with all its embellishments, carried the adventurers to the end of September. Germ 42x had to be preserved indefinitely if it was to furnish the cure for influenza. Hundreds of culture mediums were tried, and finally the successful combination was obtained.

Chocolate, the investigators called it. Actually it was a combination of agar-agar (a seaweed) and sheep's blood.

When this medium was heated to a degree approaching the boiling point, 42x sprouted sturdily.

Next, workers found that rough, pock-marked colonies of this germ produce the disease perfectly (these are the virulent type), while the smooth-surfaced clumps do not. The smooth colonies they found to be present in the throats of normal persons. When the colonies become rougher, they produce a type of cold in simians. A still more advanced stage of unevenness is associated with bronchitis. In its most jagged state, 42x means influenza. But the discovery of "the germ of the common cold" was disavowed. Other germs, perhaps, also produce the common cold.

Could this virulence be developed artificially, now that the deadly form of the germ had vanished with the disappearance of the epidemic? The scientists incubated a colony of their precious microbes. From the resultant enlarged community they selected the roughest examples, streaked them out on a culture, and let them thrive.

After fifteen repetitions of this process—that is, fifteen generations of 42x developed from the shaggiest specimens in each generation—the bacteria had achieved their ultimate virulence.

But would the virulent germs produce influenza in humans? That question is not yet answered. The fifteen men and women who had participated in the experiment were eager to replace the monkeys as test subjects. But they had all fallen victims to the malady already—fortunately without fatal results—and in so doing they had achieved an immunity of unknown duration. Others offered themselves for the test—but the scientists did not wish to subject them to so serious a risk.

The discovery and isolation of 42x is a step—a beginning—nothing more. If, as a result of further experiments, 42x will yield to the efforts of bacteriology to extract from its body a preparation that will knock the pock-mark spots out of its whole race, and if such a preparation clearly fortifies men against the disease, then the little band of workers who filled the hectic nights with their beautiful skill will get into the text-books. If more years of labor prove their trail to be a blind one, then they will deposit 42x in a neat, tight container, place it in a remote corner, and begin again.

CHAPTER II

THE STORY OF ETHYLENE

ETHYLENE, although as yet little known to the public, is the safest and most effective anaesthetic ever perfected. Its remarkable qualities were stumbled upon by men who were trying to prove that it was a deadly poison. The story of ethylene is the tale of two courageous experimenters and of a hundred unwitting pioneers of science.

The men who proved that ethylene is a boon instead of a menace, by trying it on themselves, were Professor Arno B. Luckhardt, physiologist at the University of Chicago, and his student assistant, J. L. Carter. Carnations, frogs, rats, kittens, mice, guinea pigs, dogs—these were the humble co-discoverers, with Luckhardt and Carter, of the anaesthetic that assures weak-hearted, weak-kidneyed, and weak-lunged patients immunity from the dangers of ether and laughing-gas.

The drama of the discovery of ethylene carries us over a period of about twenty years. Luckhardt's appearance on the scene dates from a luncheon gathering at which the young physiologist—he was but twenty-five at the time—and a friend of his, Dr. William Crocker, a botanist, were present.

Crocker was telling the story of an experiment with ethylene gas, which had been causing trouble by "putting carnations to sleep." He had been consulted by a group of Wisconsin carnation growers who had been receiving complaints from Chicago florists that the flowers shipped to them "went to sleep" as soon as they reached the greenhouses. Since carnations never "wake up," once they have folded their petals and "gone to sleep," the matter was serious. The florists were losing money on carnations.

Crocker visited the greenhouses whence the complaints had come. He found four tiny leaks in the gas lines. The amount of gas escaping was, from the human being's point of view, negligible. But the botanist suspected that some element in this common illuminating gas was fatal, even in infinitesimal quantities, to the sensitive carnations.

He experimented in his laboratory with some of the flowers, which he placed under glass jars, and confirmed his suspicion that a small amount of the illuminating gas injected into the pure air was responsible for the death of the carnations. What element in the gas was fatal to the flowers? The botanist did not know. He simply knew that ordinary illuminating gas included ethylene and carbon monoxide in its composition.

First, Crocker studied the effect of subjecting the carnations to a carbon monoxide atmosphere. It seemed to have no effect on them. But when he subjected the blossoms to an ethylene-sprayed atmosphere, he found that one part of the mysterious gas to two million parts of air produced their instantaneous death.

The young physiologist was stirred by the botanist's account. Ethylene was evidently more poisonous than carbon monoxide; and yet science had been satisfied for years that it was the carbon monoxide alone that was fatal to persons who met their death through gas asphyxiation.

Could this ethylene element paralyze the life force long before the carbon monoxide took effect? Here was a new problem—one that science had not yet tackled.

Luckhardt's first move was an elementary one: he mixed blood with a quantity of ethylene. Poisonous gases generally alter the color of the blood. But ethylene failed to produce that effect.

In the press of other duties, the youthful scientist postponed further work on an experiment that seemed to be leading him up a blind alley. The problem, however, was not forgotten; it fascinated him, and he came back to it seven years later. The United States was at war, and Luckhardt had been put in charge of the University's physiology department.

He had not been able to dismiss the suspicion that ethylene was a fatal poison to man and beast; so he set himself to work on new experiments.

Certain accommodating frogs were subjected to one part of ethylene in forty parts of air that was circulating in their fruit-jar homes in the laboratory. This combination was fifty times as poisonous—so Luckhardt thought—as the atmosphere that had killed the carnations. But the frogs, after breathing the tainted air, manifested complete *sang froid*. This gesture of indifference to scientific endeavor annoyed Dr. Luckhardt.

He decided to give them a terrific dose in the next experiment. He increased the percentage of ethylene to twenty thousand times more than the amount that had killed the carnations. Again the frogs figuratively laughed at him. Irritated, Luckhardt now filled the jars with a composition of 80 per cent ethylene and 20 per cent air. Only then did the frogs' eyes assume the glassiness of intoxication. They sat down and looked around stupidly, as would a late homeward-bound commuter trying to keep awake until he reaches his station.

Still Luckhardt did not understand. Deadly poison—deadlier than carbon monoxide? Was it?

Then he remembered that the frog is a cold-blooded animal; its blood assumes the temperature of its surroundings. Man, however, is warm-blooded; his body heat is essentially constant. And the rat, like man and all other mammals, also is warm-blooded. Perhaps the rat would "fold up its petals," so to speak, in an ethylene-saturated atmosphere.

Several rats, accordingly, were corralled for the experiment and placed in fruit-jars. The gas was administered. When the solution reached the 80 per cent stage, the animals began to reel in an unratly manner; finally they lay down. The physiologist lifted the inert forms out of the jars and pummeled them. But the rats were "out." Nose-tweakings, ear-pinchings, slaps on the body—all were unavailing. Luckhardt left them for dead. When he returned a few minutes later he found his "corpses" frisking about the laboratory.

Luckhardt repeated the performance several times, with similar results. Then he sat down and wondered.

He had failed—failed to prove that ethylene was a fatal poison to animals. But for the second time his work was interrupted. Problems of more immediate importance, bred of the war, clamored for his time and energy. Ethylene was laid aside.

In 1922, the scientist was no longer the youth who had been enthralled by the story of the carnations a dozen years before. He was now a married man and the father of three children. His temples were becoming tinged with gray. He had gained an eminent place in the world of scientific research. But he had not forgotten those puzzling experiments with ethylene.

Now, with J. L. Carter, an eager young student assistant, he turned again to the strange gas. He had become confident that it was not a poison, worthless to man. He had pondered much over its possibilities as an agent of relief for human pain. So the glass jars were again installed, the ethylene generated.

This time, the dog was to have his day—and the cat and the guinea pig. Upon the application of ethylene, they, like the rats before them, curled up in happy slumber. Cudgeled and pricked, they uttered no protest. Then, when the masks had been removed and the patients given a few whiffs of fresh air, the cats looked about them and purred contentedly, the dogs barked lustily, and the guinea pigs squealed for food.

Now came the semi-final step. Surgery had not yet been attempted on ethylene-anaesthetized animals. A dog was selected for the trial. Luckhardt wielded the knife; his assistant had charge of the anaesthetic. The gas was applied. Luckhardt noticed that the animal relaxed at once. He cut.

"Hold on!" cried his partner. "He's not 'under' yet."

"Too late," Luckhardt replied, regretfully. For all scientists wish to avoid the infliction of unnecessary pain upon the animals with which they are experimenting.

Luckhardt watched the dog carefully, and made an astonishing discovery. The patient showed no signs of pain or discomfort, although the blinking of his eyes was evidence that he had not completely "gone under"—i. e., lost consciousness. A few whiffs of ethylene had desensitized the dog. He remained conscious, but the valves that connected his nerves with their control centers had been closed. The dog had been operated on successfully, safely, and without pain.

One more semi-final experiment. A dog was kept under the torpor of ethylene for forty-five minute periods, fifteen times in three weeks. On each occasion his tail would wag with canine pleasure two minutes after the mask had been removed. Three minutes later he was playing around in the manner common to dogs in a state of well-being. He ate heartily of the best dog food and took on six and one-half pounds of weight during the three weeks of experimentation.

The time had now come for the test that no longer involved merely the success or failure of a theory, or the lives of laboratory animals, but the life of a human being. The marked success with the tests on lower forms of life suggested the feasibility of applying the anaesthetic to man. But man had changed in a thousand respects during his evolutionary journey, especially in his brain and nervous system. The effect of the gas might be the same on a man as it had been on the dog—then again, it might not.

Who would volunteer his life for a cause that did not promise monetary compensation, patriotic glory, medals, and showers of confetti? Luckhardt and Carter faced each other silently in their deserted laboratory. It was Sunday. The decision was quickly made. It is unlikely that any eloquent words were exchanged between them. Luckhardt was ten years older than Carter. He had a wife and three children . . . . The younger man submitted to the test first.

Carter lay down on the couch, holding his right arm up in the air. The mechanical procedure was familiar to both of them. Whether anything more dramatic happened in this stage setting than in the one with the animals will never be known. Both men were cool-headed scientists.

Together they adjusted the mask. Luckhardt signified that he was about to administer the gas, and Carter took a few deep breaths. His extended arm lost its rigidity and fell half-way to the couch; but he shot it up again. Another few breaths, and the arm dropped—all the way, this time. Carter was unconscious.

Luckhardt stopped the flow of gas and tore the mask from his assistant's face. A few seconds later, Carter was on his feet, his head clear, his body fresh, asking Luckhardt why he did not proceed with the experiment. The ethylene had done its work marvelously. The whole test had required little more than a minute, and had left the subject so free from discomfort and nausea that he did not know it had taken place.

It was Luckhardt's turn now. This time, the younger man administered the anaesthetic. The physiologist inhaled the gas. It had a faintly sweetish odor. A pain in his forehead that had been troubling him disappeared and he felt a moderate exhilaration just before he grew unconscious. That was all.

Carter checked the gas and unmasked his subject. In a moment the limp body was a vigorous man again. He was delighted with the effect of the experiment upon himself. Ethylene was harmless, as well as potent. The two men, rejoicing, made their way to the office of Anton Julius Carlson.

Dr. Carlson was their chief—the head of the department of physiology at the University. He knew something of the experimentation with ethylene, but, with true scientific skepticism, he was dubious of its possibilities. His first reaction was one that stimulates progress: he doubted, and wanted to be "shown."

Carlson was a strong man, larger than either Luckhardt or Carter. He offered to explode their conclusion by resisting the gas himself. The knotty figure of the Scandinavian soon lay on the laboratory couch. His powerful arm, with the ponderous fist tightly clenched, was held vertically above him.

He did not know that the experiment was over when he sat up and listened to the story of the two men. When they assured him that his arm had fallen a few seconds after the application of the gas, he accused them, in his droll way, of trying to deceive him. He knew that he had never lost consciousness. But on Luckhardt's solemn insistence that he had, he acknowledged his lapse, in wonder.

During their earlier tests with dogs, the scientists had learned that ethylene worked faster and more effectively than laughing gas or ether, the two common anaesthetics. It was clearly less dangerous in use than the other two gases, since it was nontoxic and could be utilized freely in the case of patients with weak hearts or lungs, or diseased kidneys. Both ether and laughing gas had after-effects that were not only unpleasant but frequently fatal to patients in a very weak condition.

It was not long before Luckhardt and Carter by further experiments—volunteers were numerous now—proved to their complete satisfaction that a human being felt no more pain from pin pricks or blows, under the magic spell of ethylene, than did a dog. They were ready for a clinical demonstration.

While noted surgeons and anaestheticians looked on, Luckhardt again submitted himself to a test. It was completely successful; the efficacy and speed of the demonstration bewildered the men of medicine. Ethylene was ready for the world's use.

The first operation in which ethylene was used professionally took place at the Presbyterian Hospital in Chicago, in the spring of 1923. With a combination of 85 per cent ethylene and 15 per cent oxygen, a surgical case of the sort that had served to introduce ether, generations earlier, went under the knife. It was the removal of a scalp tumor.

Both surgery and gas functioned perfectly. More serious operations were then undertaken with the assistance of ethylene, and in every instance most satisfactory results were achieved.

During the eight years since ethylene's debut as a substitute for ether and laughing gas it has relieved human suffering to an incalculable extent. Whereas injuries associated with the use of ether had mounted to over 100 a year, ethylene has been utilized in more than half a million operations, with only twelve mishaps on record since its introduction. Of the 500,000 patients, only three died through accidents resulting from the use of the anaesthetic.

The cause of nearly all the mishaps with ethylene has been its inflammability—a characteristic that it shares with ether. And the very few black marks against ethylene have been due to the carelessness of attendants in the operating room. The fault is in the human equation rather than in the gas and its consequences.

Ethylene is without question one of the greatest blessings that science has ever given to suffering humanity. Perhaps Luckhardt has forgotten the Sunday morning when he and Carter faced each other in the laboratory. It takes unscientific sentiment to make romance of such occasions.

CHAPTER III

MICE TELL US ABOUT CANCER

WHY should anyone want to live with 10,000 mice? Maud Slye's answer is terse: These 10,000 mice, and their 100 generations of 75,000 ancestors, offer man by their example a possible means of liberation from the most vicious of all modern scourges—cancer.

Its cause unknown, its cure undiscovered, cancer, claiming the lives of 100,000 men and women each year in the United States alone, has increased at a tremendous rate, in the face of medicine's success against almost all other major diseases. All that anyone seems to know of cancer is that it enters man's body starkly and boldly, and leads him to agonizing death.

Miss Slye's twenty years of study of a city of mice—a city of heterogeneous mice, some healthy, some ailing, all living and dying much in the manner of generations and cities of men—have made three vital contributions to the war against cancer. They are: (1) Susceptibility to cancer is definitely inherited; (2) Cancer is not a germ disease; (3) Cancer can be bred out of, or eliminated from, the human race in two generations.

