• AUGUST 1949

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RESEARCH REVIEWS

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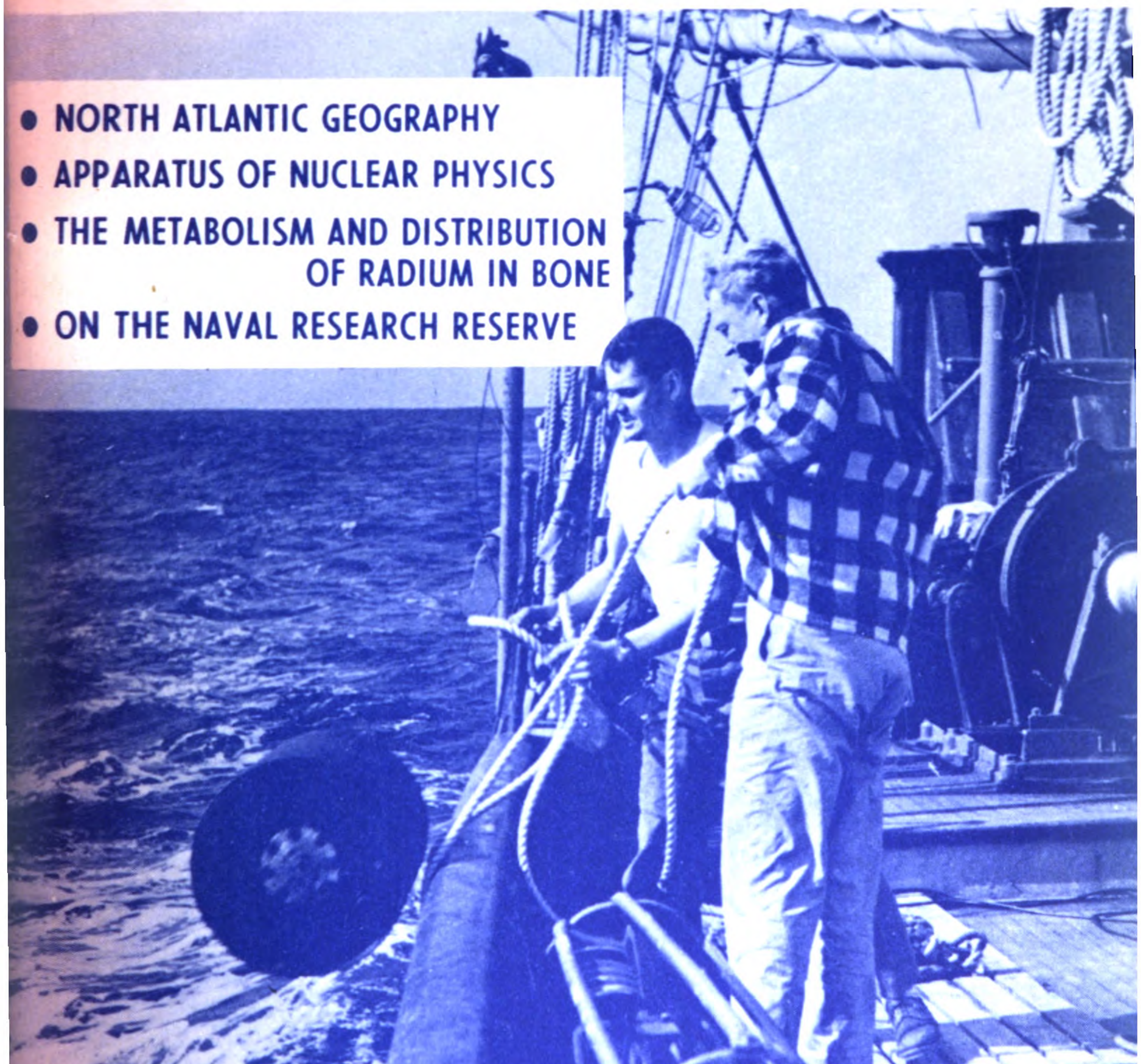
• THE METABOLISM AND DISTRIBUTION OF RADIUM IN BONE
• ON THE NAVAL RESEARCH RESERVE



OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

NAVEXOS P-510

COVER PHOTO: A depth charge is heaved over the side of the research vessel ATLANTIS. Seismic waves set off by the explosion of the charge are recorded on another ship several miles away to obtain information on the character of the rockbed beneath the ocean floor.

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AUGUST 1949

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RESEARCH REVIEWS

● Informs the Fleet of ONR-sponsored Research

Editorial Notes

About three-fourths of the funds of ONR are used to contract for basic research with scientists in our leading universities; the remainder is divided between industrial and government laboratories. From the discoveries made in basic research come the truly revolutionary developments, and ONR-sponsored research has resulted in scientific achievements of benefit to all citizens as well as to maintenance of adequate naval forces in peacetime. A few of the many discoveries and developments resulting from this research are highlighted here.

● Striking progress has been made in eliminating the fire and explosive hazards in aircraft by the development of a new hydraulic fluid called hydrolube U-4. Because this hydrolube effectively eliminates fire hazards, its use may be made mandatory by the Civil Aeronautics Authority for all commercial aircraft. It is also coming into a number of industrial applications, quite apart from its originally intended use.

● New avenues in welding research and high strength steel treatment have been opened through the findings of a Navy project which determined that austenite can be retained in fairly large amounts in very low carbon steels. The development of a new sensitive test method for the analysis of hydrogen in steels will lead us to better controlled qualities in steel.

● Synthetic mica which can be made in bulk form and readily machined with ordinary machine tools to form many electrical insulator parts is now being considered for commercial production.

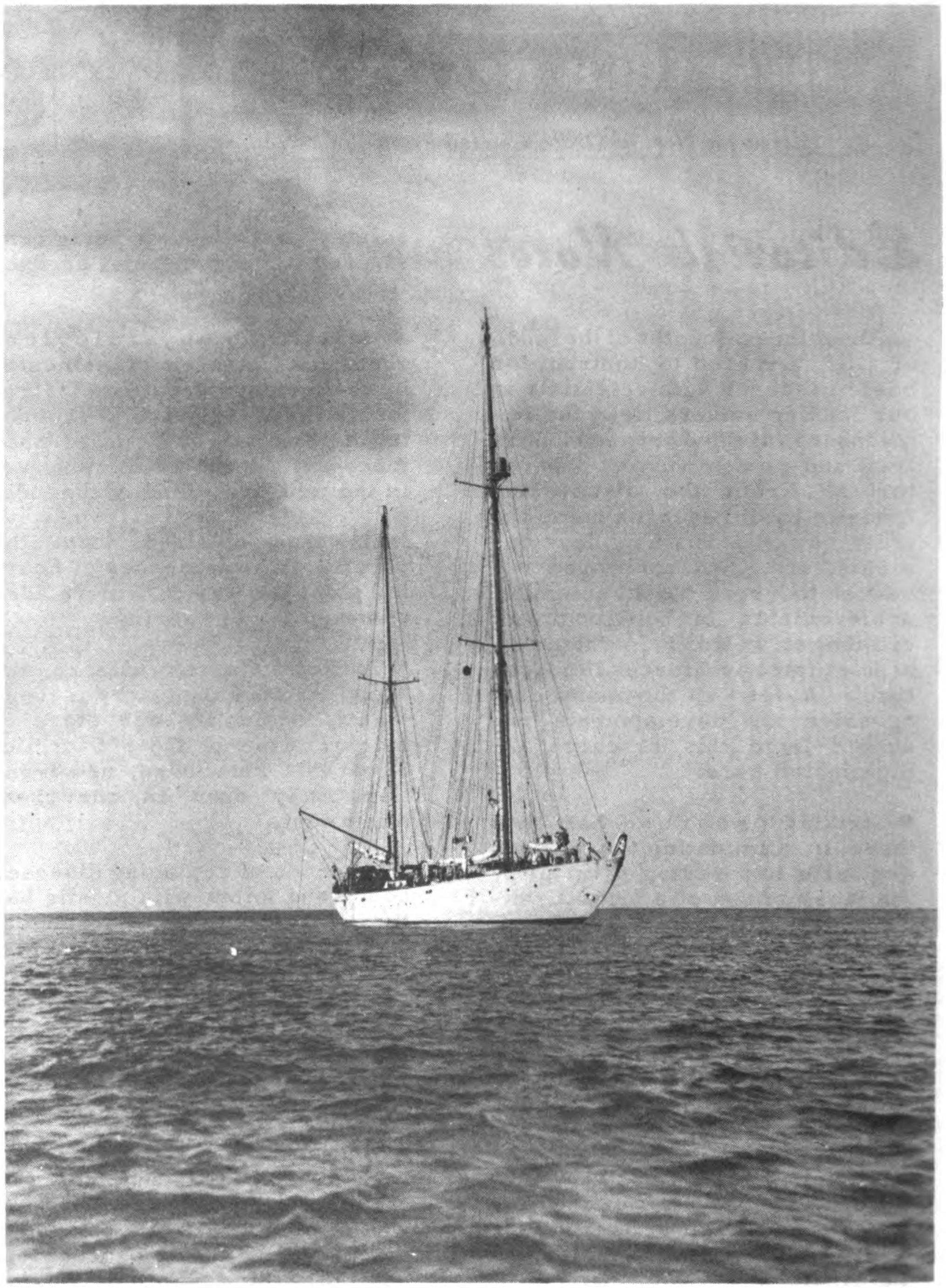
● Research in physiological acoustics has been implemented by the development of new instruments for the electrical recording of potentials in the middle and inner ear, in the auditory nerve, in the mid-brain, and in the auditory cortex. Previously unknown facts thus obtained about the physiological processes of hearing point the way to a more adequate theory of hearing.

● At Point Barrow, Alaska, the Navy Arctic Laboratory is constantly adding to our store of knowledge of the sub-arctic. From this knowledge, new frontiers may open in our great Northwest.

● A means of replacing diseased bones and joints with plastic has been developed in a project at Columbia University. Rehabilitation of persons who would otherwise be permanent invalids is foreseen.

● Preliminary data from a comprehensive experiment being conducted in a large business organization under Navy sponsorship indicate that group output can be significantly increased by making simple changes in supervisory and management procedures, costing nothing either in training or operational expense.

● Projects are being sponsored using completely germ-free animals, which afford research workers a unique opportunity for studying disease, nutrition, and hereditary transmission. In Navy dental research, using germ-free animals, it has been proved for the first time that bacteria are necessary for the production of dental caries.



The research vessel ATLANTIS which is engaged in scientific exploration of the North Atlantic Ocean. Shown here at an anchor "station," on a previous voyage in the Mediterranean Sea, she is at present preparing for her one hundred and fifty seventh cruise which will be in the Grand Banks area. In the pursuit of science, the ATLANTIS spends an average of 250 days a year at sea, and since the end of the war has secured approximately 70,000 miles of continuous sonic soundings.

NORTH ATLANTIC OCEANOGRAPHY

C. O'D. Iselin
Director, Woods Hole Oceanographic Institution

The research vessel ATLANTIS of the Woods Hole Oceanographic Institution, at the end of the war, resumed the scientific exploration of the North Atlantic Ocean. Since that time she has been at sea an average of 250 days each year, compared to about 200 days each year during the ten pre-war years of her existence. Thanks to improved instrumentation, the research ship is adding greatly to our store of physical observations. Each day at sea in the post-war period accomplishes about as much as a week's work before the war.

An imposing body of data has now been accumulated for the western half of the North Atlantic and the head start of the European oceanographers in the northeast has been overcome.

