Booked

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Last spring I was booked. I hate to disappoint you, but I must tell you that this booking was not by the police. One does not have to be hooked or rooked to be booked. That word "booked" in my case has a double meaning. On request, I signed up to be on a panel of six to rate contenders in a national book prize contest. The contest didn't have the glamor of a Miss America selection, but it was safer, and it did provide considerable fun.

The book contest was conducted by Phi Beta Kappa, our oldest Greek-letter society, founded in 1776 by America's oldest college, William and Mary, in Virginia. This organization, dedicated to scholarship, not to social activities, annually conducts three such book contests. One is the Phi Beta Kappa Award in Science, with a cash prize of $1,000 plus much more in prestige for the new book rated as best. The purpose is (quotes) "to stress the need for more literate and scholarly interpretations of the physical and biological sciences and mathematics" (end quotes). The award (quotes) "seeks to encourage books by scientists that symbolize the importance of science as a part of our humanistic studies and to remind us that the search for wisdom is still a single enterprise" (end quotes).

I am tempted at this point to pause, to hark back to Gordon Carson's exciting paper of last November on "Intellectual Luddites" and to the spirited discussion incited, and then to say that I regard this activity by Phi Beta Kappa as an attempt to coöperate with science, not aggressively to infiltrate, as a sign of appreciation, surely not a sign of repudiation. The better science is generally understood as a result of good writing in interpretation for popular consumption the better is the opportunity for humanists and scientists to draw more closely together. I regard any chasm which may exist between the two as largely a matter of misunderstanding and personal deficiencies. There are narrow-minded people in all fields and on all levels. Specialization, often intense among scientists, does invite narrow-mindedness, but scientific information absorbed by men of stature and human concern makes them grow as useful world citizens. Science begets materialism only in little men. Science is power, but also it is inspiration.

I have been on The Ohio State University Campus continuously during 57 years, possibly longer than anyone else now there. Always I have been associated with scientific men. Among them I have seen narrow-mindedness, but much more have I seen wide-awake, open alertness, and broad-mindedness --- willingness to look around and beyond and to listen. I think of earnest, cultured, wise Billy Evans as a fine example.

The pursuit of pure science or its application, as by engineers, can easily stimulate the kind of humility which is fertile ground for consideration of others, for the more one learns about the mechanisms of natural happenings, the more there is opportunity for wonder and for realization of how little we know. There are always questions beyond those answered with further answers needed to explain our explanations. Modesty becomes a scientist, and tall scientists grow humbler.

Beyond the materialism factor there is something else which encourages the misunderstanding of the scientist by some even today. It carries over from early times when the scientist was regarded as a misguided or visionary eccentric, as a dweller on Cloud 9, even as a wicked wizard. Jonathan Swift's Gulliver, on visiting Ladago, reported: (quotes) "The first man I saw was of meager aspect, with sooty hands and face, his hair and beard long, ragged, and singed in several places. His clothes, shirt, and skin were all of the same color. He had been eight years upon a project for extracting sunbeams out of cucumbers, which (beams) were to be put in phials hermetically sealed, and let out to warm the air in raw, inclement weather" (end quotes). This early investigator asked for financial help because there had been (quotes) "a very dear season for cucumbers" (end quotes). Glenn T. Seaborg, Director of the U.S. Atomic Energy Commission, has recently pointed out that there is measurable progress in our controlled thermonuclear program which encourages the hope that the effort to produce miniature suns will succeed. I guess cucumbers are still dear!

Seaborg goes on to say that we are in an era (quotes) "in which the scientist will achieve increasing stature as a human being because he is willing to look beyond the immediate results of his scientific endeavors to their social consequences" (end quotes). Glenn T. Seaborg, Nobel Prize winner and discoverer of several new elements, illustrates this, I feel sure, by doing administrative work for our Government instead of working in his laboratory.