This remarkable woman has never bothered to write a thesis for a Ph.D. degree, nor to stand examination for the M.D.

So she is not "Dr." Slye. But she is a professor at the University of Chicago, and has lived there all these years in the midst of her city of mice.

Her laboratory is not one of those stately buildings that suffuse the campus with their Gothic beauty. It is an abandoned two-story flat building on the edge of the quadrangles, unobserved by the visitors who explore the more inspiring halls of knowledge and research. To be sure, passers-by are sometimes attracted by the sign "Otho S. A. Sprague Memorial Institute Laboratory" and by the decrepitude of the structure itself. But if they approach closely enough their curiosity is apt to be dissipated by the noticeable stench that hovers about the place, and they go their way.

Inside, the woman whose first childhood pets were a pair of white mice is at work among her cages full of carefully registered rodents. The ten thousand have sprung from twenty original specimens that Miss Slye collected in her girlhood days at the university. The family tree of each one of them is recorded, with all the characteristics that have appeared in its ancestry for twenty years.

Mice are mammals, and their disease problems closely approximate human disease problems. What is more important is that their cancers are almost identical with those of man, in type, in the organs involved, and in clinical behavior and development. And it fortunately happens that since the average life of a mouse is only some six months, countless generations of them can be studied during the lifetime of one worker. These are the reasons why Miss Slye chose to work with mice.

The rodents that are making this great page in medical history have not been selected because of their ailments or susceptibility to disease; nor are they a collection of extraordinarily healthy animals. They are, as far as their physical condition goes, just individuals representing a cross-section of the world of mice.

In all the cases of cancerous specimens studied by Miss Slye—and there have been more than 5,000—cancer has never been induced by artificial means. The cases that occur among the inmates of her laboratory are spontaneous, arising in the natural life of the animals, just as man's cancers arise. Thus the problem presented in the growth of cancer among mice involves exactly the same factors that exist in human cancer.

Cancer is a malignant and generally fatal abnormal growth of tissue, in which metabolism—the development and multiplication of cells—goes on at an amazingly rapid rate. It has been possible sometimes to retard the growth, but attempts to cure it completely have resulted in failure. It is a horrifying fact that *incurable* is a dictionary synonym of *cancerous.*

The basic result of this unique "mouse lady's" efforts embodies the principle that susceptibility or predisposition to cancer, and immunity or exemption from cancer, are hereditary, in accordance with the Mendelian law of inherited characteristics. Miss Slye has not found the disease itself to be either hereditary or contagious.

Heredity, a phenomenon that we all endorse with the exclamation "Blood will tell!", is one of the most basic of all biological facts playing a rôle in the process of evolution.

Gregor Mendel formulated the laws of the action of inherited characteristics. In 1865 he hybridized, or "mixed," a number of varieties of cultivated peas and presented an analysis of his results before an obscure local scientific society in Austria, his native country. His work was lost for many years, unfortunately, and the rediscovery, in 1900, of his epochal dissertation marked the beginning of scientific genetics. Subsequent application of his theory to lower animals and humans indicated that the rules of heredity hold throughout the plant and animal kingdoms.

The Mendelian theory, pruned of all its technical trimmings, asserts that when two organisms, differing in a single unit character, mate, their offspring will show one character expression to the total exclusion of the other.

Thus, a pure black guinea pig, when mated with a pure white guinea pig, will have none but black offspring. The character difference which appears in this first generation of offspring is known as the dominant. The character which fails to appear is termed the recessive. If the first generation of black hybrids is interbred, lo! the white, or recessive, appears in the next generation, in the definite ratio of three blacks to one white. Thus, in the third generation, we have three dominants to one recessive.

Now, when the recessives, or white guinea pigs, of this third generation are interbred, they produce nothing but white, or recessive, offspring, while the interbreeding of the dominants of the third generation gives mixed results. One out of three of these dominants, or blacks, will, when crossed with a white, give all black offspring; the other two, when crossed with a white, produce half black and half white offspring.

In harmony with this law, Miss Slye found that inheritable exemption from cancer was a dominant characteristic, while susceptibility was a recessive. In her own words:

"If a non-cancerous mouse is mated with a cancerous one, no susceptibility to cancer is found in the first generation of offspring. Then mate two of these hybrid cancer-resistant mice; what do you get? In this second generation of offspring the recessive appears—one-fourth of the mice are susceptible to cancer. One-fourth of the brood are cancer-resistant, and one-half are animals which are resistant to cancer themselves, but which can transmit the disease.

"Although a mouse—or a human being, for that matter—may inherit the tendency to have cancer, the disease probably will not appear except under favorable (favorable to the development of the disease, that is) conditions. The fact that the tendency is inherited doesn't mean that the individual in question will inevitably be afflicted by cancer. These so-called 'favorable' conditions consist of chronic irritations, such as non-healing wounds or sores, the presence of bacteria causing wounds that do not heal, or continued chronic pressure—such as from a broken or malplaced tooth in a jaw.

"But the tendency not to have cancer is also hereditable, and by proper selection of parent animals it is possible to eliminate cancer entirely. Experimental work with mice has proved it to be a fact, and the same principles that apply to mice apply to human beings. I have worked with cancer of the breast, spine, lung, kidney, tongue, mouth, stomach, and all the other common types of the disease that are prevalent in the human race.

"It has proved possible to eliminate this scourge from families of mice originally 100 per cent cancerous. By mating these first generation hybrids that do not have cancer themselves, but one of whose ancestral families was 100 per cent cancerous, with cancer-free mice, I have been able to rule out all susceptibility in the family for many generations. I have bred twenty-five generations of these cancer-free hybrids who are descended from a 100 per cent cancerous family, and the disease has never appeared. But as soon as one of these hybrids is mixed with another of the same type, instead of with a cancer-free mouse, the disease appears.

"Translated into terms of human experience, this means that if the findings in regard to the heredity of malignant diseases in mice should prove to hold for man (and every biological fact at our disposal indicates that they do), cancer, the disease that accounts for at least 10 per cent of the deaths of persons who have lived to the 'cancer age' of fifty, can be eliminated from the human stock by two generations of genetic mating.

"Many persons, at first thought, are doubtless alarmed at the statement that cancer is hereditable. But instead of being alarming, the fact that cancer is hereditable should be extremely gratifying. It means that the disease can be eliminated if the time ever comes when men and women are willing to subject their own temporal happiness to the eternal benefit of the race."

Her belief in the futility of the search for the "cancer germ" Miss Slye explains by the established fact that the growth of cancer in human beings, as well as in mice, makes no early changes in the afflicted individual's system.

"Often mice in my laboratory have cancers larger and heavier than the rest of their bodies without evidencing changes in their systems," the "mouse lady" tells us. "Only when the cancer breaks down from lack of blood supply and becomes infected from some outside source, or when it grows in a blood vessel and causes fatal hemorrhage, or fills some organ and disrupts its function—such as breathing or digestion—only then do the symptoms of systemic illness appear.

"No germ disease we know behaves this way. Germs cause early and widespread systemic reactions. In both the human and the lower animal, body cancer, as is well known, does not usually make itself apparent until it is in a rather advanced condition. I cannot believe that this would be the case if cancer is traceable to a specific germ."

Here, then, is Maud Slye's humanitarian contribution. Besides proving the vital facts as to the heredity of cancer itself and the transmission of susceptibility to and exemption from the disease, she has concluded that cancer-free persons who mate will have non-cancerous offspring. These results were obtained with unfailing effectiveness in her mice. They will be equally sure, it would seem, in human beings.

Miss Slye has shown how mankind can weed out cancer. No trumpets and brass bands announced her discovery, but it is none the less one of the most momentous in humankind's long struggle against disease.

CHAPTER IV

HUNGER—FOR FOOD AND FOR FACTS

FREDERICK HOELZEL'S appetite for hardware is neither a natural propensity nor an abnormal craving. It is a deliberate achievement whose purpose is the furtherance of knowledge. Mr. Hoelzel is a scientist, though he is not a professor and has no academic rating. Indeed, he never attended college. But he has devoted his life thus far to science so earnestly and fruitfully that the giants of science call him one of their own, and he works with them in a university laboratory.

Hoelzel's main interest is the study of physical subsistence. To the labyrinthine search for facts about hunger and thirst he has given his own body in experimentation. For a score of years he has been a laboratory specimen at a large institution of the Middle West, always available, eager for any test in which the advancement of science and the betterment of life are involved.

Do not imagine him to be a passive brute that may be led out of a cage, tested for reactions, and led back. Hoelzel is a strong, intelligent man. Having been associated with scientists since he reached maturity, he has imbibed a vast lore.

His dietary activities of the last three years are the result of his own desire to experiment in his chosen field, and to provide mankind with facts regarding the rate of passage of different substances through the human body.

Scientists have long known that such facts would be invaluable. But how could they be obtained? Experimentation with lower animals would be of small use, since the alimentary and digestive system of man differs from that of all other animals.

Hoelzel recognized the value to medicine and physiology of statistics bearing on the normal rate of progress made by material of different kinds through the esophagus, the stomach, and the intestines. Such knowledge would pave the way for a signal advance by science in its struggle with mankind's physical tribulations. It would mean a marked enhancement of man's meager understanding of diet. Hoelzel was distinctly interested.

A great university offered him a laboratory in which he might live as well as work, together with materials and equipment for his adventure.

Some of the different forms of diet that he has adopted for purposes of experimentation have been extraordinary. For more than a year he has eaten every day from ten to twenty-five pellets of metal—about five grams a day—and one hundred little strands of knotted thread or twine. He has charted the progress of these objects through his system, recording their positions inside his alimentary tract by means of elaborate

X-ray photographs. He has also used other "inert" material of varying weights, such as glass beads, steel, gold, and rubber, for comparative purposes.

No particle of these unique delicacies has ever disappeared to confuse his statistics and blur the accuracy and conclusiveness of his charts. As a general rule, glass makes the fastest time on its dark journey. Gold, heavier, sometimes requires as much as twenty-two days for completion of the route. The normal length of time consumed in the course of the alimentary tour is two days.

Of course Hoelzel has also eaten a healthy man's usual allowance of more digestible fare during this period. The test material is indissoluble. Therefore, it provides him with no nourishment whatever, but it preserves its identity during the whole course of the journey, and thus its movement can be studied.

One of the fundamental purposes of the experimentation is to determine the rate of speed at which material is carried through the body by different types of food, different comprehensive diets, and under varying conditions. While the results thus far are fragmentary, they indicate that under normal circumstances there is a distinct variation in the speed at which different materials are carried through the body, and that as a rule, substances move at a rate inversely proportional to their specific gravity—heavier stuff moving more slowly.

Hoelzel has never been troubled by indigestion, despite the general suspicion that green apples, pickles, and ice cream form a more sociable combination than glass beads and pieces of solid rubber.

"Except once or twice," he admits, "when I was foolish. Like the time I ate talcum powder. Or the time I ate sand. Or worse yet, the time I made a whole meal out of glass beads. Three hundred grams—over a thousand of them. I just moistened them, put a little salt on them, and ate them by the spoonful. I had an intestinal obstruction—they told me I was lucky to get out alive."

Hoelzel's most revolutionary undertaking is less spectacular than some of the others. He has fasted, of his own accord, more than five hundred days, at different times, including a forty-two day abstinence from food. This latter record sets a mark for scientific starvation. For one thousand and one hours in the summer of 1925 he existed on water alone.

He invented a non-nutritive flour, made principally of cellulose, that can be eaten by persons who for some reason or other must eschew their normal food to a certain extent. A meal of this kind gives the diner a "full" feeling, although it offers no nutrition at all. Its value to diabetic patients has provided Hoelzel with a steady income which has made him financially independent.

A curious boy was Frederick Hoelzel when he came to America from Germany. He was not strong, and he suffered from digestive difficulties. He attended a high school in Chicago; his graduation from this institution completed the only formal education he received.

Hoelzel's digestive troubles were not complicated, but they puzzled him deeply. While his companions simply cussed their "belly aches," Hoelzel was wondering what effect a changed diet might have on the situation. This was the beginning of his experimentation. Soon he had ventured into physiological research beyond the depth of simple dietary adjustment.

He obtained employment as a technician in the Anatomy Department of the University of Illinois, where he subjected himself to tests that were commonly given to lower animals.

His interest in the human "works" rose like a rocket. The phenomena of mechanical reaction in a highly emotional animal like man enthralled him. The predictability of lowered or increased energy and resistance under different conditions gave him as naïve delight as a youthful aviation enthusiast feels when a home-made plane makes a successful flight. His scope of experimentation broadened rapidly; the more severe the test, the more gratifying the successfully predicted results.

Anton Julius Carlson, a master physiologist, had just propounded a theory of hunger. The seat of hunger was then, as it is now, unknown. Carlson held that the sensation of hunger was specifically traceable to the automatic contraction of the walls of the empty stomach. As the stomach grew emptier, or continued empty, these contractions increased.

Hoelzel's self-experimentation led him to believe that hunger was due to a much more generalized condition than that of the stomach itself. He made bold to establish contact with Carlson and offer a contradictory theory. He believed that the condition of the cells or tissues of the principal food reserve depots, such as the liver and the blood, are the major factors in hunger, and that this gastric contraction is only one phase of the phenomenon.

Hoelzel volunteered to fast for an extended period in order to settle—so far as might be possible—the dispute. Carlson offered his coöperation, and the youth came to join him while carrying out the test.

He fasted for fifteen days. Tests were made each day on the subject, but the results were not conclusive. Measurements of stomachal contraction were taken with the assistance of a balloon. This was inflated in his stomach, causing expansion as food does. The sensation of hunger did decrease, and this tended to substantiate Carlson's theory. But as the experiment wore on, the contractions of the stomach diminished. So the problem has not yet been settled.

That experiment, however, started Hoelzel off on his extraordinary fasting marathons. On May 27, 1925, he undertook to outfast a man named Levanzin, who had pulled body and soul through a thirty-one day abstinence in the course of research carried on under the auspices of the Carnegie Institution.

Hoelzel had previously fasted for fifteen days on several occasions. He had found that the fast seemed to rejuvenate him, but that its magical results were short-lived; that soon after his return to normal life, when the immediate effects of the experiment had worn off, the level of his energy was reduced to below normal.

Hoelzel fasted thirty-three days in this record effort. His diary of those thirty-three days contains some pungent lines. It shows that he lived a normal life, reading, going to theaters, walking four or five miles a day, and studying.

In the beginning, the sensation of hunger did not trouble him a great deal; toward the end, food became the only real interest in life. By the seventh day, he had lost ten pounds; by the thirty-third, he had lost thirty. The sense of smell sharpened; odors, especially meat odors, became more attractive than anything else in life.