But why are oceanographers still devoting so much effort to the collection of more or less routine data from the North Atlantic where scientific vessels have been operating almost continuously since the 1870's? The North Atlantic has the distinction of being a relatively small ocean and until at least one ocean can be described in satisfactory detail, the scope of the problems involved can only partially be understood. For example, the path of the permanent ocean currents is closely associated with the bottom topography and, even in the North Atlantic, this is only known in very broad outline. Since the war, the ATLANTIS has secured about 70,000 miles of continuous sonic soundings. It is hoped that, when these are combined with the more scattered records of Navy ships, there will be a reasonably reliable chart of the bottom topography as a starting point for studies of the North Atlantic current system.

Until recently, the currents themselves could be studied only indirectly. The classical approach was to observe the subsurface distribution of temperature and salinity at a network of stations 20 to 60 miles apart, and then to compute from these data the steady state current system, taking into account the effect of the earth's rotation and assuming that at some deep layer--for example at 2,000 meters--the flow is negligible. The file of such data from deep water in the North Atlantic now totals about 6,000 stations. However, because of short period variations and the large interpolations involved, this procedure only gives satisfactory results in regions of relatively strong currents.

C. O'D. Iselin has been associated with the Woods Hole Oceanographic Institution since it was established in 1931, first as captain of the research vessel ATLANTIS and since 1940 as director of the Institution. In addition to a number of programs in basic oceanography and marine meteorology supported by ONR, the Institution is conducting research in underwater acoustics for BuShips and in underwater explosive phenomena for BuOrd. The laboratory and sea-going facilities are also being used by several groups from eastern universities.

The introduction of Loran and rapid temperature measuring techniques has changed the situation greatly. If frequent enough fixes are obtained, it can be known at all times how the research vessel is being set by the currents and the subsurface observations can be placed where they will do the most good. The general picture which is emerging from the new surveys shows the currents, especially in the western part of the North Atlantic, as much narrower and much swifter than had formerly been supposed. East of Cape Hatteras the Gulf Stream meanders like a huge river in a level valley, from time to time throwing off large anticlockwise eddies south of its mean track and clockwise eddies to the north wherever space permits, as in the bight off New York. Maximum surface velocities of six knots are not uncommon along the narrow axis of the Gulf Stream or in newly formed eddies. Celestial navigation was too crude to show up the true character of the currents, and statistical averages of large numbers of ship reports produced current charts whose accuracy would be comparable to weather maps derived solely from mean monthly barometric data.

The search for a reliable method of observing currents at subsurface levels is being vigorously pursued. The equivalent of the pilot balloon in meteorology is needed, and in this connection the theory of the electric field induced in deep ocean currents, recently published by Stommel, provides a promising lead.

The circulation problem is the central unifying theme of oceanography. Whether it is biological oceanography or physical oceanography, investigation cannot progress far without taking into account the movements of the waters. The circulation problem is closely connected with the shape of the ocean basin and also with the exchange of energy between the ocean and the atmosphere.

It has long been recognized that currents derive a large part of their energy from the winds, yet it must also be true that the ocean is a heat generator on a huge scale. The major objective of physical oceanographers for many years to come, as in the past, will be to understand in what circumstances and to what extent the distribution of temperature in the sea is the result or the cause of ocean currents.

Curiously enough, very little reliable data on wind currents has yet been collected. How long does the wind have to blow in order to set up a current? In what direction will this current flow and how rapidly will it deepen? Such fundamental questions as these have been approached only through simplified theoretical considerations. One reason for the lack of basic data on wind currents is the great expense of operating a modern research vessel. To remain in one spot in order to observe the development of a phenomenon or to wait for a situation to arise which will provide a convincing experiment often seems poor economy to the oceanographer. It frequently appears more rewarding to concentrate on the geographical aspects of the oceans and simultaneously collect as many different kinds of observations as possible.

The ATLANTIS is at present preparing to start out on Cruise #157 which will cover a considerable area north and east of the Grand Banks. (A chart of the vessel's cruises during 1947 is shown in Figure 1.) A brief definition of the observational routine generally carried out on the ATLANTIS follows. An average cruise lasts about two months and

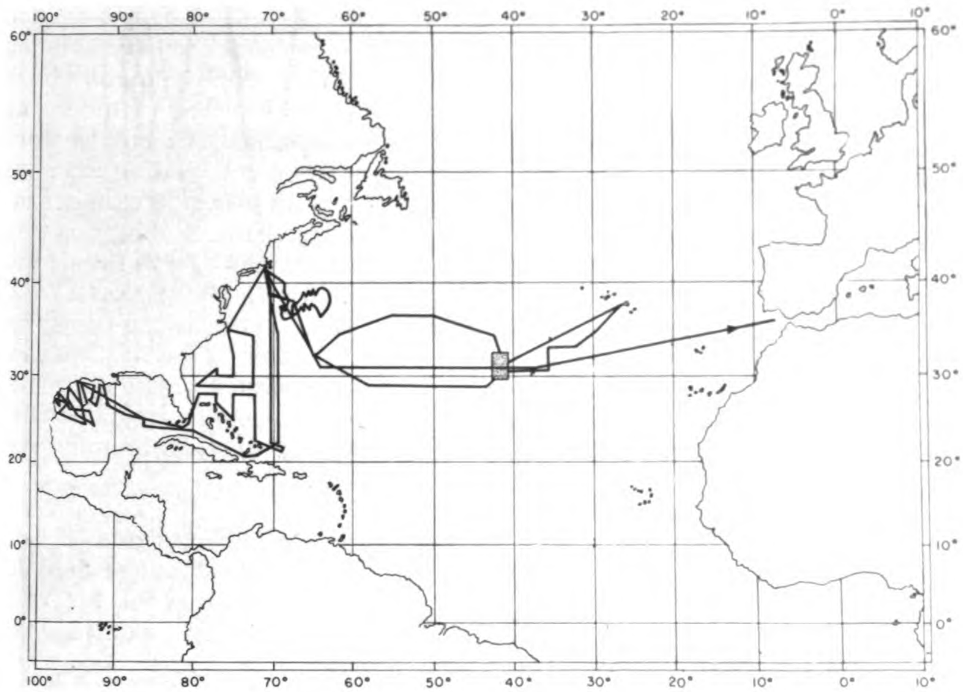


Figure 1. Cruises made by the ATLANTIS during 1947.

covers about 6,000 miles. The recording Fathometer is turned on when the vessel reaches the edge of the continental shelf. Until the end of the voyage, this precious tape must be carefully correlated with the navigational record. There is, however, a fundamental problem in the operation of the echo sounder. The geologists are naturally concerned with keeping the instrument adjusted to provide the clearest possible record of the depth; on the other hand the biologists and those interested in underwater acoustics are interested in recording the depth and intensity of the so-called scattering layer, which occurs at a few hundred fathoms below the surface. It seldom happens that a clear record of both phenomena can be obtained by one setting of the dials.

Every half hour a bathythermograph lowering is made and every half hour a hydrophone is streamed to obtain the arrival times of the echoes of a small explosive charge tossed over the stern. In this way, the thickness of the unconsolidated sediments on the ocean floor is obtained. Again, there is a conflict of interests to be resolved. The courses dictated by the incoming bathythermograph slides, which would best relate the temperature distribution to the currents, are not always the best from the standpoint of geophysics or of the bottom topography. Frequent changes in course complicate the navigational problem, but they are the means of effectively exploring the details of the physical characteristics under observation.

About twice a day, the ATLANTIS is hove to for an hour and a half or more in order to obtain a series of deep water samples and to observe the temperature distribution in the layers below the limit of the bathythermograph.

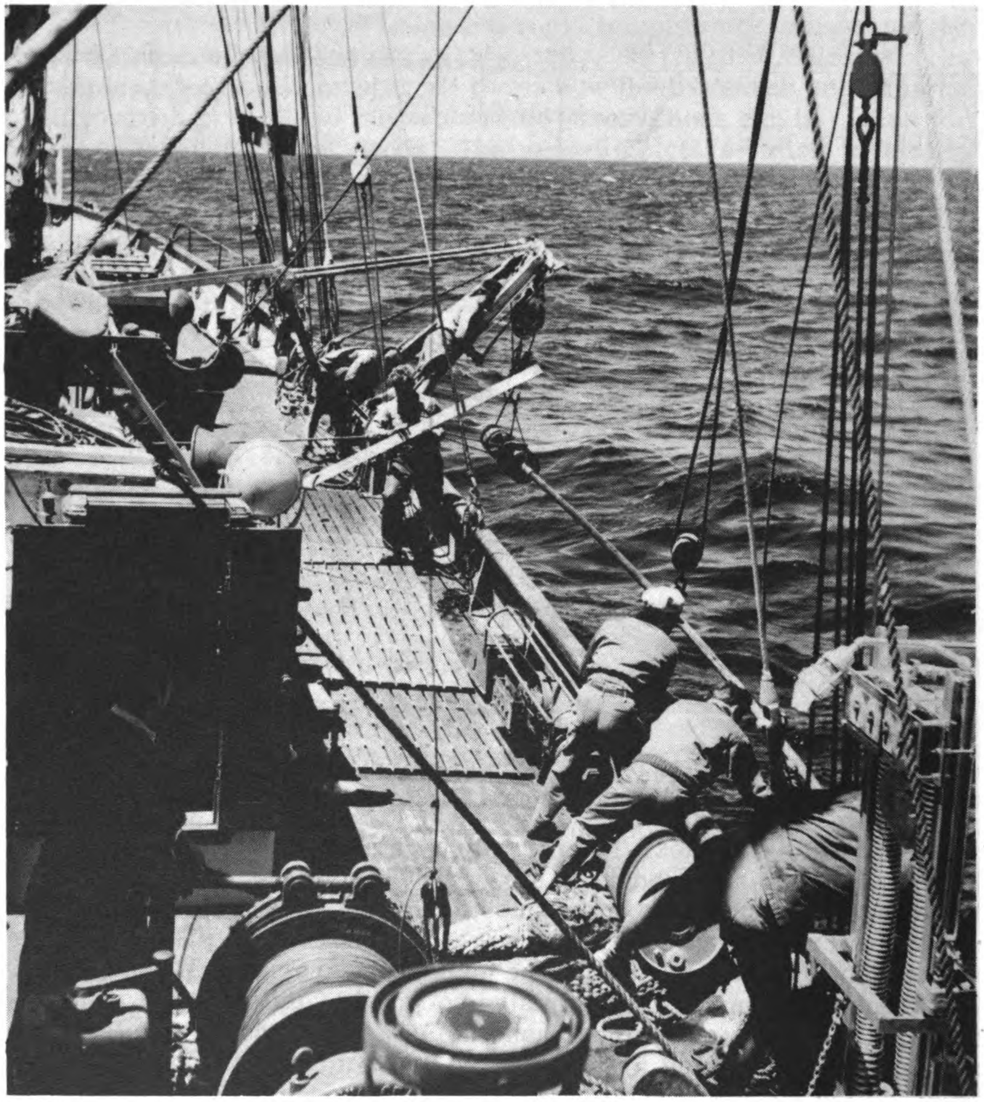


Figure 2. A long coring tube is taken alongside the rail of the ATLANTIS, after a lowering. Cores of sediment more than thirty feet in length have been obtained with this device.

It is difficult to decide how many stops are necessary to secure deep observations. Some cruises are primarily devoted to such observations, while on others the main purpose is to exploit the instruments which can be used when under way. The development of the piston-type coring tube, which can bring up sections of the bottom sediments thirty or more feet in length, (Figure 2) is a strong inducement to stop at least once each day. Through the study of such cores from deep water, much of the recent geological and climatological history of the earth can probably be charted. In good weather it is possible to obtain deep water samples and temperatures with the hydrographic winch at the same time that the heavy coring tube is being lowered on the trawl winch. Although there is some chance of fouling the two long cables, the time saved often justifies this risk. Sometimes a third lowering on still another winch is risked in order to obtain quantitative plankton hauls or other biological observations.