For all that science has brought us to cause concern it has brought many times over knowledge beneficial in human welfare. This fact has been a strong stimulus, but it must be admitted that war and preparation for defense have been the most intense stimuli of scientific research, especially since World War II. Such research has been booming ever since the 1940's.

I can perhaps illustrate this booming growth in no better way than by pointing to Chemical Abstracts, whose work I directed during 44 years. With its abstracts and huge keying indexes this publication undertakes to report and to record in available form all of the world's new chemical information. Since chemistry is a representative science and Chemical Abstracts' coverage is worldwide, observations based on it have significant measuring values. I shall make only one observation. When I joined the staff in 1911 there were only five of us working in a room about one-fourth the size of this dining room. I imagine that all of you have seen the new Chemical Abstracts building just north of the University Campus. This building with 138,000 square feet of work space is just now being occupied by the staff of 545 local, full-time workers. It will be nearly filled at once; the staff has been scattered. About 3,300 part-time workers remain scattered all over the world.

Well, I must get back to my books. As candidates for the 1964 prize 33 books were submitted to the committee consisting of two Harvard professors, one from Princeton, one from the University of California, the Director of the New York Botanical Garden, and myself. If you want to know the judging procedure I shall tell you during the discussion period.

Manifestly I should not attempt to review these books here. I shall only take up a portion of them, picking out for comment isolated bits of information which interested me extra much. There is much to marvel at in the disclosures of science and to admire in the ingenuity of researchers, a statement which I hope does not seem immodest from one who has been a recorder, not a creator of scientific achievement. In particular, life on this earth, as disclosed by investigators, is a source of wonder.

There were four biographies in the collection of 33 books. These have to do with Ernest Rutherford, Charles Darwin, John Clayton, botanist, and Georges Curier, zoölogist. Each of these books is about half biography and half broader history of science in the times of the individuals whose lives are recorded. There is inspiration in such books.

The books on Rutherford and Darwin are very well written.

A disclosure which impressed me strongly is the fact that Rutherford, a mechanical and experimental genius who changed the whole trend in man's ideas of matter, worked with very crude and simple apparatus as contrasted with that available now. We are living in a time to appreciate the extremely significant influences on the world today of the unraveling of the nature of the atom by his personal accomplishment and leadership. The last paragraph of Rutherford's paper on "Radioactive change" says (quotes) "All these considerations point to the conclusion that the energy latent in the atom must be enormous compared to that rendered free in ordinary chemical change" (end quotes). This was in 1903. It was not until 1942 that atomic energy was released on a large scale in Enrico Fermi's pile at Chicago. And it was in 1937 when Hans Bethe worked out the cycle of atomic transmutations that probably maintains the sun's energy. Such is the foresight of genius.

I rated Sir Gavin de Beer's "Charles Darwin --- Evolution by Natural Selection" No. 2 in the contest. The author has carefully evaluated the circumstances which led to Darwin's work, and has given an admirable account of the scientific and social atmosphere of the day (Darwin lived from 1809 to 1882). The Darwinian revolution in human thought is still, after a hundred years, a primary creative force in modern science. This superior book will, I believe, parallel the long-lived "Life of Pasteur" by Vallery Radot.

All are so familiar with Darwin's work that I shall not dip into this book for comment beyond an incidental note that it was on Captain FitzRoy's Beagle of the British Royal Navy that the word "port" was substituted for "larboard" to assist mariners because larboard was so easily confused with starboard, a change which was generally accepted. How many know offhand which side of a ship is the port side?