He broke his fast on the thirty-third day, with the juice of an orange, following it in half an hour with a whole orange, then one and a half pints of red raspberries with half a pint of cream. This was capped with three-quarters of a pound of porterhouse steak, fried.

Then what?

The man who had eaten nothing from May 27, to June 30, feasted ravenously for thirty-three days together. Thirty-four days after the first day of his feasting he began another fast.

This fast was epochal. It lasted nearly forty-two days—one thousand and one hours. The story of this second starvation almost duplicates the first. This time he attended fewer movies and vaudeville shows, and spent more time reading. His walking he maintained at the rate of four to six miles a day.

"Gradually," he says, "I got tired of reading stories and jokes, and near the end of the fast found myself turning mechanically to the recipe section or food advertisements of every magazine I picked up. I took my long walks, but they came to be miserably disappointing if I didn't come close enough to half a dozen restaurants to see the food in the windows and smell the frying. What did I do? Oh, nothing much. Gradually lost interest in things."

Hoelzel's weight dropped from 144 to 107 pounds during this second fast. He had lost thirty pounds as a result of the first. He gained six pounds after his first meal following the former fast, but he lost four pounds of this by the next morning. Between the fasts a typical feast included two pounds of meat or fish, one pint of cream, half a pound of butter, one and a half pounds of tomatoes or greens, two or three pounds of fruit, some sugar, chocolate, honey, and coffee. And this repast did not spoil his appetite. On the eighth day of scientific gorging he had regained twenty pounds, and when he got off to his second fast he weighed four pounds more than he had at the outset of the first.

Fasting, Hoelzel has decided, after a stomachful of it, is, generally speaking, futile. Its immediate results are exhilarating, but in the long run it gets one—as in a two-mile race around a quarter-mile track—just nowhere.

"I used to think fasting was a sort of cure-all," Hoelzel concludes. "But now I think its effects—its good effects—are temporary. It is obvious, although we overlook the fact in the hustle and bustle of the lay life, that a man in fasting becomes a cannibal. He consumes his own flesh. He lives on it.

"This tumultuous change from a food ration that contains vegetables and carbohydrates to one of meat alone momentarily energizes a person, but the eventuation of the whole business is a recession to the original state, and a tremendous depletion of energy has occurred in the meanwhile.

"Fasting to reduce establishes itself in this category of merry-go-round futility. The immediate results may be a kind of mental and physical exhilaration, an I-feel-twenty-years-younger sensation, and a modish emaciation accompanies the rewards. But the frame and the tissue will demand their pounds of flesh, and the tonnage will come back. When the exhilaration wears off, the decline to normality is attributed to a mistake in choice of diets. But I've tried them all—they're useless."

Whether or not the medical profession entirely agrees with Hoelzel's conclusions, he has made a valuable contribution to our knowledge in a little-understood field. He has earned a certain glory—whatever its worth may be. He has fasted to end fasting. He has taken his own body and given it to another quest for scientific knowledge. And, with a spoonful of glass beads (with a little salt), he toasts the health of the human race.

CHAPTER V

THE ART OF DOING NOTHING

DOING nothing," as the physiologist understands the phrase, involves the expenditure of the smallest amount of energy necessary for the sustenance of life. This means the complete relaxation of all muscles that are not integral with the basic functions that cleanse the blood and send it through the body, together with those more or less self-actuating functions essential to the living state.

Man is the slave of habits and emotions that have been accumulating through the ages. He no longer knows how to relax completely, even if such knowledge were once his. Left to his own devices, the modern man no longer understands how, by relaxation, to conserve his energy, to induce sleep, and to rejuvenate his nervous system. But science, in answer to man's unvoiced plea for guidance in the dark, is beginning to teach him the technique of complete relaxation.

Fired by the belief that such relaxation may prove to be the basis of important medical treatment, Dr. Edmund Jacobson, who was trained at Harvard and Rush Medical College, has tackled this problem. His investigations have already shown that relaxation not only facilitates the cure of nervous diseases, but also raises the "body tone"—the vigor and zest with which the healthy man is equipped to face the day's work. In addition, relaxation has been shown to play an important part in the reduction of actual pain.

Dr. Jacobson's patient lies on his back in a fairly quiet room and is taught how to relax, one by one, the various muscle-groups of his body. After a reasonable time, the patient acquires the technique of relaxing them all simultaneously.

The simplest method of training a person to relax is to have him flex one arm against resistance offered by the experimenter, while the subject notes the sensation of tenseness in his flexor muscles. By such a simple exercise, he becomes familiar with the experience of tenseness, and learns to recognize it and localize it when it appears anywhere in his body. He also makes a discovery that is fairly obvious—that relaxation is the negative of holding tense, and can be successfully effected only when effort is completely avoided.

This whole procedure sounds as easy as walking downstairs. But it requires training, none the less. Complete relaxation of a muscle-group, even by one who has had some practice in the art, does not occur instantly upon application of the intention to relax. Dr. Jacobson finds that it may require fifteen minutes, or even longer, for consummation. Daily practice periods of about an hour are recommended for mastery of the art of doing nothing.

In the treatment of certain disorders, Dr. Jacobson finds that the patient's training is but half completed when he has learned to relax lying down. His higher education involves the achievement of perfect muscular limpness in the sitting posture. And finally the patient is trained in relaxation while engaged in such activities as reading and writing.

Under the latter conditions, it is patent that relaxation cannot be complete. For the hands must continue to hold the book or move the pen, the eyes must follow the words, and the back must maintain a certain erectness. But while certain muscles must be somewhat tense during these activities, it is still possible to avoid a superfluous amount of tension in them. And at the same time it is possible to relax such other muscles as are not indispensable to the prosecution of the activities in question. In this way an economy of nervous or muscular energy can be achieved; and this is of considerable importance in alleviating disability and fatigue as well as nervous irritability and excitement.

A few years ago tests were made by Dr. Jacobson with a sudden and painful electric shock applied to the finger-tips of the subject. The natural reaction to this, of course, is to withdraw the hand hastily. Every subject withdrew his hand sharply when lying on a couch in the state that is ordinarily termed relaxation. But during the perfect relaxation induced by the method of training described, the haste of withdrawal was greatly diminished, while the sense of pain and unpleasant shock was often altogether absent.

In a series of tests Dr. Jacobson found that one subject who was most proficient in relaxation failed to show any movement of withdrawal of the hand in 96 per cent of the instances of electric shock. It seemed to this subject incredible that the electric current producing such slight stimulation was not weaker than the one which had produced pain.

These responses lend confirmation to the theory that even pain may be much mitigated by this simple therapy.

When the normal individual lies down to sleep, his muscles automatically relax to a certain extent, as if he had unloosed his grip on the taut reins of many horses. The gross tensions of the external muscles are likely to subside within a few minutes. More gradually the finer tensions of eyes, speech-organs, and other muscle-groups engaged in activities of thinking and emotion, attain to a similar limp composure. Sleep sets in only when a certain stage of relaxation is reached, depending no doubt largely upon the amount of fatigue substances in the blood and tissues.

But if the individual has been unduly tense during the day, the degree of relaxation necessary for sleep may fail to appear. Then he is likely to toss about, while his mind remains active far into the night. And since the nervous system is delicately susceptible to habit, and inclines to repeat a process that has occurred once or twice, the condition of insomnia tends to recur. For the treatment of this condition, the cultivation of muscular repose has been found most effective.

Can a man think when he is scientifically relaxed? Dr. Jacobson believes not. His subjects report a gradual fading of mental images as relaxation proceeds.

In order to eliminate the chance of human error in this problem the physiologist constructed what is probably the most sensitive instrument for detecting the natural electrical currents of the body that has ever been made.

He sank electrodes into the right biceps of a completely relaxed subject. At a predetermined signal the subject imagined himself throwing a baseball twice. No movement of the arm was visible to the investigator's eye, but the delicate instrument recorded the fact that at the moment the signal was given two "action currents"—not more than a few millionths of a volt each —surged in succession through the biceps.

With the electrodes attached to the organs of speech the instrument discovered specific but almost infinitesimal muscle tensions when the subject was thinking in terms of words. With the electrodes fitted over the eyes there was recorded delicate tension in the eye muscles when the subject summoned up a mental picture.

"We think through our muscles," says Dr. Jacobson.

Dr. Jacobson's research extends also to the emotions and their control. He is convinced that the emotions may be controlled by the application of the same principles that govern muscular relaxation. Two psychologists of the nineteenth century asserted that muscular reaction is the handmaiden of emotional reaction; that whenever the latter occurs, the former will be manifest in some form or other. Experimentation by Dr. Jacobson in his correlative study of the two phenomena has attested the truth of this hypothesis.

An important discovery by science is that lying physically still in bed is not necessarily resting. Just as obscure muscle-groups may remain tense or flutter during apparent composure and even during sleep, so may the emotions be reducing an individual's energy in the very moments when he believes that "resting" is reviving his storehouse of power.

In one interesting experiment, Dr. Jacobson examined in detail the effects of emotional stimulations on the human esophagus—the muscular tube which carries food from the mouth to the stomach.

Tenseness of the muscles in the esophagus, as in other organs, causes the phenomena known as "spasms." Such tenseness is often seriously detrimental to health and sometimes fatal, particularly in nervous or emotional individuals.

In his effort to learn whether control of the emotions can allay these spasms of the esophagus, Dr. Jacobson had his subject swallow a small rubber balloon, attached to a rubber tube which protruded from the mouth and ended in an instrument that produced a record of any change in the amount of air in the balloon. When lowered to a point midway in the esophagus, this balloon was slightly inflated. As the esophagus contracted with muscular tension, the balloon was compressed and air forced from the tube, making it possible to obtain a measure of the contractions and relaxations of the organ.

Dr. Jacobson found that the esophagus responded by contraction—a minor spasm—at the moment of slightest emotion. But when the subject was really frightened, the contraction was violent. During a protracted period of mild fear, the esophagus remained persistently tense along its entire course. Some of its contractions were much more delicate, although definitely noticeable; as, for example, when chimes in a tower a block away began to ring. A fly alighting on the nose of the subject, the whistling of a passer-by—both induced contraction. Even when the subject began to think about anything in particular, the esophagus contracted.

In these experiments Dr. Jacobson has made a contribution to the relief of human ailments and the alleviation of pain. He has opened up paths of further fruitful investigation in many directions.

The art of relaxation had become almost a lost art among us. Its cultivation in this restless age will go a long way toward eliminating many of our personal and social ills.

PART V

Families of Wheat and Men

CHAPTER I

IS THE FAMILY DOOMED?

THE young science of sociology has stumbled upon a disturbing revelation—the decline of the family.

We, who for centuries have regarded the family as the impregnable basis of human relationships, find it difficult to withdraw to a distance furnishing a perspective that enables us to study the family objectively. It is not easy to dissociate the scientific data of the family from the aura of sentiment and affection that the word itself implies.

But the sociologist has done just that: he has collected his data in a dispassionate manner and has analyzed its significance in the light of the present resources of his science.

The scope of sociology—the infant prodigy of the major sciences—is limited to a mere forty years of experience. Few of its investigations have borne as yet their expected fruit; few of its guarded predictions have had an opportunity to crystallize into actualities. Consequently, the sociologist—it is Professor William F. Ogburn, of the University of Chicago, in this instance—is hesitant to prophesy the ultimate results of the processes he now sees going on in society.

Professor Ogburn knows, as the facts that he has gathered are convincing evidence, that the family has lost an enormous percentage of its functional importance since the turn of the century. But he does not presume to forecast the extinction of that venerable institution, nor does he predict that the alarming rate at which the decline has gone on in the last fifty years will continue, nor that a reaction will set in and restore the fireside to the dominance it once enjoyed. What he is interested in are the revelations, themselves, of existing conditions.

Professor Ogburn, in a nation-wide survey of the functions that are generally attributed to the American family, finds that the institution, judged by its past record, has had seven active phases. They are: (1) affectional, (2) economic, (3) educational, (4) protective, (5) recreational, (6) family status, (7) religious.

It is commonly assumed, without much definite confirmation by data, that some of these functions have declined in scope and significance as activities of the family. What has been the rate and extent of this decline? Is it still going on? Does it provide any immediate or particular menace to the institution of family life?

Dr. Ogburn's investigation, dealing as it does with the common realities and values of modern life, presents the situation, as it affects the family, concretely and comprehensively.

To what extent, he asks, has the decline of the economic function of the family affected it? The statistics of some of the industries that compete with the handiwork of the home tell the story.

The output of bakeries in the United States increased 60 per cent from 1914 to 1925, while the population of the country increased less than 15 per cent. Obviously, the bakery is taking over the work of the family kitchen.

And we are learning to live out of the tin can and the preserving jar. During this same period the number of persons engaged in canning and preserving fruits and vegetables outside of the home—in food-product factories—increased 37 per cent, and the production of these factories increased 100 per cent, as compared with about a 15 per cent increase in the number of families.

And what is happening around the family kitchen and dinner table? While the number of domestic servants, of whom cooks and butlers are an important division, failed to keep pace with the increase in population from 1900 to 1920, the number of waiters and waitresses in restaurants has increased four times as fast as the population during that period.

In the same time restaurant keepers have increased 158 per cent and the urban population only 46 per cent. And the number of delicatessen dealers in the United States, in the ten years preceding 1920, multiplied three times as fast as the population.

But other economic functions beside the preparation of food are being shifted to outside agencies. For instance, the number of launderers and laundresses employed privately decreased by one-quarter, while the work handled by public laundries was augmented 57 per cent from 1914 to 1925.

Despite the unparalleled growth of wealth since 1900, reflected in larger numbers of well-to-do families and high wages in general, the number of domestic servants of all kinds decreased 15 per cent in twenty years, while the number of families expanded about 30 per cent.

Does this fact suggest that women have increasingly and more effectively taken their traditional place in the home? Just the opposite seems to be true. One out of every eleven married women in the United States was working for pay outside of the home in 1920—an increase of 100 per cent over the figures for thirty years before.

Do these various statistics imply any serious deterioration in the integrity of the family? Does it really matter where the cooking and laundering are done? The layman may say, "By no means; these functions are all extrinsic to the fundamental duties and pleasures of the home. How can they injuriously affect the rearing of children—the family's primary obligation?"

But the sociologist presents still hardier food for reflection. If the problems of food and laundry are inconsequential—if it is the educational and moral upbringing of the young wherein the home functions most vitally—Professor Ogburn asks us to consider the decline of this function through the increase in numbers and duties of those "substitute parents"—the teachers—into whose hands the training of children is being transferred increasingly every year.