The scientific personnel necessary to keep a cruise going 24 hours a day totals at least nine men. The crew of the ATLANTIS totals seventeen. Fuel, food, supplies, insurance, depreciation and the inevitable losses of cables and instruments bring the costs of deep sea research on the ATLANTIS to about $600 per day at sea. This is about three times the pre-war rate and it would be out of the question today to operate the ATLANTIS solely on income from the endowed funds of the Institution, as was done before the war. Although new instrumentation and machinery provided by the Navy have made the ship a much more efficient floating laboratory, she could seldom be used were it not for investigations being carried out under contract with the Government.

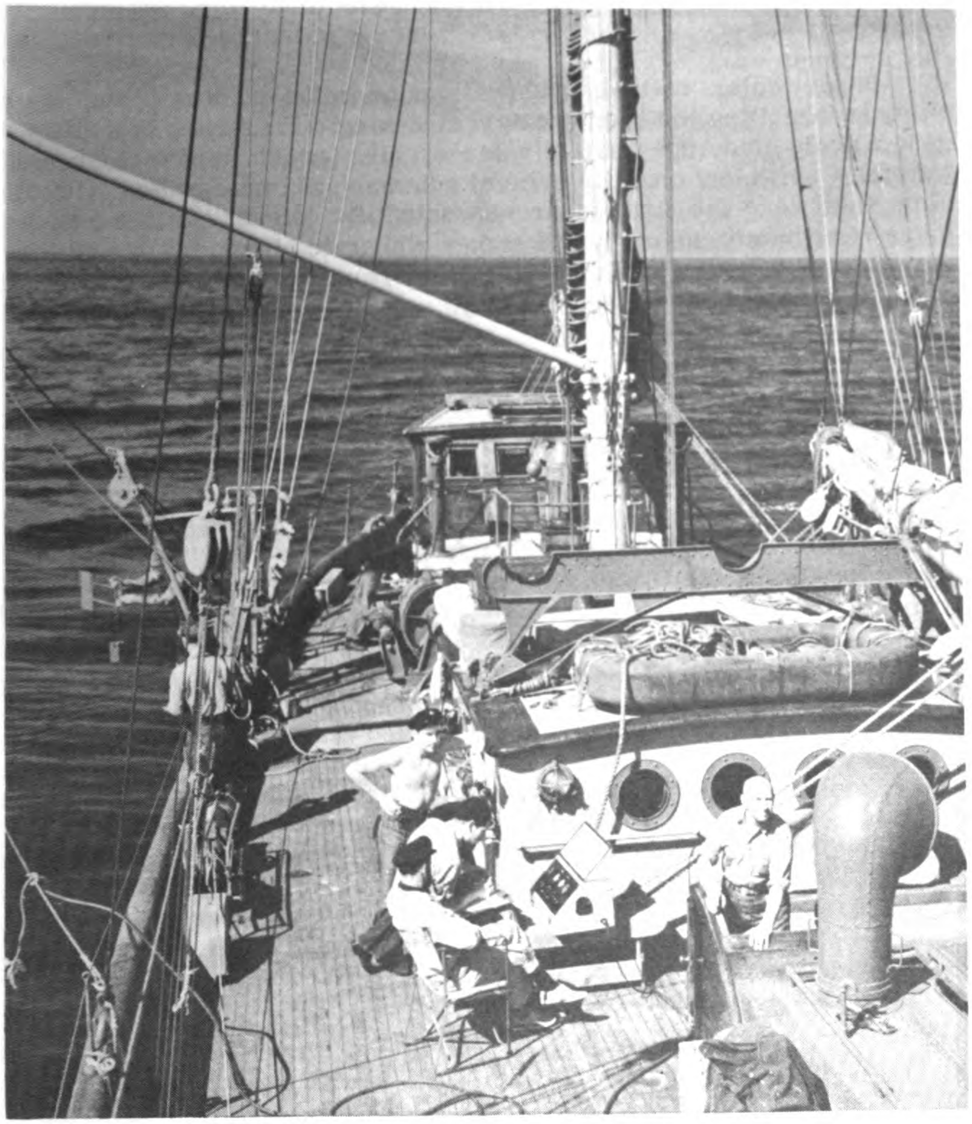


Figure 3. Deck view of the ATLANTIS on "station." In the background, a current meter is ready to be lowered. In the foreground, the dials of an electronic current meter, already lowered over the side, are being observed.

The ATLANTIS is playing a unique role in the development of oceanography. She is the only non-Government vessel in this country which regularly cruises over wide areas of the ocean, and on which graduate students can become familiar with the sea and with the many instrumental techniques now being employed (Figure 3). The ATLANTIS has been the means of perfecting many of these techniques, some of which are now in routine use on Government scientific vessels. Her continued operation will mean the advancement of oceanography of the North Atlantic beyond the exploratory stage, and in all probability the perfecting of improved methods for the scientific examination of the other much larger oceans.

The great usefulness of the ATLANTIS is her versatility. She can be and is used for all sorts of science at sea. However, at present the physics and geology of the ocean overshadow investigations in marine biology.

In particular, reliable observations as to the quantity of the larger animals inhabiting the open ocean are lacking. Fisheries biologists in general only study the relatively few species which appear in coastal waters in sufficient quantity to be of commercial importance. Although biologists were the first to arouse scientific interest in the sea and there were numerous early and rather elaborate biological expeditions, the sea still constitutes a vast biological frontier, the full significance of which can only be guessed at today.

THE APPARATUS OF NUCLEAR PHYSICS

T. Lauritsen
Kellogg Radiation Laboratory
California Institute of Technology

A great deal has been written in the past few years about the extremely high energy machines of nuclear physics: the synchrocyclotron, the synchrotron, and the bevatron, all massive, spectacular devices producing accelerated particles with energies in the hundreds of millions of volts. Certainly, there is little question that in such projects lies the hope of many new important discoveries and, probably, of an eventual understanding of the fundamental particles--protons, neutrons and mesotrons--which comprise the atomic nucleus. On the other hand, there is still a significant place in the field for the more conventional, lower energy accelerators, such as the electrostatic accelerator or the transformer-rectifier set, which develop voltages from a few hundred thousand to a few million volts, as many interesting nuclear phenomena occur in this region. High energy machines utilize forces of such tremendous magnitude that the nuclei are almost completely broken up; these machines are therefore most suitable for experiments in which the scientist wishes to study the properties of the component parts of the nucleus. In order to study a nuclear system as a whole, however, the lower energy machines are most useful, since these employ lesser forces which merely excite the nucleus.

As a crude analogy, let us consider the investigation of a piano by striking it with projectiles. Small, high-speed projectiles striking individual strings in the piano could indicate a great deal about the characteristics of the strings as individual parts; in fact, if sufficiently fast bullets were used the behavior of the target strings would be almost independent of the remainder of the structure, and would reflect mainly the properties of the materials of which the strings were composed, rather than their function in the piano. If, instead of bullets, footballs were used to investigate the piano, it is clear that the information obtained would mainly reflect the characteristics of the whole structure. Relatively light impacts would cause the strings to vibrate and emit sound waves, producing notes characteristic of the piano itself and indicative of the manner in which it is constructed. With sufficient information on all possible kinds of oscillations which could be excited in the complete structure, it might be possible to deduce the properties of the individual strings and of their interrelation in the assembly.

Admittedly the analogy between a nucleus and a piano is not very close. It is nevertheless true that with energies of some hundreds of

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T. Lauritsen, assistant professor of physics at California Institute of Technology since 1946, is now associated with the ONR-sponsored nuclear physics research project under which nuclear reactions of light elements are being studied. After taking his Ph. D. in physics in 1939 at California Institute of Technology, he was a Rockefeller Research Fellow at the Institut for Teoretisk Fysik, Copenhagen 1939-1940. During the war years, Dr. Lauritsen worked on OSRD projects.

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millions of volts, we can localize particles sufficiently well to distinguish interactions among the individual parts of the nucleus. On the other hand, by the addition of relatively small amounts of energy to a nucleus, we can induce vibrations, or more precisely, we can produce excited states of the nucleus--states in which the system can remain for a finite time before returning to the original, most stable configuration, or before changing spontaneously into an entirely different system. In fact, each nucleus has a large number of such quasi-stationary excited states with more or less well defined energies, and the distribution and properties of these states differ for the various nuclei in what appears so far to be a somewhat erratic way. Only by considering fairly large groups of states have we been able to distinguish any regularity in their dependence on, for example, the number of particles in the nucleus. This amount of information alone has helped to give us a good working picture of the structure of the heavier nuclei. For more explicit information we must learn a great deal more about these excited states than their distribution in various nuclei. We need precise measurements of the characteristics of each state, its energy, its lifetime, exactly how it can be produced, and how it loses its excess energy. To obtain this information, we need good tools, not necessarily the most powerful ones, because the energies required are not so great, but tools capable of high precision. Perhaps an examination of a typical experiment will illustrate this need for precision.

To excite a nucleus, it must be given additional energy in one way or another. Ordinarily the most convenient way of accomplishing this is to make the nucleus by a transmutation process. For example, if we wish to study the boron nucleus of mass 10--consisting of five protons and five neutrons--a thin piece of beryllium metal can be bombarded with high-velocity hydrogen nuclei (protons). Some of the protons will penetrate the target or be lost, some will strike beryllium nuclei and rebound, and some will enter the nuclei and produce transmutations. Because the beryllium nucleus has four protons and five neutrons, the addition of a proton makes boron-10, with an excess energy compared with natural boron-10. This excess energy is derived from the energy of the bombarding protons (about one million volts) and from conversion of some of the mass into energy (about six million volts). Now it appears that if we use exactly 988 kilovolts to accelerate these protons, we produce boron-10 in a quasi-stationary state with some 7.4 million electron-volts excess energy. At slightly higher or lower voltages we can still produce boron-10, but the amount produced with a given number of protons decreases rapidly. In other words, there is a resonance for the production of excited boron-10 at 988 kilovolts bombarding energy. If the bombarding energy is increased to exactly 1,077 kilovolts, there is again a sharp increase in the production of boron-10. If the beryllium target is very thin, the yield will be reduced to half by a change of one kilovolt either way from the peak value. To study this reaction, the voltage of the machine must therefore be held constant to better than one part in a thousand and all protons must have the same energy to this accuracy.

Once we have produced one or the other of these excited states of boron-10, we are interested in knowing what happens to them. In these particular cases, a number of things can occur: radiation can be emitted, removing the excess energy and leaving normal boron-10; or the nucleus may break up, emitting heavy hydrogen nuclei (deuterons), helium nuclei (alpha particles) or re-emitting the protons. With so many particles involved, detecting instruments must have sufficient resolving power to differentiate between the various emitted particles and to measure accurately their energies. Here again, we require precise instruments which are capable of measuring the energies of these extremely minute objects to fractions of one percent. A common method for such measurements relies on the curvature of the trajectory of a charged particle in a magnetic field. From the strength of the magnetic field and the curvature, the energy can be calculated with an accuracy determined by the precision of the measurements of the field and the curvature.

Such procedures as those described, when applied to all the excited states of the nuclei, imply a long experimental program, both in actual measurements and in the design and construction of suitable apparatus. However, our experience in other fields of science leads us to the conviction that eventual understanding of atomic nuclei can only be obtained from precise knowledge of the structure as a whole, as well as of the properties of the individual parts. Either approach requires development of highly specialized machines and techniques and the painstaking accumulation of an enormous amount of reliable and accurate data. At the present stage of the art, we cannot predict with certainty whether the most useful information will come from the hundred-million-volt region or from the regions of lower energies. We can only state that the two approaches are supplementary and mutually interdependent, and hope that by assiduous pursuit of both techniques, we may learn some of the answers to the "whys" of the nucleus.