A book submitted early for the contest was "The Last of the Few" by Kaave Rodahl, who, with his wife, spent several years among the Eskimos of Alaska. The scientific side of this book stems from the fact that Doctor Rodahl went to Alaska to study the Eskimo's adaptation to the arctic environment and to learn more about how man can become better acclimated to extreme cold. He became convinced that the Eskimo's ability to get along in his arctic surroundings does not depend on built-in endowments or racial peculiarities or on real physiological acclimatization. It is simply due to the fact that the Eskimo has completely adjusted himself to the environment. From childhood he is brought up to the art of arctic living. His mind is at ease, for he knows no better life. He is fully versed in the technique of survival in the Arctic. From childhood he has developed a liking for a diet of meat, which stimulates metabolism to higher heat production. His simple but practical garments of fur offer a far better insulation against the cold than does anything we can manufacture. He is smart enough to stay indoors in foul weather. In final analysis his ability to withstand the cold depends to a large extent on his ability to avoid it effectively. Physical fitness from a lifetime of vigorous exercise helps when he has to be exposed to severe cold. The Eskimo has survived by virtue of ingenious simplicity.

A sad further commentary is that the coming of the white man has not only brought decimating diseases to the Eskimo, but also has led to some physical deterioration because of altered diet and reduced natural hunting and other activities. This deterioration apparently can be attributed in part to the fact that Eskimos in Alaska have been put on unemployment compensation by our U.S. Government.

D. S. Halacy's book on "The Coming Age of Solar Energy" is timely on two counts: (1) We seem to be entering a space age, for which solar energy is ideal and essential, and (2) it is not too early to grow in resourcefulness as to our energy needs here on the earth. With rapid increase in world population and in use per capita of power our supply of fossil fuels (coal and oil --- stored solar energy) has been estimated to last only 100 years or less. Coal and oil constitute about 98% of our capital energy supplies and they were perhaps 300,000,000 years in the making. If Q is taken to stand for 30 billion tons of coal it can be pointed out that while the world is using about 0.1 Q of energy per year now the sun is annually drenching the earth with 2300 Q. Harnessing the sun's energy is regarded by the author as (quotes) "a far easier task than that of unleashing the atom *** a tricky and treacherous source of power." (end quotes) I add that I am more optimistic as to the dramatic promise of the atomic age. I understand that there has been a real breakthrough in the generation of electric power from atomic energy. Still I like the idea of currently using more of those annual 2300 Q of sunshine for power instead of waiting 300,000,000 years. Solar energy is now being harnessed in several ways.

"Waves and Beaches," by Willard Bascom, is good reading, though perhaps more for mechanical engineers than for scientists. Surely everyone is easily fascinated by the struggle for supremacy between sea and land. Collecting and transporting the energy of distant winds, the sea marshalls the force of its powerful waves against the land's strongest points. But the land defends itself with subtle skill. Sometimes it trades a narrow zone of high cliff for a wide low beach. The land constantly straightens its front to present the least possible shoreline to the sea's onslaught. When the great storm waves come, the beach temporarily retreats, slyly deploying part of its material in a sandy underwater bar that forces the waves to break prematurely and spend their energies in futile foam and turbulence before they reach the main coast. When the storm subsides, the small waves contritely return the sand to widen the beach again. Rarely can either of the antagonists claim a permanent victory. The waves and beaches of this shifting battleground, the surf zone, are the heroes of this book.

I learned from this book why the moon's gravitational attraction on the earth and its waters is the chief cause of ocean tides even though the sun's attraction is 150 times that of the moon and why the tides are the same on the side of the earth away from the moon as on the side towards the moon. Also I learned why tidal height is only one foot at Nantucket Island and 40 feet in the Bay of Funday, only a few miles away. It is good to read books which satisfy long-lived curiosity.

One more discovery from this book and then I must move on to another. Dangerous undertow on a beach is a myth. Orbital currents in waves and rip currents may cause some trouble to swimmers, but the former carries swimmers as much towards shore as out and one can readily escape a rip current by swimming a short distance parallel to the shore.

"Downstream: A Natural History of the River," by John Bardach, is a good story of animal life in and around fresh water. I found it extra interesting because canoeing on rivers was my hobby as a young man. Fishermen will like this book.