Since 1870, parents have tripled in number, but teachers have increased sixfold. Teachers are taking children away from their parents for longer periods of time—78 days of the year in 1870, on the average, but 136 days in 1926. And they are taking them at tenderer ages; one in six children now goes to school between the ages of five and six. These figures point unmistakably to a trend involving a decline of the family bond.

The protection of the family by its members, particularly by the husband and father, and by the adults of the younger members, is a function long recognized as native to the institution. Is this function also declining? Certainly it has been more and more shifted to the State in recent years.

In 1920 there was one policeman, constable, sheriff, or detective for every 220 families in the United States, as compared with one for every 240 families ten years earlier. The total number of protectors furnished by the State—including soldiers, firemen, and inspectors—increased 70 per cent from 1910 to 1920.

The development of the juvenile court, compulsory education laws, and child labor legislation, further indicate the trend toward a greater child-protective function on the part of the State and a diminution of the parents' responsibilities. This seems to Professor Ogburn to be an inescapable result of the increasing complexity of the modern urban environment.

Another new adjustment of the protective function is demonstrated in the growth of insurance. In 1926 the amount of insurance in force, of all kinds, was thirty times as great as it was in 1870.

Formerly, grown-up children and adult relatives were a sort of insurance for old people and for the widow with children. But now there are fewer children, and they tend to scatter to the ends of the earth. This scattering of the members of the family, stimulated by the vast network of modern industry and transportation, is making a person more an individual and less a member of a family.

With the decline in the functions of housekeeper and provider, the contracting of marriage is becoming more and more widely a matter of love rather than of economic considerations; hence the important factor of family status is losing its hold.

Many of the parents and all of the grandparents of the present generation remember when the family home was the center of recreation for the group. The members of the family participated in informal entertainment in front of the fireplace.

At the present time, 20,000 moving picture houses in the United States draw an average weekly attendance of 5,000 each. This means that 100,000,000 persons—five-sixths of the population of the United States—attend the "movies" each week. (Of course, the figures include many "repeaters.")

Today, 12,000,000 persons attend major league baseball games each year, while football attracts 25,000,000 spectators. Tennis has a following of 1,000,000, and golf is participated in by 4,000,000.

Where formerly there were individual yards surrounding each home in which children might play, the emphasis now is on public recreation grounds. The parks and playgrounds in 127 cities of the United States multiplied eight times between 1880 and 1926.

"The changes in the type of our dwellings are perhaps indicative as a sort of total summary of what is happening to our family life," Professor Ogburn goes on to point out. "For we are living more and more in apartments. For instance, in 1928, from the records of building permits issued in the United States we learn that two-thirds of the families who will be occupying these homes are to live in apartments or flats, while only one-third are to live in single apartment houses. These apartments or flats in multi-family dwellings are small, with small rooms and diminutive kitchens, and without yards or outdoor play space."

Does this radical change imply decadence or moral decay? The sociologist does not think so. He believes that the family, although it obviously plays a much less important rôle in society than it formerly did, may be just as vigorous, just as sound in its reduced size and in the more limited spheres in which it functions.

Is the individual any worse off because of the decline of the functions of the family? Not essentially. The functions have not disappeared; they simply are handled to better advantage by other agencies.

Again, is the growth of divorce an indication of a serious weakening of the spirit of affection that ought to rule in the family? Probably not. There has been, it is reasonable to suppose, just as much unhappiness and incompatibility in the domestic circle during other eras as there is now; but it was borne in silence, largely because of the economic dependence of women in former times. With the removal of that handicap, marital discord seeks a remedy in the divorce courts.

Of all the family functions, that of affection is least easily reduced to statistics. Here each individual must be his own sociologist. Professor Ogburn believes that the love that makes mortals forget that the world goes 'round may surpass in its bountiful values all the other functions of the family and palliate whatever ills these functions fall heir to. If this is in truth the perdurable state of nature, the family will survive the assaults of twentieth century civilization and the pessimists' bleat of "What are we *coming* to?" can be changed to one of "When are we coming *to?*"

CHAPTER II

DISH-WASHING AS A FINE ART

THE evening meal has been finished. The feminine head of the family taps on the table with a spoon and tries to catch the eyes of first one and then another of the group, with a glance that is at once plaintive and appealing. But the family is vegetating in the pleasant limbo of languidness that brings up the rear of a palatable dinner.

It is a moment when their vigor is at a low ebb. It is a moment when the hand that rocks the cradle fails to rule even a segment of the world. The masculine head of the family is preoccupied with an after-dinner cigar. The son and the daughter are nonchalantly conversing about matters far removed from dirty dishes.

But the dishes, as the inevitable aftermath of every meal in every home has verified, will not "do" themselves. The mother realizes it, with a sigh. Must it be forever woman's lot to waste hours daily bending over the insatiable sink? Why cannot the dishes be removed from the table, carried to the kitchen, scraped, washed, dried, and consigned to their various shelves in a fraction of the time and motion usually spent upon them? Science says they can.

Miss Nellie Vedder has come to the weary housewife's rescue. She undertook the repetition of the dish-washing process every day for six months as part of an original investigation. Her findings formed the basis of a thesis for the Master of Arts degree at the University of Chicago.

Carefully reproducing in the university's home economics laboratory the conditions of a normal home of four persons, Miss Vedder went to work. She evolved three methods of dish-washing, the most leisurely of which requires 38 minutes and 8 seconds, with 1,954 motions; one woman doing all the work, from clearing the table to storing the dishes. By the use of the most rapid method, the process can be completed in 22 minutes and 31 seconds, with 1,015 motions.

The other members of Miss Vedder's theoretical family watch the panorama of an evening's dish-washing spread before their interested eyes by an efficient scientist who has decided to hear the after-dinner radio program in the living-room instead of from the pantry.

To begin with, a tea tray has been wheeled near the table, ready for action. As soon as the meal is ended, the dishes are passed to the scientific mother, who, with a few swift motions, scrapes them off as she stacks them on the tea tray. Then she deftly wheels the tea tray into the kitchen, where the dishes are subjected to a rapid cold rinse, after which they are washed in as hot water as the tap affords.

The heat of this water should be at least 120 degrees, Fahrenheit. Soap flakes, rather than bar soap, are recommended.

The dishes are next placed in a round-type wire drainer, and boiling water from a tea kettle is poured over them for steam drying. Miss Vedder found that this natural method of drying is 100 per cent faster and more sanitary than the use of towels.

If the tap water is at 160 degrees, it is unnecessary to heat water for drying purposes, and an ordinary sink-spray can be used.

The handiworker will, it is assumed, have her materials immediately accessible; and, if she is right-handed, will adopt a rhythmical left-to-right method, with work-table on the left and shelves on the right of the sink.

For the family that is so situated as to afford three sets of dishes—including cutlery and cooking ware—the custom of cleansing the whole day's dishes at one sitting, or standing, is urged by the scientist. More than 500 motions and six minutes may thus be cut from the running-time of the three-way operation.

The labor-saving advantages of a single preparation of materials, and the uninterrupted rhythm of the operator, account for the greater efficiency of this method. For aesthetic reasons, the collection of soiled dishes may be stored away in oven, cupboard, or handy shelf, out of sight until ready for the cleansing process.

Although no comparative study of costs was made in the course of the experiments, Miss Vedder suggests the installation of a moderate-priced, plumbed-in type of dish-rinsing machine. The record time of 22 minutes and 31 seconds was established with the assistance of this device.

No subject is too humble to command the respectful attention of science. Through her experiments with the prosaic task of dish-washing, Miss Vedder has pushed along a step further the emancipation of woman from the burden of age-old drudgery.

CHAPTER III

DISEASE-PROOF WHEAT

VAST fields of wheat stretch away to the horizon—bearing the promise of a glorious harvest. An indefatigable parasite, invisible as the wind that flings it abroad, invades these smiling fields. Thousands of acres, millions of dollars, are lost.

Just as the place of origin of wheat is unknown, so is the birthplace of its deadliest enemy. All that is known is this: where wheat is, there also is the killer—wheat rust.

Wheat is the most important food of temperate climates, and next to rice the most widely used of all grains. The health of wheat is too vital to have escaped the attention of science. For a century the farmer and the scientist battled the insidious enemy, but for many years the foeman appeared to be insuperable.

Man had waged a losing war—not toe-to-toe with his fellow man as the enemy, but against a tiny fungus, a shriveled, spongy dwarf of a degenerate race of plants. And man was about ready to admit defeat. Even scientists were nonplused. The wheat rust's infinitesimal tentacles were countless, and they encircled the earth. The farmer, the merchant, the consumer, would all apparently have to continue paying the bills of the wheat's unwelcome guest.

To be sure, if the wheat could manage to exist, after a fashion, the public purse could somehow bear the burden. But if the rust increased in virulence, it might devastate the granaries of the world, with a panic as the inevitable result. In 1891, Prussia alone had begged off the demon with $100,000,000 as a temporary sop. Five or ten years like 1891 would be disastrous—and who knew when the blow might fall?

In 1928 there came an unpretentious announcement from Minnesota, whose golden fields yielded the world's finest grains: Rust had been conquered. "Humph!" murmured the doubters; the grip of the rust seemed unshakable. But the word had come from the University of Minnesota's experimental farm, respected for its contributions to agriculture.

Where was the evidence that the enemy had been laid low? It was not in the form of the dead bodies of the last of the wheat rust fungi; it was in the form of a new kind of wheat, the product of twelve years of forced evolution.

It happens that plants are especially tractable to evolutionary promptings, a fact demonstrated many years ago by Luther Burbank. Hybridization of plants has stocked the earth with hundreds of succulent fruits and vegetables of new varieties, and garnished its gardens with gorgeous flowers which nature, unaided, might not have produced for aeons. This process was to furnish the effective weapon for the battle against wheat rust.

The announcement from Minnesota gratified scientists, but it did not startle them; for they were familiar with the past accomplishments of Professor Herbert K. Hayes, expert in plant genetics, and of his associates at the institution's Agricultural Experiment Station.

Since 1900, Minnesota's crop of spring wheat had risen from 50,000,000 to 80,000,000 bushels a year, and then had dropped to a low of 21,000,000 in 1927. Diversification and the transfer of thousands of acres from spring wheat to other grains and grasses in the interests of dairying were partly responsible for the drastic fall in wheat production, but the dominant factor was wheat rust.

It was known that the barberry bush acted as host in one part of the life-cycle of the wheat rust. At first an effort was made to get rid of the barberry. But the rust learned to live without it. Moreover, the berries of the bush were useful in medicine. Clearly, the salvation of wheat could not be found in a hopeless direct struggle with rust.

Why not, then, quit fighting rust itself, and produce a wheat that would do the fighting on its own account? If the enemy found itself confronted with a triple-armored wheat, would it not be compelled to call quits and retire from the field?

The idea was excellent, but how could it be realized? Two of the vital factors involved in the problem were clothed in mystery. Science did not fully understand the process by which plants get their food, and the nature of the deadly power of rust was obscure.

There was only one course open—to go at the task pragmatically. Science would ask no questions, but simply select the types of wheat that for some unknown reason most effectively resisted rust, mate these types for several generations, selecting and interbreeding the most rugged offspring in each family, and thus produce a wheat hardy enough to ward off the venomous parasite.

Fungi are types of plants generally characterized by the inability to manufacture their own food. They must, therefore, obtain their sustenance from organic matter. Many are parasitic on other living plants; others live on decaying vegetation.

To the class of fungi belong molds, mildew, smut, mushrooms, toadstools, puffballs, and rust. Some of them are neither nuisances nor poisons, while others are both. But most pernicious of the fungi tribe is this rust that saps the life of growing wheat.

Some of the early stages of its life-cycle are spent on the barberry bush, which acts as both host and nursery. The rust organism produces spores—a type of reproductive or germ cell—and these spores are sometimes carried off by insects but are generally dispersed by the wind. Drifting through the air, they while away their brief childhood until, when they find a haven in the leaves of the ripening wheat, they have attained their deadly maturity.

How does this tiny murderer do its work? Not in the manner of the crude assassin (though it actually kills some of the plant's cells) but by means of the subtler strategy of starvation.

Plants get their nourishment from three sources—the sun, the earth, and the air. The sunlight falling on its leaves unites the water taken from the earth with the carbon dioxide inhaled into the plant's pores from the air. Thus the substances that we call carbohydrates—the plant's food—are produced. The process is called photosynthesis.

Precisely what happens when the sunlight falls on the plant's leaves botanists and organic chemists do not know, though they know the result. If ever they learn how this magic process works they may be able to reproduce it in laboratories. Then plants would no longer be necessary, since the food products we obtain from them could be manufactured by artificial means!

Decades of research have revealed one significant fact about photosynthesis: it cannot take place unless a green-tinted stuff known as chlorophyll is present in the leaves. Fungi have no chlorophyll; thus photosynthesis—the direct manufacture of food—is impossible for them. So they attach themselves to living hosts, which, unable to repulse them, pay with their lives for their unwilling charity.

The wheat rust infects the leaves of the blooming grain, bores into the tissue, and in some manner destroys the vitality of the leaves, so that white spots appear on their surface. These barren spots reduce the amount of surface of the living leaf that is exposed to the sun; consequently, photosynthesis is retarded, and the ailing stalk finds itself starving.

In cases of extremely virulent infection, the plant is stunted or killed. The presence of rust invariably means that the grain will be decimated. What fruit the diseased stalk succeeds in producing is shriveled and deprived of most of its food value for man.

The Minnesota scientists bent themselves to the tedious, fumbling task of breeding a rust-resistant type of wheat. The project meant vigilantly watching, for years, thousands of stalks of mated wheat. A generation of wheat requires a season in which to mature, and the trial specimens could be interbred only once in a generation. Then there were statistics to be compiled—volumes upon volumes of unerring data, the life history of each specimen, the faults and advantages of each "cross."

Professor Hayes and his company of experimenters prepared their subjects for the test by planting the seeds of a stalk of wheat that had fared inordinately well in a field otherwise badly infested by rust. The fruit of these seeds was crossed with other desirable specimens.

From the University's Division of Plant Pathology, where the lame, the halt, and the blind among plants are studied and treated, a hatful of thriving, malignant rust spores were procured—the most virulent obtainable. Then the row of vigorous wheat—the progeny of the "cross"—was deliberately infected. The results were watched intently.

When, at the end of the season, the crop was harvested, those plants that had weathered the barrage of infection with no damage, or with comparatively little, were again interbred. As this eugenic mating was repeated, year after year, with the healthiest stalks of each generation chosen to carry on the strain, a highly rust-resistant wheat slowly emerged. In these particular generations, all other qualities were disregarded.

Then this rust-resistant variety—possibly quite undesirable in other respects—was crossed with the best available wheat, measured by crop characteristics and milling qualities. Such matters as stem stiffness, average yield, ease of harvesting and handling, entered into the category of "general desirability."