THE METABOLISM AND DISTRIBUTION

OF RADIUM IN BONE

Frank E. Hoecker and Paul G. Roofe
University of Kansas

Interest in the metabolism of radioactive substances in the body was first aroused by cases of radium poisoning which resulted from the handling of radioactive powders. In many of these cases, death followed the development of osteogenic sarcoma. Post mortem studies of the bones of certain victims of osteogenic sarcomas, whose history showed association with radioactive substances, revealed the presence of radioactive substances in the bones. Eventually, studies on living persons suffering from radium poisoning, and on laboratory animals disclosed that radium (the chief substance responsible for early cases of radioactive poisoning) when taken into the body is ultimately deposited in the skeleton in such a manner that its elimination or removal is practically impossible.

The development of nuclear energy sources, the increase in the number of persons handling radioactive substances, and the possibilities of radioactive warfare have, during the past five years, greatly intensified interest in the metabolic fate of radioactive substances which enter the human body. Numerous studies have been undertaken to trace the course of diseases induced by the radiations from these substances.

Among the more interesting of these diseases are the osteogenic and osteolytic sarcomas whose development has been so frequently associated with, and hence attributed to, the presence of radium metabolically deposited in the bones. Since by far the greater portion of the energy liberated by the disintegration of radium and its product in the tissues is due to alpha-particles, and since the concentration of energy absorbed by the tissue from alpha-particles is greater than from the

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Frank E. Hoecker an associate professor of the Department of Physics and Astronomy at the University of Kansas, received his Ph. D. degree from that University in 1935. He was chairman of the Department of Physics at the University of Kansas City from 1934 until 1942. At that time, he accepted the position of senior physicist with the U. S. Public Health Service, where he supervised the protection of individuals handling radium. In 1944, continuing as special consultant to the U. S. Public Health Service, he joined the research staff of the Radiological Research Laboratory at Columbia University. Dr. Hoecker returned to the University of Kansas in 1945 and is teaching and directing a Navy research project there.

Paul G. Roofe, professor of anatomy at the University of Kansas Medical School since 1945, received his Ph. D. degree from the University of Chicago in 1934. He was assistant professor of anatomy at the University of Louisville before coming to Kansas. Dr. Roofe has cooperated with Dr. Hoecker on a joint ONR project of radium metabolism in the mammal. Under another ONR contract, Dr. Roofe is investigating the effect of protein deficiency upon hemopoiesis in the white rat.

other radiations, it is reasonable to assume that the sarcomas associated with radium in the bones are the result of alpha-particle bombardment of osteoid tissue.

The work of Hamilton[1] has shown that plutonium, americium, and curium, also alpha-particle emitters, are deposited in the bones in a manner similar to that of radium. It may reasonably be assumed that osteoid sarcomas would result from these substances also under conditions of equivalent alpha-particle tissue dosage.

A notable similarity among these alpha-particle emitting substances is the fact that they are not uniformly deposited and the concentration appears to vary widely from point to point in the bone. A quantity of the order of 5×10^{-6} grams of radium fixed in the skeleton of a human being is likely to produce a bone sarcoma[2] within a period of 10 to 20 years. Yet a calculation of the total tissue dose, or the daily tissue dose, (approximately 0.3 r/24 hrs.) because of an assumed uniform distribution, yields a value far below an amount which might reasonably be expected to produce sufficient tissue damage to induce malignant growth.

As sarcomas have been frequently observed in radium poisoning and have been experimentally induced in laboratory animals, their production has been variously attributed either to the enhanced biological effects of alpha-particles or to the non-uniform distribution of the radium. However, detailed microscopic and autoradiographic studies of the distribution and deposition of the radium in osteoid tissue have not previously been made and the mechanism by which sarcomas were induced has been unknown.

The purpose of the work to be discussed has been to study in detail the deposition and the distribution of radium in rats. There are several reasons for the choice of radium as the radioactive substance. First, a large amount of radium is handled in powdered form in connection with the production of luminous dials on various types of instruments, and hence constitutes a definite health hazard for persons employed in this work. Second, radium and many of its disintegration products are alpha-particle emitters. Information gained from study of the biological effects of alpha-particles originating from these substances may be applied to problems involving other alpha-particle emitters; particularly is this the case when it can be shown that the deposition of radium in the tissues follows a pattern similar to that of several of these other substances. More will be said of this later. Third, the assimilation of radium and the total amount present at any time in the body may be conveniently followed through the radon and the gamma radiation produced. Fourth, the development of a precise technique for maintenance of registry between the alpha-particle track pattern and the bone matrix structure has permitted study of the bone in relation to the concentration of radium at any point.

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[1] Hamilton, J. G., "Metabolism of Fission Products and the Heaviest Elements." Radiology 49: 325-343, 1947.

[2] Martland, H. S., Occupational Tumors. International Labor Office, Occupation and Health: 1-23, 1939.

Radium Assimilation and Elimination

A very important phase of the study of the metabolism of radium in the body is the determination of the rate of its elimination from the body and the study of its mode of deposition. Earlier studies[3] of this type did not completely settle the questions because the methods of measurement were subject to serious errors.

It should be recalled that measurement of the total amount of radium present in an animal body at any one time requires the measurement of the gamma radiation emitted which is due to that fraction of the radon, produced by radium disintegration, which disintegrates in the body. These measurements which can be made with good precision yield information as to the amount of radium (gamma-radium) which is producing radon that disintegrates in the body.

The remainder of the radium, producing radon which is eliminated from the body in the exhaled breath, produces no gamma radiation in the body and is much more difficult to evaluate. The total radium present is, of course, the sum of the gamma-radium and the radium producing radon which is exhaled.

In human beings, the latter fraction of radium is estimated[4] by measuring the concentration of radon in a sample of the exhaled breath. A similar method was used by Evans[5] to estimate this radium fraction in rats. The method is, however, open to numerous objections since assumptions must be made regarding the rate of breathing, the degree of equilibrium between the radon concentration in the blood stream and in the alveoli, the psychological state of the subject, and the particular method[6] of obtaining the breath sample. It is, however, the best method proposed so far for use with human beings and living rats.

In order to establish more definitely the rate of elimination of radium in rats and to determine accurately the manner in which the gamma radium fraction (and hence the radium fraction corresponding to the exhaled radon) was emitted, a different method has been used in this work.

In one series of measurements, 25 twelve-week-old rats were divided into five groups and injected intraperitoneally with radium chloride in physiological saline in doses varying from 10 to 50 micrograms. One rat from each group was sacrificed at the end of 3, 6, 9, 12, 14 days after injection. Careful measurements of the gamma radiation from each rat were made before killing. Immediately after killing, each rat was hermetically sealed in a thin walled metal can and frozen. Gamma measurements were made at intervals during a thirty day

[3] Thomas, H. E., and Bruner, F. H. "Chronic radium poisoning in rats," Am. J. Roentgenol. and Rad. Ther., 1933, XXIX, 641.

[4] Evans, R. D., "Radium Poisoning II." Am. J. Roentgenol. and Radium Therapy: 37, 368, 1937.

[5] Evans R. D., Harris, R. S., and Bunker, J. W. M., "Radium metabolism in rats, and the production of osteogenic sarcoma by experimental radium poisoning," Am. J. Roentgenol. and Rad. Ther., 52, 353-373, 1944.

[6] Hoecker, F. E.: Radon/Carbon Dioxide Ratio as An Index to Excessive Radium Absorption. Jour. Ind. Hyg. and Tox.: 26, 281-288 1944.

period after sealing, and found to follow a normal radon growth curve. From these measurements or from that of the gamma radiation emitted after 30 days, the total amount of radium present in the rat at the time of killing could be accurately determined.

No waste of material is involved in this method of total radium determination since the tissues and bones are used in other studies.

This method eliminates all uncertainties in the determination of the radium fractions except those inherent in Geiger-counter measurements, and these can be reduced as much as desired by choice of the total number of counts. The radium elimination data obtained in this manner are free of all uncertainties introduced by methods of feces collection and radon exhalation. The data do, of course, embody uncertainties due to individual differences among the rats. These are, however, surprisingly small.

The data shown in Figure 1 were obtained in the above manner. There are included, also, data obtained from rats injected in different manners and kept for longer periods of time before killing. It will be seen that the radium elimination is very rapid during the first three days; after this period the rate decreases very rapidly and becomes essentially zero after 15 to 20 days.

A notable contribution of these data is the fact that the percent of total radium eliminated at the end of any period of time is essentially independent of the initial amount injected. This is true whether all the radium was given in a single injection or in two injections separated by several days. Essentially, 30 percent of the total injection is permanently retained.

These data indicated that at the end of 14 days, approximately 2.5 percent of the initial injection is gamma-radium, that is, it would be measured by means of the emitted gamma radiation. This is 8.5 percent of the total radium present at that time. Consequently, 91.5 percent of the radon produced is being exhaled.

One of the interesting aspects of the data on radium metabolism is the continued increase in the intensity of gamma radiation from the rats after injection. Careful and frequent measurements show a continued gradual increase in the gamma radiation for a period of approximately 100 days after injection of the radium. Since the total radium in the body is decreasing, rapidly at first and later very slightly, if at all, the increase in gamma-radium must be accompanied by a corresponding decrease in the exhaled radon.

This is presumed to result from the incorporation of some of the radium into the bone matrix in such a manner that it is not accessible to the blood stream and the elimination of the radon is interfered with. The process is difficult to interpret since the accumulation of radon from particles of radium fixed in this manner would follow the normal growth relation and would only gradually become apparent.

It may be remarked here that autoradiographic studies to be described later, yield unmistakable evidence that a large portion of the radium carried to the bones appears in the periosteum and endosteum soon after injection. These studies show also that in animals killed several months after injection, the periosteal concentration has become incorporated into the bone matrix.