Just a comment or two about fish will get into this paper. One of the few generalizations which can safely be made about river life is that the bigger the river, the bigger the fish it will contain. The great rivers of the world are the homes of such giants as the rapacious Nile perch, the Mekong catfish, the Columbia squawfish, the arapaima of the Amazon, the sturgeons in the Volga and the Yangtze, and the disappearing paddlefish of the Mississippi. A sturgeon weighing 3,000 pounds containing 800 pounds of eggs (caviar) and probably 100 years old has been reported. The sturgeons of today are scarcely less primitive than their fossil remains, dating back 120 million years. Sturgeons hibernate in deep water under ice by sticking their heads down in the mud on river bottoms with their tails protecting like a forest of poles. The arapaima of the Amazon reaches twelve-fifteen feet in length and its flesh is to the inhabitants of the upper Amazon what beef is to the rest of Brazil. After trapping an arapaima in backwater and killing it the natives place a water-filled canoe under their catch and then bail out the water till the canoe with its big burden is afloat.

"Wasp Farm," by Howard Ensign Evans, is a charming book because of the obvious intense interest in wasps taken by the literate author. He finds the drama of evolution (quotes) "absorbing above everything else" (end quotes) and is content, in spite of convergence and reversals, to do what he can (quotes) "to put a few pieces of a very large and complicated puzzle in place" (end quotes). A good deal of this rubs off as one reads this fine book. Evans says: (quotes) "Wasps share our planet, but live in a different world. We would do well, now and then, to stretch out on the good earth with a notebook, camera, or sketch pad and chronicle the lives of some of our less selfimportant neighbors. To a person attuned to them, like myself, the world seems full of wasps" (end quotes). On his eight-acre wasp farm 100 of the known 250 species of wasps have been observed. By means of fossils the existence of wasps 200 million years ago has been observed and little change during this long period is apparent. Wasps are relatively scarce and make little impression on men and on the insects on which they prey. Perhaps the best that can be said for wasps is that at one point early in their history they gave rise to the ants, and at another point somewhat later on to the bees. Much depends on standards, but ants and bees are not failures by any standard.

"Desert Animals," by Knut Schmidt-Nielsen, fascinatingly deals with the physiological problems of heat and water. How do desert animals survive in their inhospitable environment?

Animals that live in the desert could attempt to reach a solution to the rigorous environment in three ways: (1) evade the heat, (2) put up with it, or (3) combat it by evaporating water.

The size of animals is important. Some animals have virtually no defense against overheating --- they do not sweat or pant. Owing to their large relative surface they would need too much water for heat dissipation and the only solution is escape. Small desert animals therefore are nocturnal. They come out of their burrows at night only.

In the water balance of an animal, gain and loss must be equal. In an environment where water intake is limited, only animals that can reduce their output can survive. It is therefore valuable for a desert animal to have an efficient kidney that can excrete a highly concentrated urine and an intestine that can remove much water from the fecal material, and, if possible, to have mechanisms that can reduce the evaporative loss of water. Since evaporation is the largest single factor in the water balance, and also the most variable, the ultimate success of a desert animal hinges on the manner in which the avenue for water loss is handled.

The kangaroo rat, which lives primarily on air-dried seeds without drinking water, maintains its water balance without stored water. This is done by water intake which consists of oxidation water in its food and by the utmost economy of water expenditure: a low evaporation, an extremely concentrated urine, and the formation of small amounts of feces with a low water content.

How about the camel? A whole paper could easily be written on this strange animal. The camel's exceptional tolerance of heat and water deprivation does not depend on the storage of water, the author says, though he adds that in a single drinking session it can ingest water over 30% of its body weight.

The hump contains fat, the metabolism of which yields more water than the weight of the fat, but there is more loss of water than that gained because the ventilation of the lungs to furnish the oxygen necessary for the metabolism of the fat involves more loss of water than that gained.

In the hot desert the camel exhibits a slow rate of water loss, mainly because of its fluctuating body temperature (this may exceed 6° C.) and the well-insulated body surface. The body temperature fluctuations are important in the water balance for two reasons. (1) As body temperature rises during the hot day, water otherwise needed to keep the temperature down remains unexpended. The excess heat is stored in the body and is dissipated to the cool environment at night without use of water. (2) An elevated body temperature reduces the heat flow from the hot daytime environment to the body, and therefore reduces the amount of water needed to prevent further temperature rise.