Under the Mendelian law of heredity (which was originally based on plant life but obtains in both the plant and animal kingdoms with equal predictability) the progeny of the first cross was all uniform. But in the second generation there occurred a recombination of the characters of the two parent plants, by which certain of the offspring combined the best features of each, the most desirable qualities of the two progenitors.

About 1,000 of these choice products of the second generation were designated as the parents of the third—but not until the entire second generation group had been exposed to a severe infection of the rust fungus. Again it was largely on the basis of rust resistance, in this secondary cycle, that the selected specimens were chosen; so that, while the essential qualities of fine wheat were being perpetuated from generation to generation, it was this heroic, elusive rust-resistance that was being ingrained in the developing new strain.

From the second through the fifth generation there were again selected the thousand stalks in each season that had best withstood the severe ordeal. At last the gulf had been bridged; all the attendant qualities of healthy, vibrant, life-giving cereal had been infused into the new stock.

But the job was not yet done. Here were a lot of individual stalks of wheat, all of them—the cream of the fifth generation—endowed with quintessential features of the perfect, or near-perfect, grain. Each was a thoroughbred, each an aristocrat. But where was the new variety—the new single, specific variety? That had yet to be engendered. In the sixth generation, then, began the final separation of the peerless wheat—the incomparable new variety.

Before the chosen stalks were admitted to parenthood for the sixth generation, they were subjected to the most fiery test of all—the disease garden. In this testing-ground the plants proved their relative mettle in resisting all the other malignant enemies of wheat besides rust. Samples of the harvested grain were put through a milling and baking trial. For five more years the aspiring candidates were made to jump through the hoop, so to speak, the hoop being raised higher each time.

In the sixth generation, the scientists had planted 200 strains of wheat; by the twelfth, the candidate strains were reduced to forty. Then came the climax of years of profound, unrelenting research and experiment: one of these forty strains was to be selected for distribution to Minnesota farms, whence it would, if the hopes placed in it were realized, spread east and west across the plains of the United States, north to Canada, over the seas to South America, to Australia, and around the world.

From the University experimental farm and its three substations there were assembled thirty men. They constituted the jury—botanists, organic chemists, plant pathologists, agricultural experts, scientific wheat growers. They examined the forty specimens, heard the case of each one, its history, its merits. The forty grains represented the cream of forty noble families, refined through twelve generations of eugenic mating.

The jury deliberated. The jury voted. A new wheat, the Supreme Marquis, as it was called, stepped out and was presented to the world. It made good. And from its descendants still finer strains have been and are being bred by science.

PART VI

TOWARD UNDERSTANDING THE HUMAN MACHINE

Chapter I

TRANSPLANTING EYES

WHAT is responsible for the strange ability of certain fishes and amphibians to camouflage themselves by changing color? What takes place in the process? Most men are content to look at these phenomena admiringly, without feeling any great urge pounding in their breasts to understand the causes.

In 1920 a young Austrian, Theodore Koppanyi—now a professor at Georgetown University—found himself fascinated by the problem and was thereby led into a field that had been practically forgotten since a time long before, when certain scientists had dabbled there unsuccessfully. This field was the transplantation of the eye.

In his early physiological work, before winning the Ph.D. at the University of Vienna in 1923, Koppanyi devoted much of his time to a remarkable species of fish which turned dark when placed in a dark dish and pale when removed to a light one. The process was sometimes slow, the scientist observed, and sometimes astonishingly rapid, according to which type of the species was used.

After some preliminary experimentation, he found that if he removed the eyes of the fish, or covered them with black cloth, the creature ceased to show an active adaptation to the color of the environment and assumed a uniformly dark—almost black—color which did not react to external stimuli.

How were the eyes involved in this phenomenon? Koppanyi asked himself. To solve the problem, he decided to experiment with transplantation. Scientists had often attempted the transplantation of bodily organs, but with disappointing results. Not only did Koppanyi choose this difficult method but he selected for his work one of the most delicate organs in the body.

Simple transplantation of skin had long been a familiar operation. Today, the grafting of skin, of tissue-investing bone, and of fatty tissues, is a common medical procedure.

But transplantation of intact organs within a species or even an individual is not so easily accomplished; for the "taking of the graft," which is the process of uniting the grafted portion with the "host," depends upon its early vascularization.

Vascularization is the establishment of a connection between the grafted tissue and the delicate ducts and vessels that will carry blood to it. If vascularization fails, the food of the graft is cut off and the graft itself starves and degenerates rapidly, until it becomes an alien body simply pinned on to the host, serving no function whatever. The graft must receive nutrition almost immediately after it has been attached; otherwise it will quickly degenerate and die. It is obvious that vascularization of an organ presents more difficulties than that of a thin layer of tissue.

There are many other factors that operate seriously to prevent the successful "taking" of the graft. And yet, there exists in the body a marvelous regenerative power, such as that which makes possible the healing of wounds, and on which the scientist may count for aid.

Koppanyi migrated to the United States, became affiliated with several universities in the East and in the Middle West, and forgot—for a time—his study of the adaptation of color to environment. But the grafting problem still fascinated him. With the coöperation of American physiologists, anatomists, and pathologists, he began a series of experiments.

His immediate goal was the successful transplantation of an eye in a fish or an amphibian. But his dream, implicit in this undertaking, was the transplantation of the eye of a human being—an age-old, "impossible" medical objective.

In modern physiological history countless attempts had been made to graft organs so that they might function usefully in the new settings. Few of these met with even temporary success. A significant technical innovation was introduced by Drs. Murphy and Carrel, who successfully established immediate blood supply for the grafts by suturing—or stitching—the blood vessels of the grafts to the blood vessels of the host. But Carrel, the leader in this line of experiment, failed to obtain satisfactory results even with this improved method, and he dropped the work for more promising research.

Koppanyi, in his preliminary experiments in Europe, had achieved results which encouraged him to go ahead. As he progressed, he became convinced that the graft should not be attached to the host by artificial means. Other investigators confirmed him in this belief.

He therefore relinquished all sutures, artificial compression, and the other devices employed to force graft and host together, relying solely upon the natural propensity of the graft to take root. He believed that by means of this technique the wound-healing and regeneration could be encouraged to proceed without having to overcome such artificial barriers as stitches.

His first move was an attempt to transplant the eyes of young amphibians on to the necks of individuals of the same species. To his delight, he found that the transplanted eye-grafts not only "took," but that they also regenerated a perfect retina and even an optic nerve. The regenerated optic nerve sometimes grew into the nearest nerve tissue in the spinal column.

So far, so good; the transplantation in itself was successful. But for Koppanyi it was a negative success. When he removed the normal eyes of the host, the transplanted eyes on the neck did not prevent the appearance of the dark color characteristics of the blind amphibians, nor did these animals evince any ability to adapt themselves to the color of their environment. A frog, for instance, apparently was unable to see by means of its transplanted eyes. The eyes did not function.

The only conclusion Koppanyi could draw from the experiment was that the chemical changes set up within the eye and transmitted through general nervous pathways were not responsible for the phenomenon of color adaptation. This implied that the color change was in some way related to the higher optical centers—to vision—and that the animal was unable to perform its mysterious trick when the eyes were in seats other than their original sockets.

"When I undertook the next step in my investigations," Koppanyi reported some time afterwards, "I could not help feeling a horror at my blasphemy and lack of reverence in that I dared to replant the eye into its natural environment, into the eye-socket or orbit, and had the audacity to expect, or at least to hope, that I might be able to establish a connection between the visual receptors of the eye and the higher optical centers."

But he went ahead and performed the experiment on a large number of fishes and frogs. Just as he had ventured to surmise, the dark color of many of the blind animals disappeared about three months after the transplantation, and at about the same time they began to exhibit their lost ability to adapt themselves to the color of their environment.

Here was success—partial success, to be sure, for Koppanyi wanted to know not only if the faculty for color adaptation depended upon vision, and to what degree it depended, but just what the process of this baffling performance was. At last, however, he had a clue to a large problem.

The results that he secured indicated strongly that not only color adaptation but also vision itself was restored by the replanting of the eye in the eye-socket.

Subsequent experiments confirmed this supposition. The animals with new eyes were harassed by lights—both weak and strong lights. To weak lights they began to show positive phototaxis—attraction by a light in the direction of that light. To strong lights they showed negative phototaxis or photophobia—movement away from the light. Positive phototaxis to weak light is typical of the normal members of the species that he tested, as is negative phototaxis in the case of powerful light.

The animals with transplanted eyes succeeded in chasing and capturing prey with the efficiency of normal animals of their kind. Even if a glass jar was placed between the creature and its prey, both the operated individual and the normal specimen were able to aim unerringly toward the prey, whereas the blinded animals ignored it.

Transplantation of the eye in fishes and frogs was now an experimental fact. But how about the higher orders of life—the mammals? Koppanyi chose the useful rat for his new research. He obtained successful results with this species also, although in a much smaller percentage of the cases than with fishes and frogs. The vision of blinded animals returned, and their severed optical nerves regenerated themselves. Still later he added a rabbit to the list of successful experiments.

Koppanyi is not yet done. He is climbing up the hierarchy of life. But the scientist in him makes no rash predictions; he utters only a problematical "may" as to the future. "Transplantation of the eye, therefore, in every class of the vertebrate kingdom," he says, "is a practicable procedure which *may* lead to regeneration of the optic nerve and the recuperation of the vision."

As to the application of his methods to the human species, the man who has restored sight to blinded animals makes no predictions. Science treads softly—one step at a time.

CHAPTER II

THINKING AS A CHEMICAL PROCESS

BY DEVISING and employing one of the most delicate machines ever contrived—a machine so sensitive that the energy used by a house-fly in climbing an inch of screen would break it—science has learned that thinking is a chemical process not a great deal more complicated than the transformation of water into steam. To many this may be disturbing news in the light of the unquestioning reverence with which all ages, including our own, have regarded a gift which has assured to the human animal uncontested supremacy over the other creatures with which man shares the earth.

The instrument was recently perfected for the purpose of his experiments by Dr. Ralph W. Gerard, physiologist at the University of Chicago. For several years, in America and abroad, he sought an apparatus that would register the heat produced by the impulse of a nerve.

Many scientists during the last twenty-five years had believed that the impulse which shoots through a nerve and causes a muscle to respond is the result of oxidation.

Bodily oxidation occurs in breathing: oxygen is inhaled by the lungs and unites chemically with the constituents of the blood. There are two obvious results of this union: heat is produced, and so is carbon dioxide. The heat is necessary for life; the carbon dioxide is exhaled. To provide this heat, the food-stuffs in the body are burned, just as the "food-stuffs" of a piece of wood or paper are burned when they unite with oxygen, to produce a visible fire, concentrated heat, and carbon dioxide mingled with other gases and "soot" in the form of smoke.

That oxidation is responsible for muscular energy was proved several years ago by Professors A. W. Hill of London and Otto Meyerhof of Berlin. Their significant discovery was rewarded with the Nobel prize.

The energy for the contraction of a muscle was traced to a rapid breakdown of sugar into lactic acid (the acid of sour milk), a process that does not involve oxygen. The muscle was found to be restored to its normal energy level—ready for the next contraction—by the oxidation of one-fourth of this lactic acid, the other three-fourths being rebuilt into the sugar from which it originated.

Corresponding to these two processes are two phases of heat production: an initial one which is independent of oxygen, and a later one which does not occur if oxygen is absent. In the absence of oxygen, oxidation cannot occur; the lactic acid accumulates, and the result is muscular impotence, or death.

No proof was obtainable that any such chemical reactions as the consumption of oxygen and the production of carbon dioxide are linked with nervous impulses, nor had experiment been able to record any production of heat during the activity of a nerve.

Until the last century all that was known about the nervous system was that it consisted of combinations of single cells that send out a thread-like extension, over a meter long in the larger animals (the largest ordinary cells are less than a tenth of a millimeter in length), and that along this fiber was conveyed something which was able to induce marked changes in the organ with which it was connected. The only means of proving that a nerve—a bundle of thousands of these fibers connecting the brain and the spinal cord with a muscle or other organ—was alive was by observing that irritation of the nerve caused the muscle at the other end to jump.

Many explanations had been advanced as to what the "something" was that traveled down the nerve, and how a stimulation at one end could produce an effect at the other. Nerves were regarded variously as mechanical ropes, such as a bell-pull, as pipes carrying a stimulating fluid, as conductors of energy waves acting as a column of water does in transmitting a vibration, and as conductors of electricity.

Nearly all theories regarded the nerve as a sort of elevator shaft—a passive instrument that allowed energy or substance applied at one end to reach the other.

Three-quarters of a century ago the momentous discovery was made that when a nerve is active, a wave of electric charge passes along its length, though not as an electric current is carried along a wire, since the speed of the nerve charge was only 120 meters a second in man—incomparably slower than that of electricity. Each part of the nerve appeared to produce its own electricity.

A little later it was observed that there was a lapse of one one-thousandth of a second between these electrical impulses. There followed on this revelation the discovery that when a nerve was deprived of oxygen it gradually lost its power to conduct a stimulus.

Science saw in these facts an indication that this "something" was not an electric current carried along a wire, but more like a train of ignited powder burning itself and carrying the explosion in short detonations from one end to the other. This meant that the nerve actively participated in the transmission of an impulse, and did not serve simply as an inert pipe through which the impulse was projected.

Did the nerve breath? If it could be proved that respiration —the consumption of oxygen and the production of carbon dioxide and heat—took place, nervous activity could be indentified as the result of a chemical process not unlike that which animates muscles. But the process would be diminutive, since nerves are so much smaller than muscles.

It had already been established that without oxygen the nerve lost its power. A Japanese scientist named Tashiro discovered that there was a slight increase of carbon dioxide after a nervous impulse has passed. Now, if it could be proved that heat was produced, the process would be known to be oxidation.

Dr. Gerard constructed the apparatus with which he hoped to find out if there was any heat produced by a nerve impulse, and to measure that heat—if and when created. The instrument consisted of a thermopile, an instrument for converting heat into electric current, and an inconceivably sensitive apparatus for measuring the current. This latter apparatus was composed of two galvanometers, or current measurers, connected only by a beam of light.

The scientist removed several nerves from the hip of a frog. These nerves can be kept alive for a day or even longer. The nerves were laid on the thermopile and were stimulated at one end by 280 electrical shocks a second. A single stimulus of electricity generated in each of the 3,000 fibers of the nerve one-millionth of a millionth of a calory of heat, and the temperature rose only one ten-millionth of a degree.

Measurement of the oxygen consumed and the carbon dioxide given off corresponded, Dr. Gerard found, to that of the heat produced.

His conclusion is that the nerve gets its energy from burning food-stuffs—not sugar, the oxidation of which produces muscular energy, but some basic food that he has not yet been able to identify.