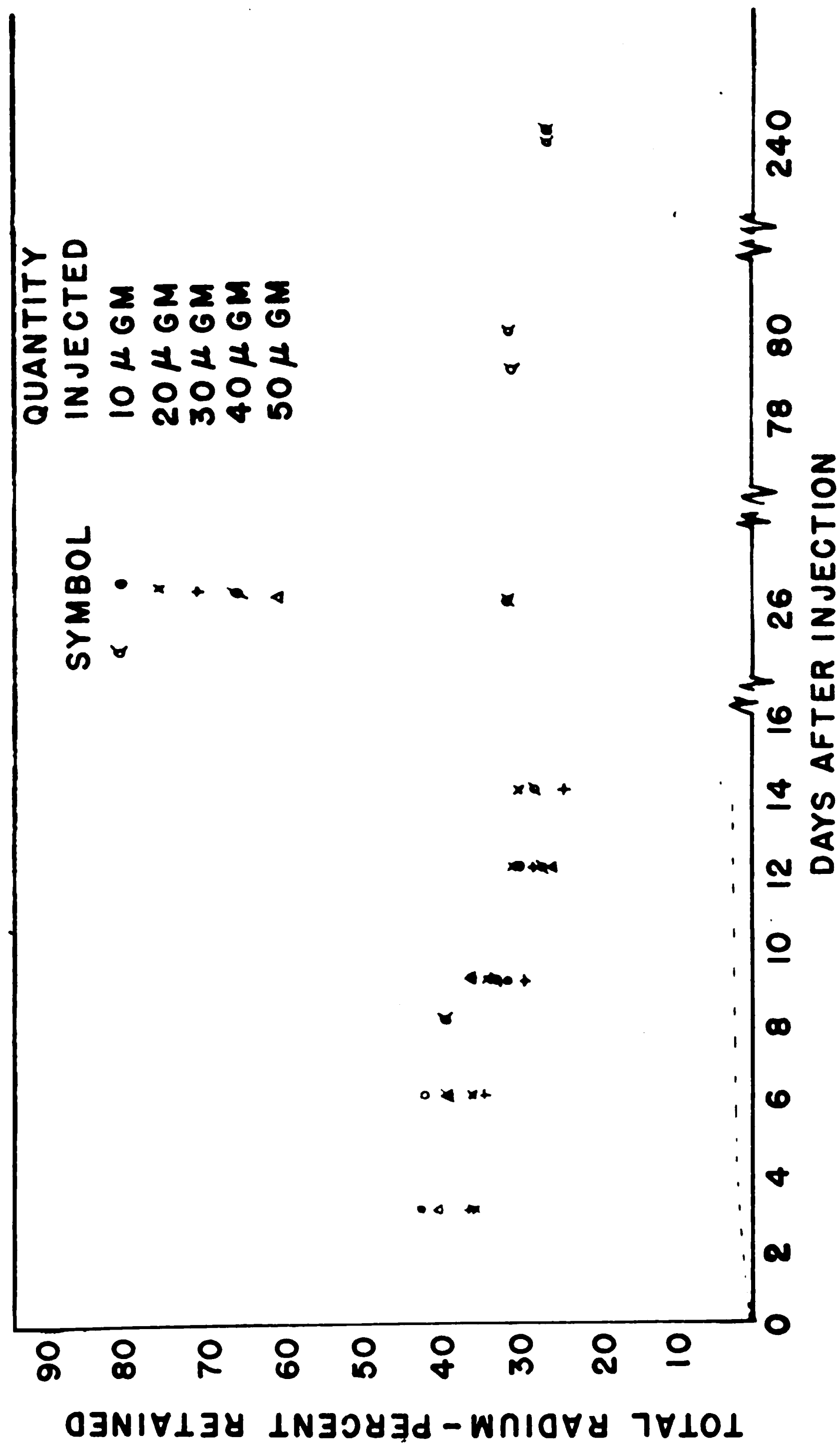


Figure 1. Data showing the retention of radium in rats.

Bone Studies

It was mentioned above that the nonuniformity of distribution of radium in the bones of animals appears to play an important role in the production of osteoid malignancies. It may be that the mode and site of deposition have a part equally as important in this process. But since all these factors have been largely unknown, little progress has been made in determining the mechanism by which osteoid neoplasms are induced. It has, therefore, seemed desirable to study these factors with the hope of obtaining as much information as possible and, in addition, of augmenting our knowledge of the relation between tissue damage due to ionizing particles and the induction of neoplasms. The distribution of the radium which was metabolically deposited in the bones of these rats was studied autoradiographically through alpha-particle tracks in nuclear track plates (Eastman NTB). The bones studied so far have been chiefly tibias and femurs. The matrix of these bones has been examined microscopically and photomicrographically for changes in structure and for differentiated areas associated with radium deposits.

Experimental Techniques

The microscopic investigation of radium distribution in bone and its relation to the cellular structure of the bone matrix required the development of a new method of bone sectioning. Such studies require the examination of hundreds, perhaps thousands, of bone sections.

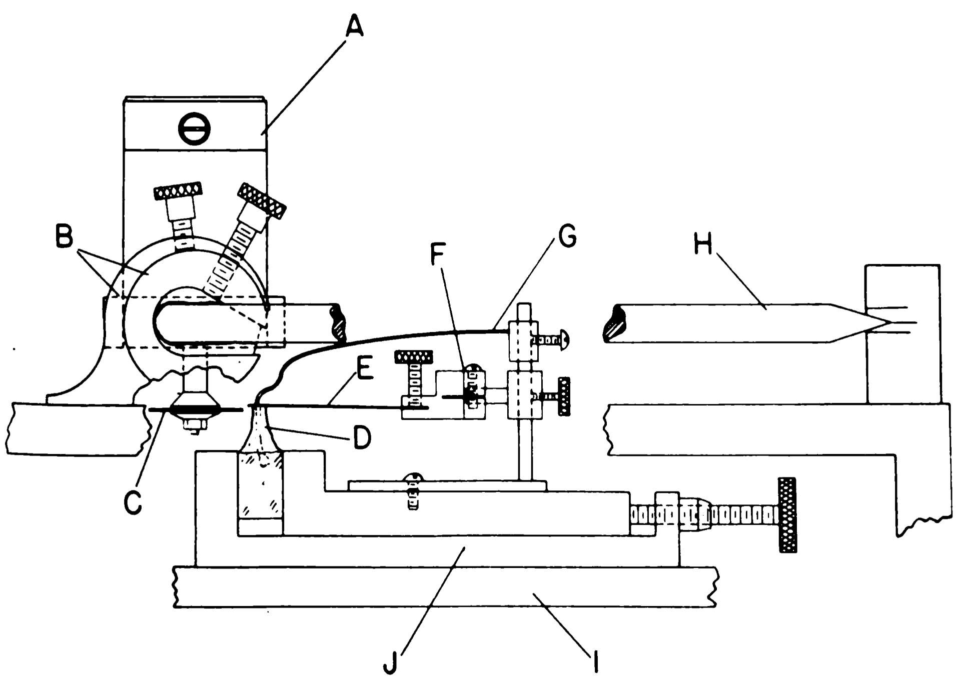


Figure 2. Diagram of bone-sectioning instrument. A-Motor. B-Motor mounting blocks which permit rotation of the motor about a horizontal axis perpendicular to the plane of the paper. C-Saw blade. D-Bone mounted in bioplastic. E-Flexible cover slip resting on upper surface of bone to retain cut section. F-Cover slip clamp. G-Wire for adjustment of pressure between cover slip and bone. H-Index arm for adjustment of attack angle of saw. I-Carriage way. J-Bone carriage.

Older methods of preparation were much too slow and laborious. Moreover, in many cases bones from animals as much as two years old were studied and former methods proved unsuitable for these.

To eliminate these difficulties a method of cutting sections of uniform thickness, thin enough for microscopic and photomicrographic examination was developed. A small circular saw blade one inch in diameter and 150 microns thick mounted on the shaft of a small, variable speed motor was substituted for the knife blade on a brain microtome. Figure 2 shows a diagram of the essential constructional features.

Several precautions must be taken in order to ensure uniform thickness of cut sections. The motor armature must be ball-bearing mounted to prevent end play and the motor mounting must be very heavy to ensure rigidity. In addition, the motor mounting must permit a small amount of rotation of the motor about a horizontal axis perpendicular to the direction of motion of the bone carriage. This must provide a very rigid, but fine adjustment of the angle of attack of the saw blade. This avoids any tendency of the saw blade to cut out of, or too deeply into the bone.

The bone to be sectioned is prepared by embedding in bioplastic. After this material solidifies, it is trimmed by means of a hand grinding tool so as to leave a thin shell of bioplastic surrounding the bone. A portion of the bioplastic extending beyond the end of the bone is left in the form of a block to permit the bone to be clamped in the movable carriage of the microtome. The carriage is then moved in the conventional manner but much more slowly so as to feed the bone to the saw. The speed of the saw is controlled by means of a variable transformer. The cut section is retained on the lower side of a plastic cover slip, one end of which is clamped to the microtome carriage in such a manner that the opposite end rests on the squared end of the bone which forms the upper side of the cut section.

Sections may be cut in this manner at the rate of at least one a minute. Serial sections may be cut along the full length of the bone with the loss of only about 150 microns of bone between sections. They are of uniform thickness which may be as little as 30 microns. Figure 3 is a photomicrograph of a section of old dried human bone cut by this method.

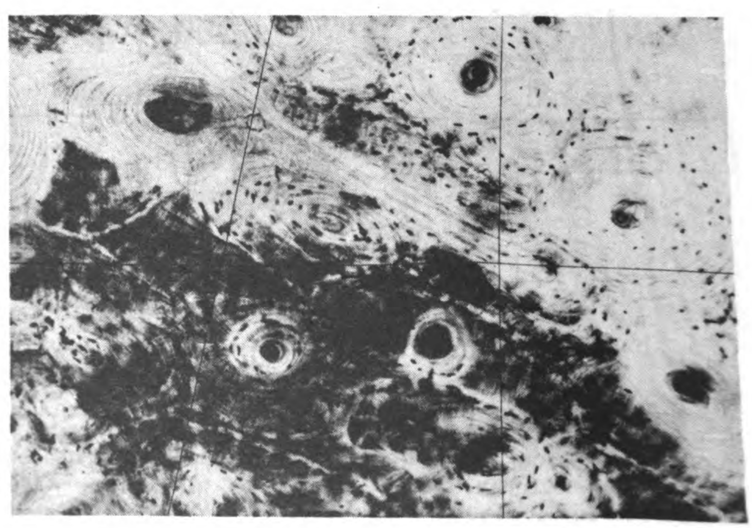


Figure 3. Section of old, human bone cut by the bone-sectioning instrument.

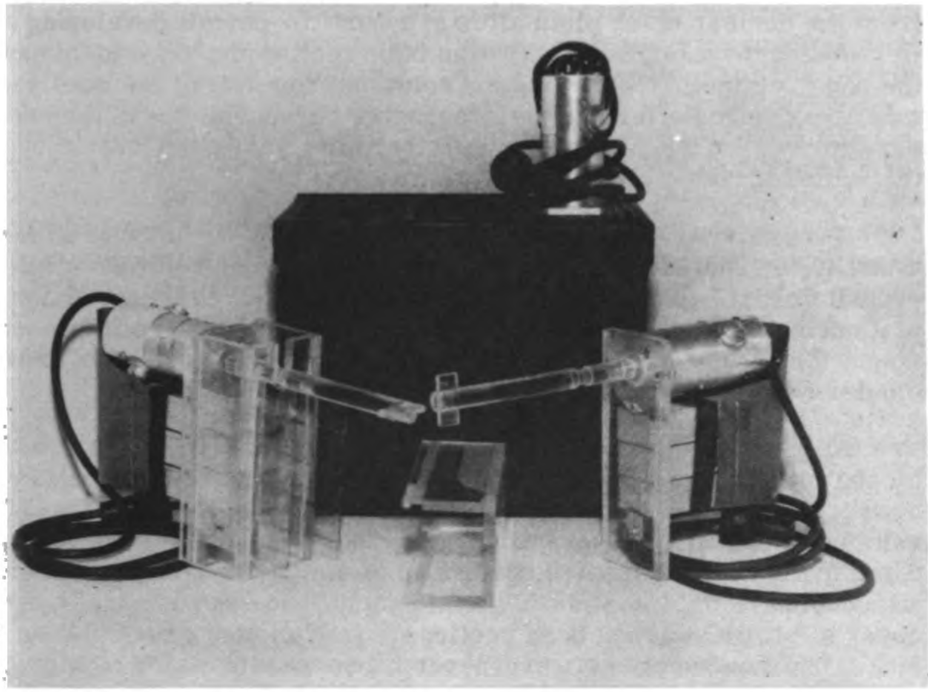


Figure 4. Tank used for processing nuclear track plates.