The camel sweats, but its fur does not become wet.

The camel has a powerful kidney. Under certain circumstances urea can be withheld from excretion and be resynthesized into protein by the microbial flora of the rumen.

In addition the camel can withstand considerable dehydration, at least 27% of its body weight, twice the dehydration which brings other mammals into lethal, explosive heat rise. When the camel becomes dehydrated the loss of water is not accompanied by a proportional loss in plasma volume.

The maintenance of a high plasma volume facilitates circulation, which is one of the first functions to suffer during dehydration of other animals by heat.

I think no one could fail to be interested in "The Thunderstorm," by Louis J. Batton. This most spectacular of our phenomena of nature was little understood till about 30 years ago. All know of Benjamin Franklin's kite experiment, but it was not until the introduction of modern electronic equipment such as radar and the expanded use of airplanes courageously flown into the midst of storms that it was possible to make the kind of measurements needed to describe the thunderstorm. Weather satellites help.

It is estimated that at all times an average of 1800 thunderstorms are in progress over the earth. In addition to the often-needed rain produced, these storms serve an essential purpose in preventing the temperature near the earth from getting too high. I wish there were time to go into the formation of thunderstorms, to talk about lightning and hailstorms, etc., but there isn't. May I lend you this book?

W. E. Knowles Middleton's "History of the Barometer" consists of almost 500 big pages of surprisingly interesting reading. The 17th century saw the invention of six valuable scientific instruments, the telescope, the air pump, the pendulum clock, the thermometer, and the barometer.

Particularly interesting in this book is the prehistory of the barometer for the days when the existence of a vacuum was denied on the basis of logic and the idea of a vacuum was anathema to the church. The Torricellian experiment marks the real beginning of the barometer as an instrument. Descriptions are given of literally hundreds of barometers developed to serve portability, provide corrections, improve accuracy, and facilitate weather predictions.

Sir Christopher Wrenn, builder of London's famous St. Paul's Cathedral and deviser of the first meteorological instrument, became interested in atmospheric pressure, and the Royal Society gradually developed in England from meetings of men, including Wrenn, started in the 1840's after the performance of England's first barometric experiments. Adolph Waller has told us of the origin of the Royal Society.

"These Fragile Outposts," by Barbara Blau Chamberlain, is a book on the geology of Cape Cod, Martha's Vineyard, and Nantucket, all three visible hilltops which are the final remnants of a once extensive coastal plain. The buried backbones of the Cape and Islands are the old coastal plain hills. The hill buriers were glaciers of two ice ages. The sea between the present main coast and the Cape and Islands was a coastal plain as late as about 6,000 years ago.

To the trained eye are visible the remains of creatures and forests which lived a million years ago.

This story of an historic portion of our country is one of the most charming of all encountered in this book adventure of mine.

George Gamow has written a book about an old friend of ours. It is entitled "A Star Called the Sun." This is a good book, but I shall note here only a few statistics and observations.

The diameter of the sun is 109.1 times that of the earth. The mass of the earth is 5.966×10^{27} grams and the value of its mean density is 5.52 with respect to water. The mass of the sun is 331,950 times as large as is the earth. I omitted giving the millions of square miles on the earth's surface because parking frustrations are big enough.

The surface temperature of the sun is about 6000° C. and the temperature near its center is about 20,000,000° C. In this center the material has a density about 100 times that of water. A pint of it would defy lifting by you or me. We know more about the interior of the sun, about 93,000,000 miles away, than we do about that of the earth, 4000 miles below our feet. This is because the earth consists of solid and molten materials whereas all stars are made of plasma, the "fourth state of matter," which possesses very simple and easily predictable properties.