So elaborately intergeared is the process, however, that a nerve produces in a muscle of the same weight 5,000 times as much energy as it uses to stimulate the muscle. In the frog's leg the muscle gives off one million times as much energy as the nerve which stimulates it. The nerve is like a fuse exploding a charge of dynamite.

Further experimentation revealed that the nerve fibers contain enough oxygen to remain sensitive or alive for several hours of continuous stimulation without receiving oxygen from the blood stream.

This means that when a man is technically dead—when he has ceased breathing and injecting oxygen into his blood-stream—the fibers of his nerves are still alive, still capable of producing the energy to move the muscles of his body. But the "match" that ignites these fuses—that is, the nerve center located in the brain or the spinal cord—requires seventy times as much oxygen as the nerve fibers. The nerve center does not have that reservoir of oxygen, and consequently it perishes within three or four minutes after respiration ceases. And then the living nerve fibers cannot be ignited.

What has this to do with thought? It proves that nervous activity is the result of a basal chemical process. Its connection with thought is this: the nerves that control thinking processes are of the same general construction as the nerves that control action processes. Thus thinking, science believes, is a chemical process, resulting, as does action, from oxidation.

To the familiar formula for achievement—inspiration plus perspiration—there may now be added oxidation. The thinking that goes into the creation of a sonnet or into such an experiment as Dr. Gerard's involves these three factors and several thousand others as yet unknown and not, in all probability, so simple.

CHAPTER III

AS A RAT THINKETH

WHAT does man know about the inside of his own head? The brain is the most complex mechanism known. But does it present the most difficult problems? That is a moot question.

This much is indisputable: it is an organ complicated beyond visualization. Anatomists estimate that in the human brain there are 12,000,000,000 neurons, or nerve cells. The cortex, or outer brain (the gray matter), which comprises more than half the brain's mass and wields a dominating influence in thinking, holds 9,200,000,000—more than nine billion—neurons.

Every one of these cells, physiologists agree, is potentially in contact with every other cell through synapsis. These microscopic bridges or couplers, whose nature is as yet largely unfathomed, play a significant rôle in all cellular coördination and coöperation. The number of possible combinations of these cells is vast beyond comprehension, far exceeding even the largest astronomical figures.

It is but natural, therefore, that the brain should offer a fascinating field of study for science. But unfortunately it is a field surrounded by formidable walls. To be sure, brains of dead humans and animals are available by the score—even brains with biographies attached. But they are of little use to science. Other dead organs may, upon dissection, reveal the nature of their former activities—the brain does not.

Psychology probes it indirectly, seeking to unravel the enigmas of the mind. But the physical brain—its structural relations and its functional processes—remains in the dark, enshrouded by an opaque casing of bone and of skin.

Until recently, analysis of the brains of dead humans and of living and dead lower animals tended generally toward support of the theory that behavior is localized in special cubicles of the brain; that every physical, mental, and emotional reaction is dispatched through the nervous system from a particular brain area that handles a single activity and a single habit.

But ten years of research—the first comprehensive experimentation to determine the relationship between the structure of the brain and the learning process—has convinced Professor K. S. Lashley that in the rat, and by inference in the human being, the mind in solving a problem functions as a mass, with scarcely any connection between complex activities and specific compartments of the brain.

The cortex of the rat has a dozen areas architecturally distinct; the human cortex has more than fifty such areas. It had been assumed that difference in structure connoted difference in function—that the cortex resembled in principle a telephone switchboard in the main office of a department store, each plug being connected with a different department. Each department makes its requisition over its private wire to the switchboard, and the orders are given over lines extending from the switchboard to the supply rooms—one for each department. The orders are filled in the supply rooms, and the goods are delivered over other marked routes to the sundry departments. An attractively simple analogy, but it is not supported by the results of the latest research.

Professor Lashley did not attempt to define intelligence before he began his work, nor did he claim to have made, at its conclusion, any revolutionary incursions into that mysterious realm. His research concerned itself only with learning, and the limitations in his study of learning were enormous. Rats bear a striking resemblance, in many ways, to men, but in other respects are almost at opposite poles. Dr. Lashley's rats were tested for their ability to learn with various parts of their brains removed, and for the ability to retain knowledge under those conditions.

He undertook his work at the University of Minnesota and continued it at the Institute for Juvenile Research in Chicago.

Early in his investigations he found that the multiple system of restricted paths of conduction—the switchboard idea—did not function in the neatly patterned manner that had been widely accepted as basic. On the contrary, it appeared that large masses of nervous tissue participated in the mechanics of the brain, and that there was a more generalized and plastic principle of correlation than had been assumed.

He recorded the mental ability and habits of normal rats facing actual problems, and then removed sections of their cortex to see what effect the destruction of these structural compartments had on the animals' learning and retaining powers. In one or another of his rats, every section of the cortex was removed, and the brain then allowed to heal, with the remainder of its mass intact, before the animals were subjected to the tests that had already been given their normal brothers.

The investigator terms his own work a "crude preliminary survey." But it is a notable scientific study of the interdependence of the various parts of the brain, and certainly an impressive contribution to the solution of a vexed question.

Twenty-two normal rats were subjected to a series of mental tests. The most involved proposition that confronted the rodents was a maze, or labyrinth, through which the rat undergoing the test had to find its way. The maze consisted of a covered box about four feet long. The rat entered through an irreversible door at one end, and, unable to get out by the way it had come in, had to locate the sole available exit—a door at the other end of the box.

In case the rat happened to be inordinately dull—and some of them were—a spread of cheese of the most penetrating fragrance was placed just beyond the gate that opened outward and led to freedom. Thus even the most phlegmatic were stirred to action.

Having passed through the one-way door, the rat took stock of the situation. The interior of the box was divided into four parallel streets, connected by openings near the boxed-in termination of each street. The rat had to follow a zigzag path through the maze, making four turns, alternately left and right, to extricate itself from prison. In case the rat failed to make the turn, or turned the wrong way, it ran into a *cul-de-sac,* or blind alley. There were eight of these *culs-de-sac*—one at each end of the four streets.

Statistics on the ability of the animals to find their way through this and various other mazes were compiled, so that every time a rat made a false turn or wandered into a *cul-de-sac,* the error was automatically recorded, along with the time consumed in each trial. The number of errors for each trial decreased as the rat learned the maze, and the animals were given five trials a day until they were able to complete ten consecutive trips without making a mistake.

In case any animals exhibited subnormal intelligence, they were discarded after having failed to learn the maze in 150 trials, which is more than seven times the average required by normal animals. The latter took about twenty trials before they could achieve ten errorless excursions.

Professor Lashley's next problem was a fascinating one. When part of the animal's brain was removed, what happened to the faculty that enables a rat to run through a maze? When various parts were removed? Did it make any difference in the acquisition of knowledge and habit if one section of the cortex rather than another was destroyed?

The localizationists—those who contend that each function of mentality is connected by a special transmission line to a specific section of the brain—answered this last question affimatively. Dr. Lashley was skeptical about this localization; he was determined to find out for himself.

Fifty normal rats were conscripted for the tests. The twenty-two animals that had been subjected to the tests previously as "controls" or subjects of comparison in the process of establishing normal rate statistics, could not be used, since it would be impossible to decide how much of its previous contact with the problem the rat was able to remember after the operation.

A different amount of the cortex was destroyed in each animal, ranging from areas of 1.5 per cent to 81.2 per cent of the total gray matter. The operations were so conducted that every compartment of the brain was destroyed in one rat or another, while the remaining bulk was left uninjured.

The operations were performed under deep anaesthesia. Having cut through the skin and removed as much of the skull as the experiment required, the surgeons destroyed specified chambers of the brain with a red-hot, pencil-like instrument. The removal was accomplished, in fine, by burning—a method that prevents the flow of blood and kills bacteria. In a few days the animals had recovered from the physical effects of the operation and were ready for the tests.

Is it harder for an animal to learn when part of its brain has been destroyed?

The answer to that question, as might naturally be inferred, was, "Yes." This revelation, when the operated rats had been run through the tests, and the system of analysis had been applied to their trial-and-error efforts, was not sensational. But the more subtle results were startling. The operated rats, with an average of 31.1 per cent of the cortex removed, required 6½ times as much practice as did the normal animals before they could achieve ten errorless trips through the labyrinth of the four-street maze. On simpler mazes, however, the crippled rats turned the trick after only 2½ times the practice required by their normal brothers.

Here, then, was discovery No. 1: Brain lesion does not affect the ability to conquer simple obstacles to an impressive extent. But in the case of involved problems, the impairment of ability is greater in proportion, by far, than it is in the relatively easy tests. Injury to the brain, then, or destruction of part of it, hits hardest the higher intellectual demands, while the trivial performances of the mind are retarded to only a slight degree.

Discovery No. 2 follows: Reduction in the capacity to learn is roughly proportional to the amount of destruction of the cortex. In itself this second fact is again one which might easily be assumed.

But the next step in the investigation disclosed the telltale relationship between the brain structure and the mental ability of the rat: The same retardation in learning is produced by equal destruction in any part of the cortex; that is, the damage to the animal's learning capacity depends simply upon the amount of brain-matter destroyed, and is independent of the architectural divisions of the mass.

Repeated experimentation substantiated the conclusion that it makes no difference which part or parts of the cortex were destroyed. All of the principal areas were removed from one animal or another, and most of the possible combinations of these compartments were blocked by cauterization. But the results were persistent: the effect of the destruction was quantitative, not qualitative.

Professor Lashley, as a result of these experiments, relegates to the limbo of outworn theories the conception of the brain as a central bureau in which each performance of the superbly organized human machine has its call-box. In short, he nullifies several widespread beliefs of long and sanctimonious standing. So his work has been, in a double sense, destructive. But destruction, when it clears the way for the onward march, is the strong right arm of science.

CHAPTER IV

IS WEATHER SENSE GOOD SENSE?

SOME people know when it is going to rain—but they do not know why or how they know. Probably everybody, at one time or another, has overheard or participated in a conversation something like this:

"Why, you're crazy! The sun is shining like a baby's smile."

"I know it is. But just the same—let's not go to the game today. It's going to rain. I feel it in my bones!"

"What do you mean—'feel it in your bones?' You don't know what you're talking about."

And so he doesn't. He can't explain that feeling in his bones. And his friend regards him as a crank or an idiot.

As a matter of fact, the speaker is often right. Rain confirms his pessimistic prediction. The other fellow, who went to the game, puts in a water-logged appearance later in the day, and grumblingly admits what now cannot be denied. Yes, it did rain, he assents. "But not because you said it would. You can't make a man in his right mind believe such trash."

That was the general attitude, in spite of the fact that the alarmist's forebodings were so often fulfilled. "Superstition" was the common verdict.

Nevertheless, science has discovered an extremely simple and natural explanation of the rheumatic individual's uncanny ability to predict the coming of storms. And apparently the same explanation applies to the case of animals that seek shelter before there is any apparent indication of an approaching disturbance in the weather.

During his work on an experiment designed to solve an abstruse physiological problem, Dr. C. S. Smith, of the Texas State Normal College, found that dogs and rats retain water under low barometric pressure, and that dogs particularly become restless. This discovery turned the scientist's attention along lines that resulted in an explanation, at last, of the "feeling in the bones" that a storm is imminent.

A curious fact that has long been known to scientists is that starving animals do not lose weight at a steady rate. On the contrary, the loss of weight fluctuates, and sometimes the animals even gain slightly—only to lose weight more rapidly later.

Several explanations had been offered to interpret this puzzling fact, but the one that impressed Dr. Smith the most deeply was the theory that on days when the barometric pressure was low—as it always is before bad weather—animals do not lose water as rapidly as under ordinary conditions.

He set out to investigate the possibilities of the theory, with dogs and rats as subjects. He used a glass-walled tank in which the pressure might be raised or lowered at will. Experimentation developed the fact that under the influence of lowered pressure there was a decrease in the rate at which water was eliminated from the body through the kidneys, lungs, and sweat glands. Dogs, which have no sweat glands, were observed to become restless after a long period under low pressure.

Reasoning from these results, Dr. Smith deduced that the "weather sense" in certain of the lower animals and in rheumatic human beings is conditioned by this retention of water. The lower animals feel restless in the low pressure atmosphere which precedes storms; and they learn, after a few experiences, to seek shelter when this condition recurs. In the same way, it is probable that rheumatic persons, whose constitutions and nerves are in an abnormal condition, are sensitive to the increased hydration of the body tissues which occurs when the atmospheric pressure drops.

This sensitivity, then, may be the source of that mysterious and unaccountable "feeling in the bones" which some people experience before the advent of a storm.

Dr. Smith's discovery was an accidental by-product of a complex investigation. True, it doesn't make life much richer to find out why some people can predict rain. Now if Dr. Smith had stumbled on a sure method for prophesying who will win the ball game—but maybe it's only a matter of time.

Chapter V

HOW OLD WAS TOM?

JOHN JOHNSON did not know a great deal—he admitted it frankly. He did not even know much about his seventeen haphazard sons and daughters. But this he did know—that if the Oil Company kept bringing strange Indian youths around until Judgment Day, he would not recognize any of them as his son Tom. He knew that Tom had been killed in jumping from a train to elude a railroad detective who objected to Tom's occupancy of the railroad's rolling stock. John Johnson had identified his son's body, and had taken it home and buried it in the family plot—or, more specifically, the back-yard of his Oklahoma domicile.

So much the bronzed and wrinkled old man knew. But he did not know why the Oil Company wanted to prove that his son was not dead.

In 1923, two years after Tom's passing, the United States of America had told him that there was oil under the quarter-section of land of which this son, a Reservation Indian, had been part owner. He testified that Tom was eighteen at the time of his death, and the Indian census of 1903 corroborated the estimate. And he testified that Tom was dead—completely dead.

And so, following an offer of a sum of money that startled his composure but warmed his heart, John Johnson signed a lease as administrator of his son's estate, assigning the exploitation of the property to a large Oil Company. Then he began to enjoy comforts of living which he had never tasted before.

Two years after the signing of the lease, the Company had found the land enormously fruitful. And the more oil that was sucked from its depth, the larger John Johnson's "cut" in the profits became.

Then the Oil Company shrewdly decided to test the validity of the contract—on one count or another. Through its counsel, it asserted that young Tom Johnson was still alive; that his father had depended upon a carelessly sentimental eye in identifying a body that had been buried as an anonymous cadaver on the railroad's right of way and then disinterred for identification. The mistake must now be rectified by proving that Tom was still alive.

Thus it was that the quiet of John Johnson's abode was shattered by the entrance of a file of nondescript young Indians. Each of them in turn, sponsored by the Oil Company, eagerly presented himself as John Johnson's missing and now contrite prodigal son.