The correlation of radium distribution in each bone section with the structural details of the matrix necessitated the development of a special autoradiographic technique, which permitted exact registry to be retained between the alpha-particle track image of the radium distribution and the alpha-particle sources in the bone section. This problem was greatly magnified by the necessity of removing the bone sections

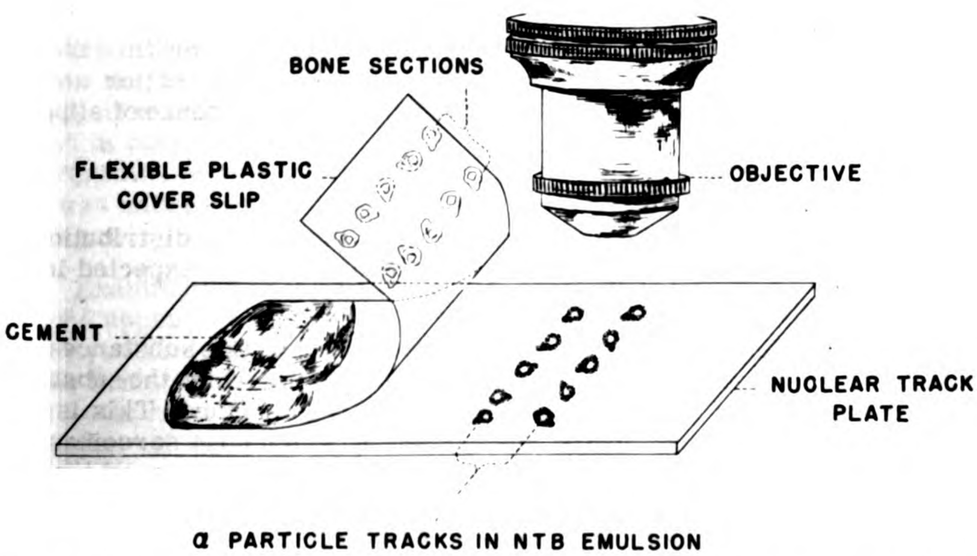


Figure 5. Method of studying alpha-particle tracks on the nuclear track plates.

from the nuclear track plate after exposure to permit developing solutions to reach the emulsion under the bone section and to avoid immersing the bone section in the developing solution; removal of the bone section was also desirable for photomicrographic purposes. It was then necessary to return the bone section exactly to the position occupied by it on the nuclear track plate during exposure.

These requirements were met by mounting six or eight bone sections at the end of one side of a transparent plastic cover slip. The opposite end of this cover slip was then cemented to the emulsion side of a nuclear track plate with the bone sections in contact with the emulsion. The bone sections were pressed in intimate contact with the emulsion during exposure.

At the end of the exposure period the nuclear track plate with attached cover slip was placed in a specially constructed processing tank shown in Figure 4. This tank contains three sections; one for the developing solution, one for washing, and one for fixing. The nuclear track plates with cemented cover slip on which the bone sections were attached, were held in slots in plastic shelves in such a manner that the cover slip with attached bone sections was held above the solution surface. The bone sections were never immersed in water or any processing solution at any time. Each compartment had its own motor driven stirrer.

Following development, the bone sections and their respective autoradiographs were examined microscopically. Photomicrographs of interesting fields in the bone matrix and the associated alpha-particle tracks were made. Best photomicrographic results were obtained by lifting the end of the cover slip with attached bone sections away from the nuclear track and focusing the microscope directly on the alpha-particle tracks as illustrated by Figure 5. Then the bone sections were allowed to fall back to their original positions and the microscope focused on the bone section. This technique eliminates the necessity of focusing through the reverse side of the slide and interference due to passage of light through the bone section.

Careful tests have been made to determine whether this method provides and maintains exact registry between the bone section and the alpha-particle image of the radium distribution. No evidence of slippage has been found.

Results

While it has long been recognized that the radium distribution in the bone matrix was non-uniform, the variations to be expected in the volume density have not been known.

Possible understanding of the effects of radioactive substances deposited in bone depend on knowledge of the manner in which the substance is deposited and of maximum volume densities to be found. This is particularly true in regard to the mechanism by which bone sarcomas are induced by radium in the bone. It has previously been assumed that the effects of radium in the body of an animal must necessarily be proportional to the total quantity of radium fixed in the bones. This may be true with respect to acute effects resulting in the development of anemia. It may not necessarily be true in regard to the development of bone sarcomas usually associated with chronic radium poisoning.

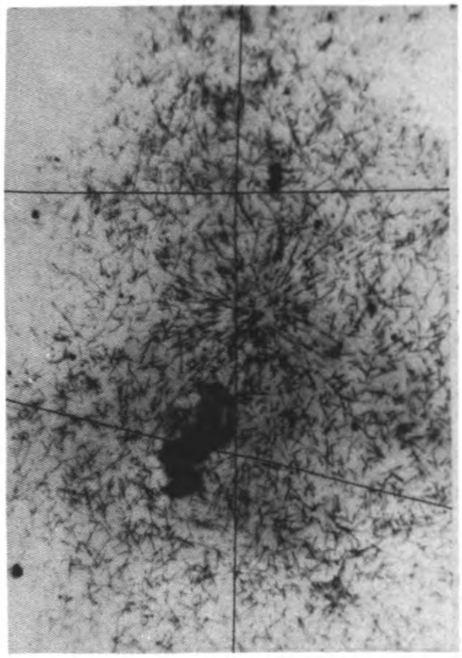


Figure 6. Photomicrograph of alpha-particle track autoradiograph resulting from the presence of radium in a thin section of a rat tibia. Exposure 40 hours.

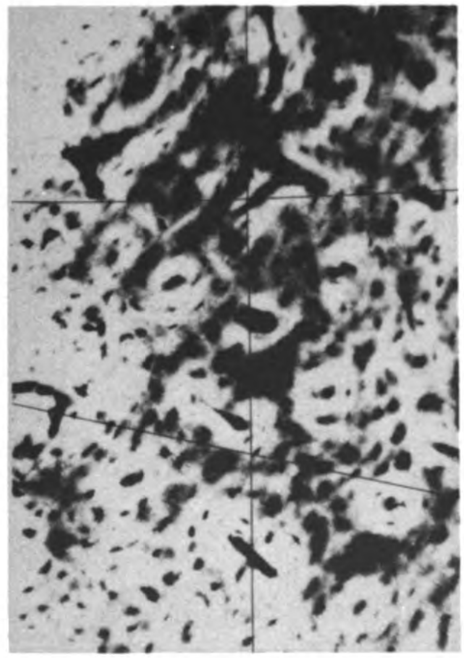


Figure 7. Photomicrograph of the portion of the bone section of which Figure 6 is the autoradiograph. Distance between intersection points of lines is 180 microns.

Microscopic studies of alpha-particle autoradiographs in these experiments have disclosed minute localizations of radium at various points in the bone matrix, in the endosteum and the periosteum which seem to bear no simple relationship to the total radium in the bones. One type of localization is illustrated in Figure 6 by the alpha-particle autoradiograph of a thin section of a rat tibia. When this is compared with the photomicrograph of the bone section, Figure 7, the high alpha-particle densities are observed to coincide with areas of increased optical density in the bone matrix. This coincidence may be more clearly shown by superimposing the autoradiograph and the bone-section photomicrograph in registry. The rat from which this tibia was taken received 30 micrograms of radium chloride intraperitoneally at the age of 12 weeks and was sacrificed 14 days after injection. Radium burden at death was 6.9 μ gm.

Examination of large numbers of bone sections and their autoradiographs appears to affirm an invariable association of areas of optical density or of differentiated areas with localized concentrations of radium in the bone. It cannot be definitely stated, at this time, that there is a metabolic relation between the darkened areas and the localized radium deposits. If there is such a relationship however, it appears that the radium is concentrated in this manner because of the presence of these differentiated areas rather than the reverse. This conclusion is based on the observation of differentiated areas unaccompanied by heavy deposits of radium. The microscopic details of the optically dense regions do not show clearly in the photomicrograph but careful study seems to disclose a higher density of canuliculae in these areas.

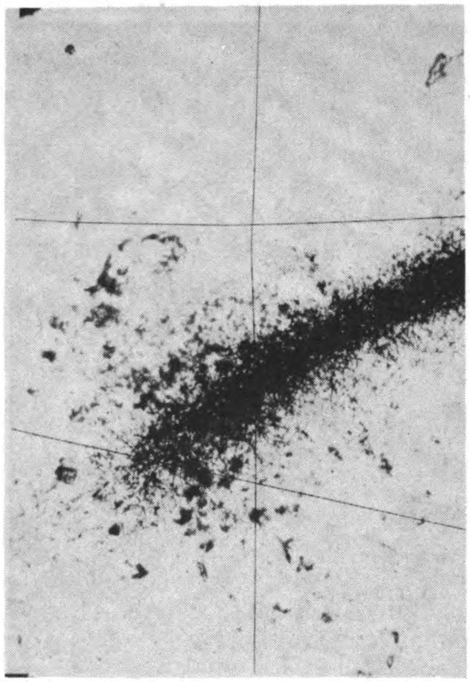


Figure 8. Medium-power photomicrograph of alpha-particle autoradiograph of rat bone section. Rat sacrificed five months after injection of 40 micrograms of radium.

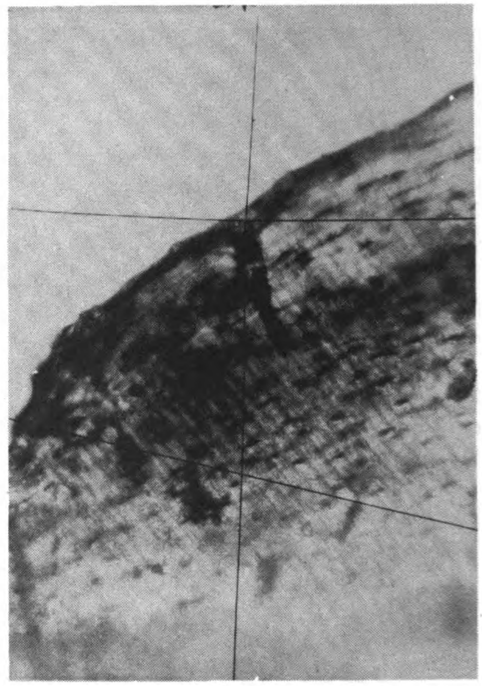


Figure 9. Photomicrograph of same section. Darker differentiated area coincides exactly with the dense alpha-particle pattern of Figure 8.

Concentrated deposition of radium is found to be associated with differentiated regions in the bone which appear to be abnormal. This is best illustrated by the autoradiograph of Figure 8 and by the associated bone section of Figure 9. The clear and unquestionable relation between the peculiarly altered portion of the bone matrix and the radium deposit is even more clearly demonstrated by the low-power photomicrographs of Figures 10 and 11. The striking coincidence between the shape and extent of the radium deposit and differentiated area of the bone leaves little doubt that the two are closely related.

This is shown in a somewhat different manner by the autoradiograph of Figure 12 and the bone section of Figure 13. In these the radium deposit forms a sharp, nearly ring-like alpha-particle track pattern which is nearly concentric with the marrow cavity of the bone. This sharply defined radium deposit is, however, not found in the region of either the endosteum or the periosteum, but within the matrix of the bone itself.

It seems possible to offer an explanation of the form and location of this radium deposit in the light of observations made on other rats. It is almost invariably observed that when rats are killed soon after injection of the radium (three to fourteen days) the heaviest deposits are consistently found in the periosteum and endosteum. This would seem reasonable, since this is the tissue in which calcium is being concentrated and which is actively engaged in the production of new bone.