The sun derives its energy supply from the nuclear reactions which take place in a relatively small region near the center. Surprisingly, the rate of heat liberation in the sun's body is only a fraction of one per cent of that in the human body due to the metabolic processes. Why, then, is the sun so hot? The explanation is simple. The rate of energy production within a given volume is proportional to that volume, i.e., proportional to the cube of its size. On the other hand, the heat losses are proportional to the surface, i.e., only to the square of the size. Therefore, the larger a body is, the less is the rate of heat production necessary to maintain its temperature.

The body of an elephant metabolizes about one-thirtieth as rapidly as does that of a sparrow. If an elephant metabolized as rapidly as does a sparrow we would soon have roast elephant, more than even Nov Fawcett could eat at a buffet-dinner sitting. I wonder if this will give ideas to such ample and glamorous dinner producers as Clark Pritchett and Kristopher Lacey Kat!

The sun is made of essentially the same chemical elements as make up our earth. Its atmosphere is 99% hydrogen and helium, the two lightest elements.

It is difficult to stop talking about the sun, but I must.

"Exploration of the Moon," by Franklyn M. Branley, is timely, but I have reached this book at an untimely part of this paper. I shall give only the author's conclusion, namely, that (quotes) "man's destiny is not to remain earthbound" (end quotes).

Other contesting books which I shall not have time to discuss at all have to do with: (1) "The Process of Ageing," (2) "Philosophical Problems of Space and Time," (3) "Biology of Birds," (4) "Breakthroughs in Mathematics," (5) "Brains and Machines," (6) "The Physical Foundations of the Psyche," (7) "Heat and Life," (8) "Missles," and (9) "a history of astronomy."

In addition there is a book entitled "The Enjoyment of Chemistry" which I shall skip, not because of any lack of interest, but because of too much interest to be just a part of such a paper as this is.

May I put in an incidental paragraph here? Exactness is essential in scientific investigation. Exactness should be regarded as essential in the reporting of scientific information. Too often poor nomenclature and poor language in scientific writing defeat exactness. In a number of the contesting books bad English was rather frequently found. For example, I repeatedly found such expressions as "Star A is 25 times smaller than Star B." That is an awkward, fuzzy statement. Presumably the author means "one-twenty-fifth as large." One time smaller would be zero. I am a great believer in pride of pen.

Now I shall end this paper with a few paragraphs about the book which won the contest --- Verne Grant's "The Origin of Adaptations."

I cannot here do justice to this big, well-written book (606 pages), but I want briefly to picture a few high spots which stirred my interest. In particular I enjoyed Grant's stage setting with general and organismic background information.

The theory of evolution is one of the great theories of science.

The author speaks of cosmic evolution, which he divides into four phases.

The original and basic form of matter seems to have been the hydrogen atom. Hydrogen atoms have undergone nuclear reactions inside the stars to form the other more complex types of atoms, such as helium, carbon, nitrogen, oxygen, sulfur, and iron. All atoms consist of the same few basic particles --- protons, neutrons, and electrons, plus other particles which barely exist outside the atomic nucleus. The formation of the elements, a gradual process, may have continued into the earliest period of earth history.

This largely preterrestial phase of development of the universe is called the stage of atomic evolution.

The second stage of cosmic evolution is the period during which the different kinds of atoms became combined into chemical compounds of varying degrees of complexity. This phase, chemical evolution, lasted from an early period in earth history until about one and a half billion years ago.

It is believed that during the latter part of the period of chemical evolution conditions existed which permitted the formation and accumulation of very complex carbon compounds. Such compounds could have served as the food materials for the simplest and most primitive forms of life, assumed to have originated at this time. The origin of life initiated the third phase of cosmic evolution, called organic evolution. This occurred at some unknown time when the earth was still fairly young (perhaps about the year 1.5 billion on the basis of the life of the earth). Organic evolution has continued at an ever-increasing tempo up to the present time.