But the accommodating young men were spurned by the Indian as none of his. He averred that he knew what his own son looked like, even though he had sixteen other children to keep in mind. At last the Oil Company withdrew its barrage of claimants and sent them their various ways.

Unable to prove that any one of their protégés was young Johnson, the Company lawyers started on another tack. They moved to exhume the body that lay in the blossoming family back-yard. For, even granting that the body was Tom's, if it could be established by medical testimony that the young man was over twenty-one at the time of his death, the lease would be invalid, inasmuch as he had been represented as a minor, eighteen years of age. This possibility appealed strongly to the Oil Company's attorneys.

The body, accordingly, was exhumed. A physician retained by the oil interests examined it exhaustively, and testified that the individual represented as the deceased part-owner was a man of at least twenty-eight years' growth.

This assertion he substantiated with the anatomical explanation that there was an apparent closure of the growth centers—the ends of the two principal bones in each of the two joints of the arms and legs. He based his deduction, he said, on research just completed at Western Reserve University, proving that the epiphysis, or "floating" end, of the long bone of the shoulder unites with the long bone proper between the ages of twenty-five and twenty-eight.

At that University, where study of the union of bones has recently produced important new knowledge, a collection of 1,500 skeletons, all classified by racial stock, age, and sex, had been worked upon for several years by Professors Todd and Stevenson, two noted physical anthropologists. They proved conclusively that the age of a person, living or dead, can be determined by X-ray examination or actual inspection of this bone growth.

But the conclusion propounded by the petroleum people's physician was not accepted by the representatives of old Johnson. His attorneys happened to be acquainted with the trend of work at Western Reserve Laboratory, and they sent their story thither. A young research worker attached to the University staff was dispatched southwestward. His name was Wilton M. Krogman.

Krogman had the body exhumed again. He spent several days in its company. As a result of his examination, he announced that the Oil Company's physician had been mistaken in his findings. Krogman declared that the state of the epiphyseal union of the bones placed the age of the boy between eighteen and twenty years, with an indication that his exact age was eighteen years and seven months. His evidence proclaimed the old Indian triumphant over a potent corporation and its keenest legal talent.

Here, in brief, is the scientist's report:

(1) The head of the humerus (upper arm) is not united to the shaft. This places the corpse's age under twenty, because this union always takes place at that age. (2) the distal, or lower ends, of the radius and ulna (the two bones constituting the skeleton of the forearm) are not united with the actual shafts of the bones. This places Tom Johnson at under nineteen. (3) But the epiphyses of the tibia and fibula (the two bones constituting the skeleton of the lower leg) show signs of

beginning union with the shafts—a condition which places the boy's age at over eighteen, and, by virtue of the progress of union in the leg bones, at eighteen years and about seven months.

By such criteria, the age of a person can be determined in stages of one year through a considerable period. The eruption of the teeth is an early determinant. At seven, the epiphyseal union of the bones becomes calculable. The epiphyses are at the juncture between the bones proper and the segments of bone which adjoin their ends. The connection is maintained, in babyhood, by the existence of cartilage, a translucent, elastic tissue popularly known as gristle. These segments fit into other bones, or into other segments, which form the joints.

As the body develops, these segments, or epiphyses, gradually unite with the bones by the process of ossification of the cartilage, a transformation that turns the cartilage into bone. This ossification is accomplished through the contribution by the blood cells of bone material in the chemical form of calcium salts. The deposition of organic salts gives the body structure an increasing rigidity with the progressive destruction of the cartilage. Thus, elderly persons' bones are increasingly brittle.

At the age of seven, the epiphyses for the head of the humerus and the bone's greater and lesser trochanters (the two rough prominences in the upper part of the femur which serve for the attachment of muscles) unite as one fixture, although the ultimate union of this new entity with the shaft of the arm itself takes place at twenty.

At twelve and one-half to fourteen and one-half the epiphyses for the phalanges—or digital bones—of the hands and feet unite. On the femur, popularly known as the thigh bone, the condyle, or "kunckle," unites with the shaft at nineteen, and the two trochanters are joined at eighteen.

After the general closure of the epiphyses, the theme of growth is taken up by the skull sutures. These sutures, three in number, are the junctions of the four bones that form the skull in early life. They close gradually, beginning at the age of twenty-two, and have as a rule completely closed at forty-seven. By the stages of closure in all three (the process begins in the cleft at the front of the head, continues in that of the crown, and ends in the one on the back of the skull) the age of a person can be determined with reasonable exactness well into middle life.

By his own admission John Johnson did not know a great deal. What he did know, he divulged without hesitation. What he did not know, such as the lore of epiphyseal union, he did not bestir himself to learn. When the experts had withdrawn from his presence, he shook his head in a puzzled fashion. But he learned at last that the Oil Company would go on paying him for Tom's land—and that was really all he wanted to know.

PART VII

CHAPTER I

"SHOOTING" THE MOON

AN AMAZING super-cinema has been announced. It has not been bill-boarded yet, nor has it appeared at any popular theater. In all probability it never will.

The story portrayed by this film has never been put on celluloid before. It is unique in that the scene of the picture (there is only one) is two hundred and forty thousand miles away from the camera. Stranger still is the fact that the sole actor in the story is located ninety-three millions of miles away from the scene depicted.

A super-production it is, although it was not made in or near a movie studio, and the motion picture industry as a whole knew nothing about its manufacture.

Scientists have just succeeded in "shooting" a motion picture of sunrise on the moon. This novel contribution to man's knowledge of the universe in which his earth is merely a cog has been achieved at Princeton University, where Professor John Q. Stewart directed the recording of the phenomenon by means of combining the properties of a motion picture camera with the magnifying power of the 23-inch astronomical telescope at the university's observatory. Robert F. Arnott, a New Jersey consulting engineer, perfected the mechanism for the experiment.

With the moon nine days "old"—that is, two days past the first quarter, the powerful telescope was focused on the earth's satellite 240,000 miles out in the heavens.

To the eye-piece of the telescope, which enlarges the image of the distant body in the manner of a microscope and then concentrates it so that it can be encompassed by the human eye, was attached an amateur motion picture camera, using a 16-millimeter film and driven by an electric motor. Both the motor and the camera were contained in a metal box, and the focusing and operating speed were controlled by attachments on the exterior of the box.

The telescope is an instrument thirty feet tall, weighing thirty tons, and had to be adjusted every two seconds to avoid blurring of the motion pictures. For four continuous hours the operators guided the delicately combined mechanisms.

Projected on a regulation motion picture screen, the film discloses in enlarged form, within the course of four minutes, what an astronomer would see in four hours of tedious, unrelieved observation through the telescope. The film furnishes for the first time a permanent record of what happens on this barren, ghostly globe that pursues its methodical course around the earth, century after century, with never a sign of insubordination to the planet to which it is lashed by gravity.

The moon, the earth's nearest empyreal neighbor and its only stepchild, has been studied by man at relatively close range since the invention of the telescope three hundred years ago. Photographs of it, in repose, taken telescopically, reveal it to us as a "dead" body, much similar to the earth and far different from the violently incandescent sun and most stars.

Little happens on the moon to induce adventurers to pack up their clean shirts, button on their greatcoats, and set off for the unpromising land on a skyrocket, a kite, or a bicycle. We know that its surface is devoid of life; at least no trace of the type of animate organisms that inhabit the earth has ever been seen there, and we know that if life exists in lunar regions it must be one that we cannot conceive, one that prospers without air and without water, for the moon has neither.

Without water and air, the moon is a naked place, where there are no clouds and no mists, no dawn, no twilight.

While the earth rotates on its axis once in twenty-four hours, presenting all of its faces to the sun during that period, the moon itself ambles around once in about thirty of our days. Consequently, the sun shines on the moon for nearly fifteen of our days, never dimmed or softened by a cloud or an atmosphere. Baked and parched by the furious solar rays, the surface rocks of the moon are heated almost to the boiling point of water.

Then, as the sphere turns itself elliptically out of the sun's range, night falls in a sudden curtain, as though the sun had been switched off like an electric light. Without any blanket of air to retain the heat of the day, the temperature drops rapidly. In two hours the freezing point is reached, and before day breaks again, two weeks later, the temperature has descended to between 200 and 300 degrees below zero, Fahrenheit.

Static photographs of this phenomenon in various stages have been taken for many years, but the successful experiment at Princeton marks the first animated picture of the coming of day and night—the only activity, although it is a borrowed one, that transpires on the moon.

Only one other form of change, scientists assert, occurs on the moon. A diffused hail of small, stray particles, most of them rocks, must be falling upon the satellite daily. We know that twenty millions of these particles of cosmic matter, or "stardust," fall into the earth's atmosphere every day. We call them meteorites, and often they can be seen hurtling through the heavens, attracted by the earth's gravity. Our atmosphere protects us from the direct striking action of these bodies, for they have lost most of their velocity before they reach the surface.

Allowing for the greater attraction of the earth and the smaller area of the moon, over a million of these particles, invisible from the earth, must strike the moon every twenty-four hours. Astronomers note that since the moon has no atmosphere to consume these projectiles or check their momentum they must rain down upon its surface at every conceivable angle, traveling at a speed as high as 44 miles a second.

Therefore, as a result of this bombardment, there must be a continual wearing process, somewhat similar to the erosion of the earth's surface by water and wind, going on upon the moon. But we can only postulate this, since it is invisible.

The new super-production features a "close-up" of an area of 200 miles by 330 miles on the moon's surface. In the center of this area is seen Copernicus, the giant crater named in honor of the Polish astronomer who in the sixteenth century promulgated the now long-established theory that the sun is the center of our planetary system. The mountain walls which form the almost perfect circle of this crater are two miles high, and the diameter of the hollow pit is fifty-six miles.

There are 30,000 of these craters on that hemisphere of the moon which is always facing the earth, and some of them reach diameters of fifty, sixty, and even 100 miles, and depths of 10,000 feet. Photographs of the full moon reveal a preponderance of extensive smooth basins in the central part of the hemisphere facing us, as compared with the elevated, mountainous areas that pervade the rim. The craters in these basins are few and small, while on the uplands and mountainous tracts of the rim appear pits in great numbers and of huge size, many of them surpassing in breadth and depth the volcanic craters of the earth.

The late Thomas Chrowder Chamberlin, originator of the planetesimal hypothesis of the origin of the earth (a theory, now generally accepted among scientists, that the world began small and cold and accumulated matter that, like itself, had been sent whirling into space by the sun), suggested shortly before his death, in 1928, that the vast basin areas of the moon are heavier than the mountainous areas, and that we see the heavy end, or hemisphere, of our satellite. This theory, which is congruous with the planetesimal hypothesis, serves as the first reasonable explanation of the hitherto baffling fact that the moon turns only one side to the earth.

Science recognized long ago that this phenomenon meant that as the moon makes one revolution around the earth it rotates exactly once around its own axis. It is easily perceived that if there were any change in this one-rotation-per-one-revolution combination, the moon would not be able to keep this same side to the earth at every point in its journey.

What agency acts as a stabilizer to correct any influence that might tend to change the moon's rotative relation to the earth? That the gravity of the earth holds the moon in its orbit is obvious. This same gravity holds to the earth every body on its surface, and in the air and water surrounding the earth. Any bird, balloon, or airplane that might make a round-the-world trip, or one revolution around the earth, would rotate precisely once on its journey and thus keep the same "face"—the bottom of the basket of the balloon, and the underside of the bird and the airplane—toward the earth.

Since the rotation around its axis is so slow as to be imperceptible in an airplane flying around the world, the principle is hard to comprehend. But it becomes clear if we envision a "loop-the-loop," in which the airplane makes a small revolution and a striking rotation, whereby it keeps its underside facing the imaginary object around which it revolves.

Both the moon and the airplane are held to the earth by gravity. The one-rotation-per-one-revolution principle, on which the moon and the airplane both appear to operate, is known to depend on three factors: gravity; a heavier and a lighter end, with the heavier end responding more strongly to the gravitational pull, as in the case of the balloon basket and the underside of the bird and of the airplane; and a resisting medium—the atmosphere, in the case of the balloon, the bird, and the airplane—sufficient to give the heavier end an advantage and cause it to take the position nearest the center of gravity—the earth—and keep it.

Does the moon have a heavier and a lighter end? Does the moon have a resisting medium around it?

Chamberlin collected evidence that tallies perfectly with the major principles of his earth-origin hypothesis. And he answered these two questions in the affirmative, thus indicating that "the moon is dynamically a part of the more intimate system of action to which the high-flying bird, the balloon, and the flying plane belong," and that the problem of its rotation falls into line with that of these familiar things of earth.

The great geologist, his genius undimmed by eighty-five years and the imminence of death, reasoned that as the moon grew by the accretion of material in space, one end became denser than the other, so that its hemispheres became unequal in density—just as did the earth's, with all of the continents except Australia in one hemisphere and almost all the water basins, except the Atlantic and the Arctic, in the other.

Thus this heavy end, the basin-hemisphere, of the moon constantly faces us, and it is held in that position by the resisting medium of the rain of meteorites through which it is passing, and the gaseous molecules of the earth's ultra-atmosphere through which it revolves.

"Shooting" the moon is the most recent of several revelations regarding that body achieved within the last few years. If "God's last nickel thrown across the counter of the skies" has any more secrets, it had better hide them well.

CHAPTER II

NEW LIGHT ON THE WORLD'S BIRTH

THE world is coming to an end—but not for a while. The terror of a sudden blackness and the chaotic obliteration of the whole earth, with everything on it, has pursued mankind down the ages. But the twentieth century tenant of the globe, more complacent than his ancestors, goes about his business from day to day with never a thought of a cosmic catastrophe which will write an unexpected *Finis* to the checkered history of the world.

And yet the ultimate destruction of the earth at some time in the future is a consummation against which science is powerless to underwrite an insurance policy. The same kind of cataclysm that created our planet will in all probability eventually demolish it.

But—and it is an immensely reassuring *but*—such a cataclysm, according to the reckoning of astronomers, can occur only once in a period of a thousand times a million times a million years. And as the last cataclysm of the sort occurred only a fraction of that period of years ago, there is no likelihood of a repetition of the fireworks for untold millions of years to come, And there is another fact to fortify our peace of mind as to the chances of the earth's outlasting our generation: about 100,000 years before the catastrophe takes place, a warning of its approach will be visible in the skies.

This assurance is based on a theory of the creation of the earth, suggested by Dr. Thomas Chrowder Chamberlin and Dr. Forest Ray Moulton, thirty years ago, and now known as the planetesimal hyphothesis. This explanation quickly supplanted all previous theories, including that of the French astronomer, Laplace, which held sway during the nineteenth century.

According to the planetesimal theory, our planetary family was fathered by a cataclysm that occurred when a passing star —or sun—in its journey through space swerved in a hyperbola past our sun at tremendous velocity, three to five billion years ago.