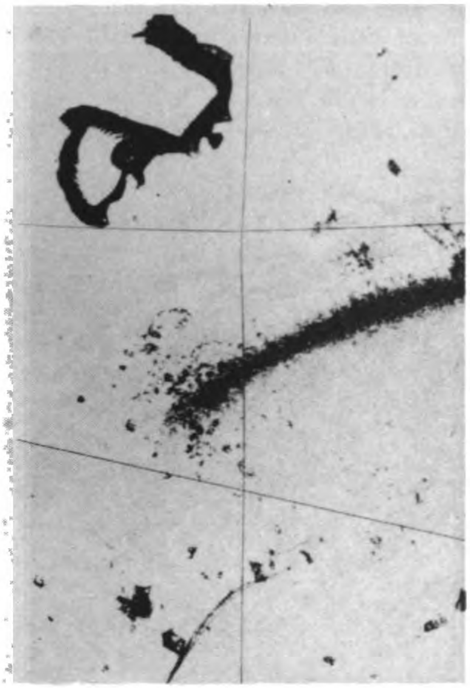


Figure 10. Low-power photomicrograph of alpha-particle track pattern of Figure 9.

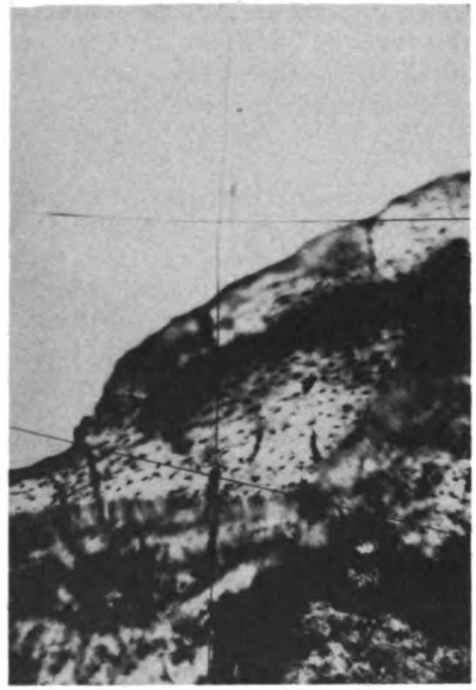


Figure 11. Low-power photomicrograph of bone section of Figure 10. Note the very dark region in the bone which coincides with the alpha-particle pattern of Figure 10.

The material shown in Figures 8 to 13, however, came from a rat which was killed five months after injection of the radium. It may well be reasoned that that portion of the bone matrix in which the heavy radium deposit was found after five months represents the portion which was in process of formation at the time of the injection. This seems reasonable when we observe the normal bone almost entirely free of radium on both sides of the region in which the radium concentration occurs.

Perhaps the most interesting localization is the type shown in Figure 14. The alpha-particle track pattern appears to emanate from a radioactive deposit in a region of very dense bone (Figure 15) confined to an extremely small volume estimated at 5×10^5 cubic microns. The relation between the radium deposit and the dense bone area is shown by the composite photomicrograph of Figure 16 in which the photomicrograph of the autoradiograph and the bone section have been superimposed in registry. The tissue in the immediate region of a radium localization of this type must, of course, receive a very heavy bombardment by alpha-particles. The ionization produced in any given minute volume of tissue during a reasonably long period of time, say 24 hours, will depend upon its location with respect to the radium deposit. Microscopically, this deposit does not appear to be a point source. On the other hand, the autoradiograph indicates that as the center is approached, the number of alpha-particles per unit volume increases rapidly.

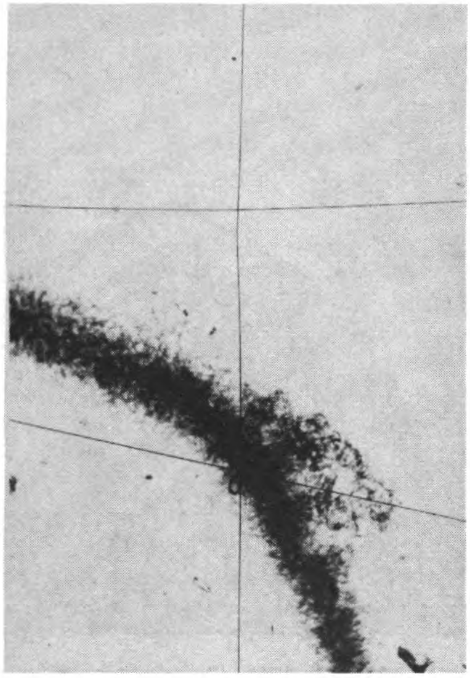


Figure 12. Portion of alpha-particle pattern of autoradiograph showing ring-like deposit of radium in the bone concentric with marrow cavity.

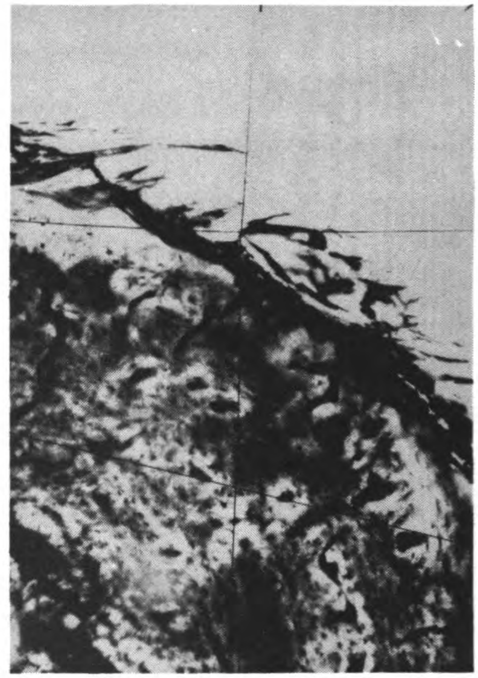


Figure 13. Photomicrograph of bone section corresponding to autoradiograph of Figure 12.

Consequently, it is extremely difficult to express the tissue dose due to alpha-particle bombardment in terms of roentgens or roentgen equivalents. The problem is complicated further by the high specific ionization due to alpha-particles and the consequent greater biological effectiveness.

However, the average ion density may be estimated and when this is converted to roentgens on the basis of 1.62×10^{12} ion pairs per gram of tissue, some idea of the alpha-particle tissue dose may be obtained.

An estimate of the tissue dose due to the alpha-particles has been made as follows. A reduced (twelve-hour) autoradiographic exposure of this area was made. This resulted in an alpha-particle track density such that the tracks emanating radially from the localization area could easily be counted. An arbitrary circle of 25-micron radius was drawn about the center of the radium locus. Then all alpha-particle tracks, which, when projected back toward the center pass through this arbitrary circle, are considered to originate from radium deposited within a volume of which this circular area is the great circle.

Since a means has not yet been devised for locating the saw cut with reference to the center of the deposit, it has been assumed, for purposes of this estimate, that the arbitrary circle coincides with the center of the deposit. Any error involved in this assumption tends to reduce the estimated dose. It is assumed further that the nuclear track plate has registered one fourth of all the alpha-particles emitted from the radium in this volume.

It seems reasonable that the maximum volume of bone in which these alpha-particles would have expended their energies is a volume having as its radius, the radius of the arbitrary circle plus the maximum range of an alpha-particle in bone. This range is not known accurately but has been assumed to be 25 microns.

The total number of ion pairs produced by the alpha-particles per gram of tissue has been calculated on the basis of the above assumptions. The approximate average tissue dose thus obtained for the radium locus of Figure 15 is 500 roentgens per 24 hours in the volume considered. It must, of course, be evident that many assumptions are involved in this estimate which may have to be revised at a later date, but estimates made in other ways yield doses of nearly the same value.

Any tissue receiving such a dose would, of course, be killed. It seems, therefore, safe to assume that there will be a more or less spherical volume of tissue associated with this type of localized deposit which will be killed soon after the deposition of the radium. This volume of dead tissue would enlarge with time as the total cumulative dose at the boundary reached the lethal value. There will be at all times a surrounding volume of tissue which has received a sublethal dose, but which is subjected to continual bombardment.

A high incidence of osteogenic sarcoma has been repeatedly demonstrated in human victims of radium poisoning and in laboratory

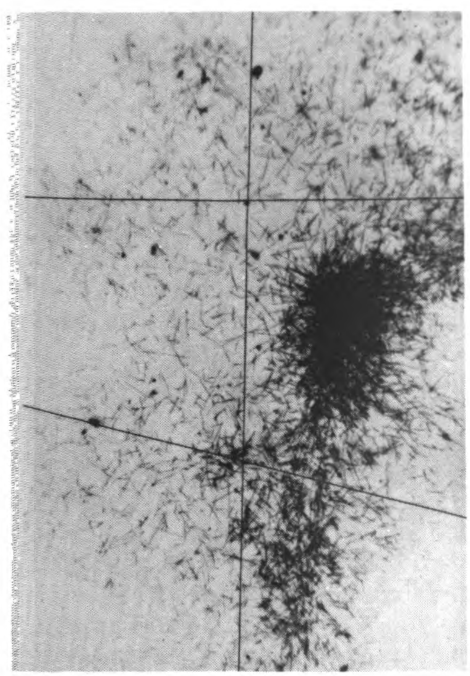


Figure 14. Alpha-particle pattern showing highly concentrated radium deposition in portion of endosteum of rat tibia. Exposure 40 hours,

Figure 15. Bone section corresponding to autoradiograph of Figure 14. Rat sacrificed 14 days after injection of 30 micrograms of radium.

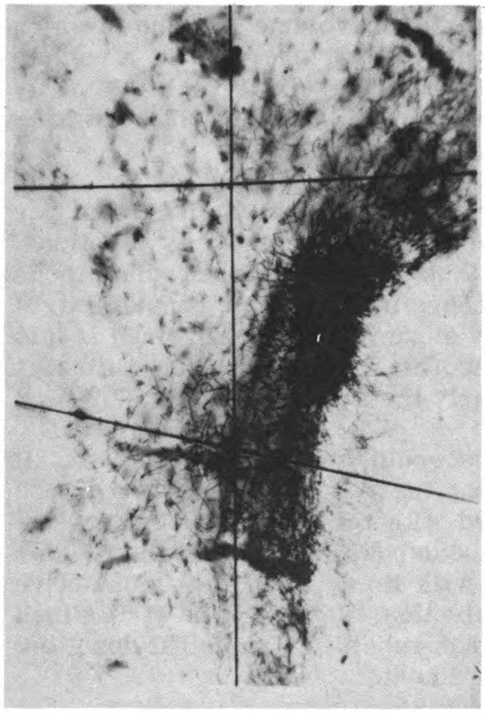


Figure 16. Composite print of negatives of Figures 14 and 15, showing coincidence of alpha-particle track pattern with differentiated portion of bone section.

animals which have received radium by injection and otherwise. These sarcomas have been attributed to the presence of radium in the bones although the precise manner in which the sarcomas might be induced has received little attention.

These studies have demonstrated the existence of microscopic localizations of radium deposited metabolically in the bones of rats. Consideration of the tissue dose due to alpha-particle bombardment and the resultant tissue reaction in the sublethal dose border region may offer a reasonable basis for a theory of the production of bone sarcomas in chronic radium poisoning. Further studies along this line are being intensively pursued.

This work has been sponsored by the Office of Naval Research under contract N6onr 260-T.O.-1.

NAVAL RESEARCH RESERVE

ANNUAL SEMINAR MEETING - JUNE, 1949

As a part of the training of the Naval Research Reserves, a scientific seminar was held in Washington, 8-21 June for 100 reserve officers from all parts of the country. This was the second of the annual seminars devoted exclusively to the scientific research programs of the Navy. A series of lectures and orientation tours were scheduled; in addition the training program was supplemented by a number of short talks, visits to ONR offices and general discussions with personnel connected with the Navy's work in research and development.

In the printed program sent each reserve officer, the keynote of the seminar had been sounded by Rear Admiral T. A. Solberg, Chief of Naval Research, who stated that the program was offered for the purpose of increasing the understanding of each officer of the scientific objectives of the Navy and also to afford a comprehensive review of the research program.