The time span of organic evolution has encompassed immense transformations in the world of life, transformations from submicroscopic organisms to giant trees 200 feet tall, and from simple biochemical systems to complex animal bodies. Life has multiplied from a small number of individuals to countless billions of individuals filling every inhabitable spot to saturation, and diversified from a few similar kinds of organisms to millions of species fitted for life in different parts of the land, seas, and air.

One of the products of organic evolution was an erect, two-legged, ape-like mammal which roamed the savannahs of Africa and Asia about a million years ago. This creature was the ancestor of modern man, who by virtue of a peculiar combination of factors --- tool-making, social grouping, learning ability, and language --- was destined to enter upon a fourth phase in cosmic evolution, called <u>cultural evolution.</u> This phase is marked by the growth and the transmission from generation to generation of a cultural heritage. This heritage, consisting of cumulative knowledge and understanding of the world, has made man the master of his outer environment to a large extent and may yet give him mastery of himself.

Can we hope for another stage, <u>spiritual evolution</u>?

To a degree all of the phases of cosmic evolution continue.

I wish I could go on to report what is said concerning the origin of life on the earth. I shall have to be satisfied by reporting the conclusion that life is a unique type of chemical system, one in which all of the special attributes (organization, self-maintenance, growth, reproduction, mutation, and evolution) are present together. Primarily nucleic acids make up the chemical system.

The diversity of organisms generated in the course of evolution is very great. Known are 8,600 species of birds and 3,200 species of mammals. Some 20,000 species of fishes and 850,000 species of insects have been described. There are 80,000 species of mollusks, 4,500 of sponges, and over 18,000 of wormlike animals. The lower vascular plants run to 10,000 known species, the algae to 8,700, and the fungi to over 40,000. Described species of flowering plants can be estimated as 286,000. Of course, the task of describing species is far from completed.

Nearly every part of the earth's surface is inhabited by life. Living organisms are found in the surface of the sea and in the great ocean depths, on the land from the tropics to the polar latitudes, and thousands of feet high in the atmosphere. Bare rocks are colonized by lichens, glaciers by red algae, and hot springs by blue-green algae. No one organism, however, lives in all of these varied environments.

The reason why each kind of organism is restricted in nature to its own habitat is that it is specialized or adapted to making a living under one particular set of conditions. Adaptation, or hereditary adjustment to the environment, is one of the universal features of life. Evolution consists in changes in the heredity of organisms.

So much for high spots from the book's extensive preliminary chapters. Here I can give only a descriptive or indicative abstract of the meat of Verne Grant's thrilling story of how adaptations occur. He summarizes the genetical theory of evolution within populations of organisms and then undertakes to extend the causal approach of the population geneticists to the more complex phenomena of specialization. After that he considers the applicability of the system of evolutionary mechanics developed to change on a macroevolutionary scale. He discusses organization and causation in biology, the nature and origin of life, the general course of evolution, adaptation and adaptability, hereditary variation, natural selection, genetic drift, the nature of races and species, isolating mechanisms, ecological relations among species, evolutionary divergence, modes of species formation, and evolutionary rates and trends.

As we have observed in our own lifetimes, species sometimes die out, become extinct, but many more live on and on with little change or with diversification through adaptation to changing environment. I can only hope to have whetted your appetite to read of the much that has been learned concerning the mechanism of the marvelous evolutionary changes from single-cell scum to our wisest and most cultured man. Or perhaps I might say from the hydrogen atom to everything. The much that is known is really only a very small part of all that remains to be learned.

Coming out from under this pile of 33 freshly written books on science I am filled with a renewed sense of wonder at the orderliness and pattern in nature. Also more than ever I marvel as I admire what men have learned since the Middle Ages, when they felt impelled to depend on the writings of traditional authorities instead of depending on direct observation of nature. Acceptance of direct observation, the scientific method, is the great turning point.

I am tremendously impressed that men have been able to do such things as weigh the earth, determine the composition of the stars, probe the moon, leave and rapidly encircle the earth with controlled, safe return, defeat many diseases, read the story of eon-old fossils, develop computers, and both discover and extensively study particles far below visibility.