This visiting star, smaller than our sun and probably dull or dead, must have approached from the southern heavens somewhere between the empty space now occupied by the "inner" planets (the four nearest the sun—Mercury, Venus, Earth, and Mars) and that which contains the "outer" four (Jupiter, Saturn, Uranus, and Neptune—if we disregard, for the moment, the newly discovered ninth planet).

The momentum of the star prevented it from colliding with our sun as it sped by. But, although the two bodies passed each other at a distance of millions of miles, terrific tidal forces were called into action.

From cones drawn out at the sun's equatorial belt by the passing star's "pull," gaseous bolts that were to form the planetary family were shot forth in four double eruptions.

As Uranus was pulled out in the star's wake it became the earth's twin, the earth being shot out simultaneously from the opposite side of the sun.

The four bolts of gaseous substances ejected toward the direction taken by the star formed the larger outer planets, while those fired in the opposite direction became the inner planets. These planet bolts emerged in accordance with the physical laws governing such phenomena, with a spiral and vortical whirl which aided their gathering into rotating solid masses.

The star that had in the course of its stroll through the heavens come near enough to our sun to draw these masses from it did not have sufficient mass itself to absorb the bolts, but it gave them enough of its dynamic energy to throw them into nearly circular revolution about the sun, where the force that draws them toward the sun is offset by the force that draws them away, so that they are held in equilibrium and circle perpetually about the sun.

These clusters of matter ejected from the sun quickly became cold, and as they traveled in their orbits they gathered up swarms of smaller bits of matter (planetesimals, or little planets), and grew in bulk until they attained their present size.

The satellites, of which our moon is one of twenty-six revolving around the various planets, were explained by Dr. Chamberlin in a book published shortly before his death in

November, 1928, as partly the result of eddies of the main planetary bolts, separated from the main swarm by the "drag" at the outer edges of the whorl, and partly as eruptions secondary and reactionary to the major discharges.

These satellite masses remained far enough from their respective planetary swarms to form independent cores at their various centers of gravity, but close enough to stay within the control of the respective planets and revolve around them.

The earth has long since collected all the planetesimals in its reach, and is now undergoing no appreciable growth, although there is a constant infall of insignificant meteorites.

The "creep" of the axes of planets and their satellites (including that of our own earth, which has a twenty-three degree inclination in its rotation) is explained by the fact that the spirally whirling planetesimals struck the central mass at one angle more than at any other, and thus gradually shifted the axis.

Such is the story of the creation of the earth, and of the other planets, which together with their satellites, constitute the solar system. Of course, it is not the "true" story if the presence of witnesses is necessary to establish truth; but it is true in so far as science can judge from the mass of evidence that accumulates in each day's and each night's research by men of integrity and scientific insight in every corner of the world.

The Laplacian theory, which saw the solar system as a mass of hot gas that cooled and contracted to form the planets, with the residue organizing itself as the present sun, crumbled under half a dozen discoveries during the decade before and the decade after the turn of the twentieth century.

The planetesimal hypothesis has since been adopted throughout the world, almost as it was in its original form. The Chamberlin-Moulton conception is glorious, though it looks at the earth with amazing humility.

"Nothing whatever has been found in the record to imply that the birth of the earth was a feature of the absolute beginning of the universe," Dr. Chamberlin wrote at eighty-five, just before he died. "The inquiry has led to the impression that the creation of our planetary system was but an incident in the history of our sun, while even the genesis of the sun might not improbably be but an incident in the history of our stellar galaxy."

The universe is an orderly household. The movements of the earth and its fellow planets, and of the sun and its millions of fellow suns, are never haphazard or capricious, Dr. Moulton tells us.

The astronomer is able to turn his telescope today on a point in the heavens that will be crossed by one of the major stars on any given date in the future. It can be done without the remotest chance of error, despite the fact that a star, moving, as stars do, about 600,000,000 miles a year would not appear to the naked eye to have moved an inch in a thousand years.

Because man recognizes, either consciously or unconsciously, that the universe is an orderly household, he goes about his work and his play with never an apprehensive glance at the sky for some sign of the world's imminent destruction.

It is true that the path of our sun will be approached again by some unknown star, in the dim and distant future. Then the earth and its fellow planets will be caught up into the arms of a new spiral nebula, to give birth to another generation of planets. It will be a fresh shuffling of the cosmic cards.

Chapter III

FINDING THE NINTH PLANET

THREE HUNDRED years after Columbus discovered America, a musician, Sir William Herschel, constructed a rude telescope. Whiling away his time, with no thought of new worlds, he chanced to focus his glass on the first new planet to be recognized in modern times.

After a good deal of disputation among learned societies, the newcomer into our planetary family was named Uranus, the Greek personification of the heavens. This was in keeping with the mythological names of the six planets that were already "old" when Alexander wept for new worlds to conquer.

Conquerors of new worlds had only about a half-century wait this time until, in 1846, another of the earth's brothers in the retinue of the sun was discovered. It was Neptune, traveling in a far-flung orbit around the sun. Neptune was first sighted, not in the sky, but in the most astonishing mathematical deduction ever made.

Uranus wobbled. Astronomers did not say that. They said it varied orbitally; that is, it had wandered in its leisurely path around the sun and had failed to appear at the spot in its normal orbit at which mathematicians had made a pencil mark on their charts of the heavens. No, it was not lost—just strayed. And strayed only a negligible few miles. Negligible, so far as the delivery of tomorrow's milk was concerned, but vital to the fraternity of men who prescribed routes for worlds a billion miles away.

The key to the mystery was found almost simultaneously by two young astronomers working independently and unknown to each other. The two scientists calculated, from the extent of Uranus's deviation from its proper orbit, just where in the celestial spaces beyond the known planetary system a new world must be.

One of the two youths—Urbain Jean Joseph Leverrier, a Frenchman—asked Johann Gottfried Galle to took at this spot from his renowned observatory in Berlin. Herr Galle looked, but was disappointed. However, he made a chart of his findings and compared it with previous charts of that same section of the heavens. Lo! He had sighted a new "star." This new luminary—just a pin point of light as seen through his telescope—turned out to be the planet later called Neptune, another world, spinning along almost three billions of miles from the sun, so far away that it takes about 164 years to make a complete revolution around the solar body.

The other astronomer, an Englishman, was John Couch Adams. He had made a computation almost identical with that of Leverrier. A British telescope, focused on the predicted spot in the same year, located the planet, which, here also, was at first mistaken for a star.

Old Sol's family now consisted of eight planets, five of them —Mercury, Venus, Mars, Jupiter, and Saturn—having been known to the ancients on the sixth planet—Earth—as bright stars. All of them, of course, were visible to the naked eye. In the sixteenth century Nicolaus Copernicus blasted the theory that these five planets, together with the sun, the moon, and the stars, revolved around the earth.

Uranus had been discovered telescopically, and Neptune was appended to the panorama by a mathematical miracle. Minor members of the solar family included hundreds of small planets, or planetoids. The earth and Neptune were known to have one moon each, Mars two, Uranus four, Saturn and Jupiter each nine. Besides these bodies there had been noted occasional comets flitting into the solar system and out again.

But Uranus still wobbled. It wobbled just as much, of course, as it always had. But a few astronomers insisted that the gravity of Neptune failed to account for *all* of Uranus's orbital variations.

A new world, a ninth child of the sun, lay beyond Neptune, they said, and its presence was butting Uranus out of the delicate orbit that had already been dented by the gravity of Neptune. Camille Flammarion, in his *L'Astronomie Populaire,* published in 1863, predicated the existence of the undiscovered body, "a large planet, sailing at 4,000 millions of miles from the sun in a revolution of about 330 years."

Flammarion died. There were no telescopes powerful enough to see a body so small and so far away. But while the laity went on about its business of patching up this old world to make it livable for another few centuries, the astronomers kept their eyes open, year after year, for uncharted worlds lolling in the depths of space.

It was not a case of heroic poses at the nether end of sky-scraping telescopes; it was charts filled with prosaic, abstruse mathematics—algebra, trigonometry, geometry, calculus, and celestial ballistics. You did not look nonchalantly up at the stars and exclaim, "Ah, there! A new planet!" You discovered new worlds on paper now, if you discovered them at all.

The charts were not romantic; but at the end of those charts, at the end of thousands of them, lay—perhaps—another earth, another manifestation of creative genius that transcends everything human but imagination. That *was* romantic.

Percival Lowell, brother of a well-known University president and of a famous woman poet, was a romantic. Traveler and dilettante, he turned his versatile mind to astronomy and built with his own wealth an observatory in the clear, crystalline air of Arizona. It was at Flagstaff, a town at the pine-wooded foot of the San Francisco Mountains.

In his temple-like laboratory he continued the search for a new world. By 1905 he was sure of the existence of "X," the trans-Nepunian planet. He predicted its location, the orbit of its course around the sun. But there were no telescopes powerful enough to pick out a body so small and so far away.

In 1916 Astronomer Lowell died and was buried at the foot of his observatory. His followers took up his work, and at this observatory, as at others in different parts of the world, the work went ahead in noncommittal silence.

March 13, 1930, was the seventy-fifth anniversary of the birth of Percival Lowell and the one hundred and forty-ninth anniversary of the first modern discovery of a planet—that of Uranus in 1781. On that March day of 1930, Professor Harlow Shapley, director of the Harvard University observatory at Cambridge, Massachusetts, received a breath-taking communication from Dr. V. M. Slipher, Lowell's successor at Flagstaff. It read:

Systematic research begun years ago, supplementing Lowell's investigation for a trans-Neptunian planet, has revealed an object which for seven weeks has in rate of motion and path consistently conformed to trans-Neptunian body at the approximate distance he assigned. Fifteenth magnitude. Position March 12, at three hours Greenwich mean time, was seven seconds of time west from Delta Geminorum, agreeing with Lowell's predicted longitude.

And so, on March 13, 1930, a new world was officially born. Our little old world gasped. It had a baby brother. But people wondered. . . . What did the "systematic research begun years ago" mean?

It was then that the public learned how worlds are discovered. Lowell's staff included many eminent scientists, all of whom had faith in the existence of this planet out beyond Neptune. With Lowell they had computed its location. The elusive planet was born on paper in 1905. But it lay deeper in the heavens than man's eye and existing telescopes could fathom. As the years went by and science devised new telescopes, enlarging the universe ten thousand times in twenty-five years, the ninth marcher in the parade around the sun paced its orbit as it had done for forgotten aeons—but for man it was still on paper.

Predictions of the new world's location were many now. Some of them, contradictory to Lowell's, were advanced by noted astronomers. But it was generally agreed that the planet really existed out there in the cosmic wastes the other side of Neptune. There were plenty of recipes for finding the unseen planet, and every great observatory was trying to set the net for it.

It happened that in 1929 the Flagstaff observatory acquired a new instrument, christened the Lawrence Lowell telescope, in honor of the astronomer's brother, the president of Harvard. It was a comparatively small affair—a thirteen-inch "triplet," but the most powerful device of its kind. The 100-inch telescope at Mount Wilson in California, the 72-inch instrument at Victoria, in British Columbia, and the 40-inch lens at Yerkes observatory in Wisconsin, were giants in their field, but they could not catch this speck of a planet. It would be like a Colossus looking for a needle. The Lowell telescope was short, its vision was attuned to the relatively tiny solar system, and its perspective was broad.

The youthful Alexander had sighed for new worlds. Two fledgelings had found the latest world—Neptune. A youth of twenty-four was destined to present the "new" world to man. Clyde W. Tombaugh, an astronomer of a year and an assistant at the Lowell observatory, detected a strange "blotch of light" on a photographic plate that he was developing in the darkroom at Flagstaff on the night of January 21, 1930. The photograph was one taken by a camera infinitely more delicate and sensitive than the human eye—the glass of that 13-inch telescope.

Tombaugh carried the plate to Dr. Slipher, who notified the six other astronomers at the station. Then the staff of the observatory studied the tiny speck that men had been looking for during some eighty years.

What happened when these men, as a result of their examination, realized that a new world had been captured? How was it rung in?

No one, except that little group of men, and a few of their intimates, is likely to know. It was a moment of epochal triumph, but there were no newspaper representatives standing about. But young Tombaugh, who has priority as the first human being to see the ninth planet, has been prevailed upon by the press to write his story:

And what did the others say when I called them in to see it? Well, you know how these astronomers are. They are used to thinking in terms of millions of years and millions of miles. They weren't excited. They said it might possibly be the lurking Lowell planet, but they would have to watch it further to check it with data they had been gathering so long.

Night after night the Lowell telescope sought and photographed anew the errant planet. It moved slightly in the same direction as the other planets.

The whole vast bulk of computations, beginning with Percival Lowell's earliest reckonings, was unearthed from the observatory's files. With just a modicum of pride, these stargazers of the desert kept their secret. They might have enlisted the assistance of the Harvard observatory, with which they were affiliated, or that of any of the other great astronomical centers in America and abroad.

But they were not yet sure; they did not want to broadcast the discovery of a new world one night and then have to retract it the next. And they wished Percival Lowell's name to have the glory that the man Percival Lowell would have shunned. So they walked softly.

By the twelfth of March, they were ready to present their discovery. The next day it was formally announced. Within two weeks the existence of the new planet had been substantiated by the great observatories of the world, most of which had been scouring the skies for the mysterious stranger but had, unfortunately, been looking in the wrong place.

One after another, astronomical stations equipped for so delicate a task reported having photographed the elusive speck. The new planet was placed at 4,650,000,000 miles from the sun, which is forty-five times as far from the sun as the earth is. As Lowell estimated, its year is 300 times longer than the earth's.

But the astronomers drew a picture of conditions on the new planet that would effectively kill the enthusiasm of a real estate agent. The uncommonly wide breach over which the parent sun has to heave its lighting and warming rays to its most distant offspring allows the trans-Neptunian planet only one two-thousandths as much light and heat as the earth gets, so that this distant world has to get along as best it can in a murkiness no brighter than moonlight. Its temperature is, it would seem, much lower than even that of Neptune, where most substances of earth would be frozen solid.

Tentative results of observations made by Dr. John Q. Stewart, of Princeton University, indicate that the new world is black as coal, nearly as dense as iron, and twice as dense as the heaviest terrestrial rocks.

Because of the great pull of gravity, according to Dr. Stewart, a man—if we can conceive one on such a planet—could jump less than half as far as he could here on the earth. The planet's density is between 6 and 7, taking the standard of water density as 1. Its diameter is fourteen thousand miles. Weighted by its great gravity, a 150-pound man would tip the scales there at something like 325 pounds.

All in all, not an attractive abode. But the discovery of the new planet pushes the frontiers of our solar system nearly two billion miles out into the dark.