During the two-week period of the seminar, more than 20 formal talks were heard by the officers in assembly meetings. Extended tours were made of four of the Navy's big laboratories and research centers, and a similar tour was made of several departments of the National Bureau of Standards and of the Applied Physics Laboratory, Johns Hopkins University. On the night of 9 June, a buffet supper at the Officer's Club of the Gun Factory gave visiting officers a chance to become acquainted with each other and with the officers and the civilian scientists of the Office of Naval Research.

At the first assembly meeting of the entire group, Admiral Solberg welcomed the visitors. He pointed out that the Navy's interest in science and in scientific research is almost as old as the Navy itself, but that it took World War II to demonstrate that science is a vital link in the chain of national security and integrity. Victory was achieved only because science, industry and the military forces joined together as a formidable team. That teamwork is as essential today as ever. Seminars such as this help to develop better teams for the scientific effort of the Navy, the Admiral stated.

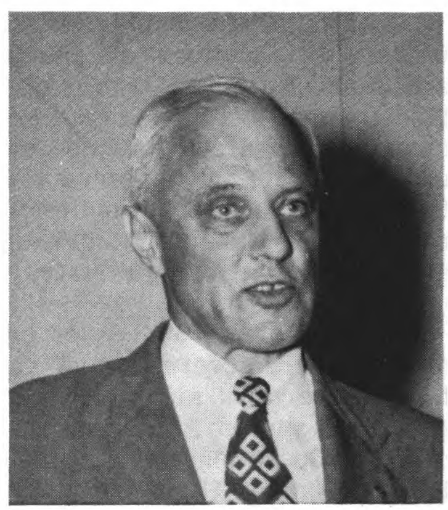
In the formal addresses given in the course of the seminar, several speakers covered a wide variety of scientific subjects. In addition there were talks along organizational and administrative lines. The group was well oriented the first day by Admiral Louis Denfeld, Chief of Naval Operations, who spoke on "Planned Integration of Reserve and Regular Navy." There was no doubt left in the minds of those who heard the Admiral as to the important relationships that exist and are further planned between the Reserve organization and the regular Navy. Dr. A. T. Waterman, Deputy and Chief Scientist of ONR gave a brief but informative talk on "ONR and the Scientific World." Of special interest was the address of Capt. C. M. Bolster, Deputy and Assistant Chief, ONR, who told how the Office of Naval Research serves the Navy.

Capt. D. P. Tucker, War Plans Officer of ONR, described the objectives of the two-weeks' training with "The Aims and Purposes of This Seminar." His address pointed out the responsibility of those attending the seminar in making contributions to the future program of training and organization, as each officer would have a chance to learn something of the general research program of the Navy, how it operates, how it ties in with ONR and what its facilities are. Another object of the seminar was to have the reserve officers know and come into contact with the scientific thinking of key Navy personnel and of the civilians and officers who staff ONR. It was important for the assembled officers to realize that the Navy has an extensive program in research outside of ONR and that only about one-fifth of the money the Navy spends on research and development is spent by ONR. It would be of mutual benefit if reserve officers managed to develop working relationships with specialists manning the engineering desks and with others engaged in research and development in the Navy and in ONR.

The development and use of special devices was a topic that obviously interested the reserve officers as they listened to the presentation of Capt. J. R. Ruhsenberger, Director, Special Devices Center, Sands Point, Long Island, N. Y. He explained that the earliest trainers were developed for aerial navigation and for gunnery since it was in this field that synthetic training was most effective and where maximum economy would result. The importance of human evaluations of trainers was stressed, and it was explained that it is standard procedure at the Special Devices Center to make human engineering studies of all man-machine relationships. In many instances, as the result of these studies, it has become obvious that a training problem could be simplified.

In the development of some training devices, it is necessary to simulate actual equipment or combat situations. Good examples of work in this direction is the Anti-Sub Tactical Evaluator at Key West and the

Rear Admiral C. B. Momsen



Dr. Karl T. Compton

Admiral Momsen, Assistant Chief of Naval Operations for Undersea Warfare, and Dr. Compton, Chairman of the Research and Development Board, were among the speakers at the Naval Research Reserve annual Seminar Meeting held in Washington, D. C., 8 - 21 June 1949.

computors for guided missile analysis. A variety of devices covering many fields are being developed at Sands Point and a few projects have been assigned which are not primarily Navy but are significant in the over-all program for national security.

Information on a top level came the way of the Research Reserves when a talk on guided missiles was given by Rear Admiral Daniel V. Gallery, Assistant Chief of Naval Operations for Guided Missiles. The next day an equally high level address on "Application of Research to Undersea Warfare" was given by Rear Admiral C. B. Momsen, Assistant Chief of Naval Operations for Undersea Warfare. That afternoon, the work of the Army was brought into the picture when an account of the research and development of the Air Materiel Command was given by Brigadier General Ralph P. Swofford, Deputy Chief, Engineering Division.

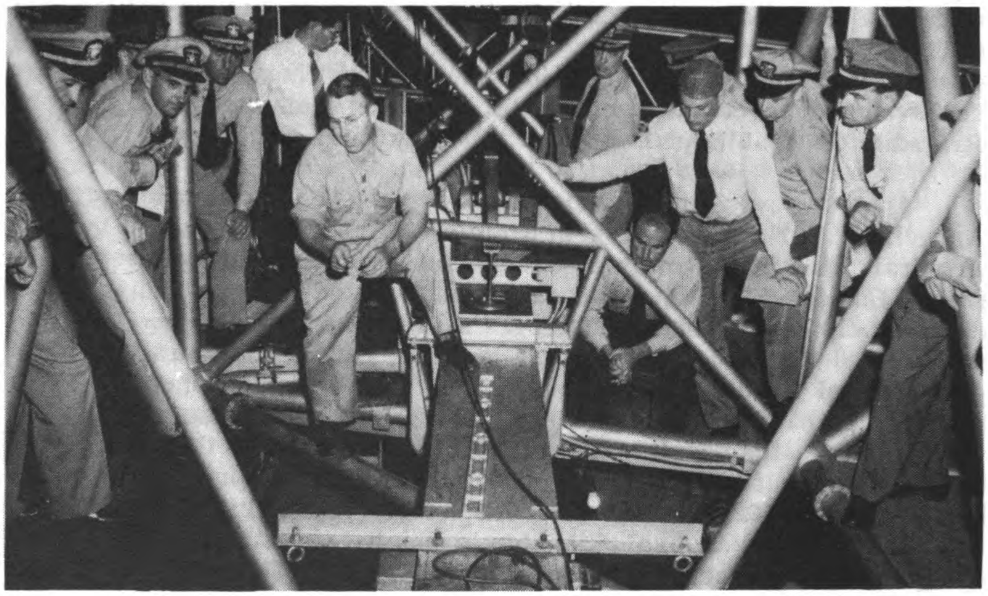
Another Navy Admiral added to the top level orientation when "Some Aspects of the Navy's Interest in Atomic Energy" was discussed by Rear Admiral T. B. Hill, Director, Division of Atomic Energy, Office of the Deputy Chief of Naval Operations. He outlined the way in which the Navy has participated in the broad program of atomic energy development, and pointed out that the interest of the Navy extends beyond the current problems of the destructive possibilities, to the future when it may be possible to harness atomic energy to power plants. Large ships are well suited to the possible use of such power because they can spare the room and carry the weight such a power plant will probably require. In addition, the Navy has considerable interest in the radiation that may be expected from an exploding atomic bomb, and the progress that is being made to protect our personnel from such radiation.

Dr. Karl T. Compton, Chairman of the Research and Development Board, in speaking to the Reserves on "Research with the Armed Services," outlined the mission of the Board in coordinating and guiding scientific research and development within the national military establishment. Specifically, the Board has large responsibilities for the allocation of funds and determining the emphasis of the research and development program. Dr. Compton also touched on the manner in which the Board has been required to ensure that appropriated money would be spent most effectively in the broad program of research and development as approved.

The scientific work of ONR was covered during the course of the seminar by a series of talks from key ONR personnel. Capt. W. H. Leahy, Assistant Chief for Research, had as his topic, "How Scientific Reservists Can Assist ONR." "Medical Research in the Armed Services" was discussed by Capt. C. W. Shilling, and Commander C. L. Westhofen talked on "The Reserve Scientists' Role in Naval Research."

At the Naval Medical Center, Bethesda, Maryland, the group had an opportunity to see at first hand how research in the medical field is carried on at one of the Navy's first line establishments.

The laboratory trips, which included visits to the David Taylor Model Basin, the Naval Research Laboratory, the Naval Ordnance Laboratory, the National Naval Medical Center, the National Bureau of Standards, and APL, Johns Hopkins University, were of particular interest to many of the Research Reserves. Each tour was expertly organized and smoothly conducted. The short talks preceding each tour provided good basic information and background for the more detailed explanations given as the groups visited the different scientific divisions and departments of the laboratories. Specific research problems were discussed by the scientists in charge, and explanations of various technical developments and equipment were given.



Naval Research Reserves on board one of the ship model towing carriages in the Basin Building at the David Taylor Model Basin. The visit to DTMB was one of six laboratory tours arranged for the Reservists during the second scientific seminar held in Washington.

Other speakers at the Seminar included Capt. G. N. Robillard, Asst. Chief for Patents, ONR, and Patent Counsel for the Navy, who spoke on "Navy Patent Problems," Mr. Earl Nash, Director, Publication Relations, ONR, Mr. Edward McCrensky, Director Personnel Division, ONR, who discussed "Scientific Personnel Requirements." Commander Fred C. Wiesner, USNR, Commanding Officer of Battalion W-1, Volunteer Research Reserve, gave some pointers on "Programs for Research Reserve Units" and Major R. H. Skinner, AUS, Coordinator, Army Organized Reserve, Research and Development Program, brought out the Army's activity in this direction by his remarks on "The Army Research Reserve Program."

In order to acquaint the Research Reserves with the current problems before the Department of the Navy as a member of the Military Establishment, a talk on "Naval Power" was given by Capt. A. A. Burke, Assistant Chief of Naval Operations, Organizational Research and Policy Division. It is vital, Capt. Burke pointed out, for the Navy to be maintained as an effective force--with an air arm, with marines and with missions in which close integration can well be expected to carry objectives. Capt. Burke's talk ended with a lively question period, evidence that the 100 Research Reserves were concerned about Navy problems in an active way. It was heartening to the Director, Naval Research Reserve--Commander R. S. Woodbury--and his staff at headquarters, that the especially selected Reserve Officers were applying themselves to the Navy's job, and could be counted on for positive contributions in the future.

* * *

OFFICERS' CORRESPONDENCE COURSES

Additional information on officers' correspondence courses is contained in Naval Reserve Multiple Address Letter No. 19-49, dated 14 May 1949, issued by the Bureau of Naval Personnel. The letter states "It is a firm policy of this Bureau that officers' correspondence courses will not be issued to any activity in bulk for use as the basis of a curriculum for drill training. The reason for this policy is two-fold: First, under existing Laws and directives governing Naval Reserve Non-disability Retirement and the Reserve promotion requirements, correspondence courses serve as one of the media through which credits may be earned toward promotion and retirement. The earning of such credits through correspondence courses is to be an individual effort on the part of each officer concerned, and not the result of a joint or class endeavor, which could lead to compromise. Second, the directives governing retirement provide that point credits may be earned by both correspondence course study and attendance at drills. Work on correspondence courses during drill periods would result in double credit being awarded for one effort, which clearly is in violation of Public Law 810. Therefore, correspondence courses are not to be used during drill periods."

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