Artificial Radioactive Tracers:

Applications to Chemistry and Medicine

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ABOUT 450 INDUCED RADIOACTIVITIES are now known, there being at least one radioactive isotope for each of the elements of atomic numbers 1 to 96, inclusive. The work in connection with the Plutonium Project of the atomic bomb development has given rise to vastly superior methods for the large-scale production of a number of these isotopes and, in particular, a number of the most important ones. The outlook at the present time, therefore, is a very optimistic one, with almost unlimited possibilities for research. It is not at all out of the question that the greatest gains to humanity from the atomic energy development will result from the widespread use of tracers to solve a multitude of problems rather than from the harnessing of the power itself.

The present discussion will be concerned entirely with the induced radioactivities, because these now far surpass in importance the natural radioactivities for application in the atom-tagging field. The natural radioelements have been used as indicators or tracers in physical and chemical investigations for about 35 years, the first experiments having been performed by G. Hevesy and F. A. Paneth, but these early investigations were limited to those few elements which have naturally occurring radioactive isotopes. After the discovery of artificial radioactivity, the principle of investigation by "atom tagging" was extended at once to these new activities.

Immediately following the discovery of artificial radioactivity, a large addition to the list of radioactivities was made during 1934 and 1935 as the result of the work of E. Fermi and his associates, who produced unstable isotopes by neutron bombardment of the elements. Also, many radioactivities were produced by several other groups of workers, mainly as the result of bombardment with high-speed charged particles from artificial sources—in particular, bombardment with high-speed charged particles such as protons and deuterons, which were accelerated in various types of high-voltage apparatus.

Following this early work with these many types of particle acceleration apparatus and until recently, the main source for the production of radioactivities was the cyclotron, the use of which added hundreds of isotopes to the total and resulted in the production of very intense radioactivities. However, this did not result in the transmutation of weighable amounts of isotopes.

THE URANIUM PILE

The recent accomplishment of the self-sustaining nuclear reaction in uranium marks another milestone in the field of artificial radioactivity. In addition to producing new isotopes, the chain-reacting units have increased by many orders of magnitude the amounts of the radioactivities which can be made available. As is now well known, the uranium chain-reacting units, called "piles," have given rise to the transmutation of elements on a weighable scale—in fact, on a scale not only of micrograms, milligrams, or grams but even of kilograms in some cases.

The fission product elements, *i.e.* the radioactive isotopes in the region of atomic numbers about 35 to 60, inclusive, are available in tremendous amounts. The pile, as a powerful neutron factory, also makes it possible to produce important amounts of practically any radioactive isotope which can be produced by neutrons; and, since almost all the important known isotopes can be produced by neutron irradiation, this means that in the future practically all such isotopes should be available in huge intensities. In a recent announcement from the headquarters of the Manhattan Project it was disclosed that a large number of such radioisotopes are now available for distribution to research men through qualified research institutions. A complete description of the available isotopes, their method of production, and the form and quantity in which they are available, together with a description of the organization for their allocation and distribution has been published (*Science*, June 14, 1946).

In the near future there will also be available other devices which will give rise to other milestones in the field of transmutation. Among these are the betatron and the synchrotron, with which it will be possible to accelerate electrons to the energy region of hundreds of Mev and, hence, to produce electromagnetic radiation of this energy. Also, the new 184-inch giant cyclotron at the University of California, Berkeley, is ready for operation. Using the new frequency modulation principle in order to compensate for the relativistic increase in mass at these tremendous energies, this instrument generates

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deuterons at 200 Mev and helium ions at 400 Mev of energy. These instruments should give the means for further study of fundamental particles, such as the mesotron, for production of new fundamental particles, and give rise to entirely new nuclear reactions. For example, from nuclei which have been bombarded with particles and radiation of this energy, there will come a literal shower of neutrons and protons—for example, a dozen or more at a time—and possibly in some cases even nuclei with mass below that of the heaviest region will undergo fission and give rise to their own groups of fission products. The use of these instruments will undoubtedly add to the list of induced radioactivities.

ARTIFICIAL ELEMENTS

One of the most important and interesting uses to which artificially induced radioactive isotopes have been put has been the investigation of the properties of those elements which do not exist in nature. In most cases so far, this type of chemical investigation has used a "tracer" technique (see *Science*, October 25, 1946, p. 379). The most spectacular examples of its application lay in the discovery and study of the chemical properties of *new* elements nonexistent in nature, *i.e.* the transuranium elements of atomic numbers 93, 94, 95, and 96. Element 93 (neptunium) was discovered in May 1940; element 94 (plutonium), late in the same year (see *Science*, October 25, 1946, pp. 379–380). In the case of plutonium, a long and complex process for its separation from uranium and fission products was to a considerable extent worked out before anyone had ever seen any plutonium even under the microscope. These studies have also led to the elucidation of the electron structure of the heaviest elements, the evidence indicating that these form a series of actinide elements, the added electrons for most of the 14 successive elements starting with thorium going into the 5f, an inner electron shell, similar to the addition of successive electrons to the inner 4f shell in the case of the 14 previously known lanthanide earths.

The experiments of Seaborg, R. A. James, L. O. Morgan, and A. Ghiorso in the Metallurgical Laboratory at the University of Chicago have recently led to the identification of isotopes of elements 95 (americium) and 96 (curium), making it possible to study the chemical properties of these elements by the tracer technique.

In the meantime it has been possible to produce neptunium and plutonium in weighable amounts in the chain-reacting piles. The isotopes which have been produced in this manner are the neptunium isotope of mass 237 and the famous plutonium isotope of mass 239, which is so important in the atomic energy field. With these it has been possible, using the methods of ordinary chemistry, to extend greatly the knowledge of the chemical properties of these elements.

There are also a number of lighter elements which are now known to be extremely rare or nonexistent in nature, but whose chemical properties have, nevertheless, been rather well defined as the result of their production by artificial means and the investigation of their properties by the tracer technique. Many experiments have been performed with unweighable amounts of these elements, which have atomic numbers 43, 61, 85, and 87.

C. Perrier and E. Segrè were able to show in 1937 that the deuteron bombardment of molybdenum produces radioactive isotopes of element 43, and they used these to study its hitherto unknown chemical properties. This is particularly interesting from an historical point of view because this is the first of the artificial elements to be discovered. Their experiments showed that the chemical properties resembled those of the heavier homologue, rhenium, to a much greater extent than they resembled those of manganese, the lighter homologue. These investigators used rhenium as carrier for the radioactivity in order to show that element 43 is precipitated by hydrogen sulfide from alkaline or acid (less than 10 N) solution. They investigated other properties, including the volatility of the oxide and chloride and the conditions for the electrolytic deposition of the metal. Recently R. P. Schuman and also D. C. Lincoln and W. H. Sullivan, working on the Plutonium Project of the Manhattan District, have independently observed the radioactivity (with very long half-life) due to the lower isomeric state of 43^{99}, formed in the fission of uranium. This is interesting because it is now possible to isolate this isotope in weighable amounts. This particular isotope of element 43 was discovered by Segrè and Seaborg, who produced it from the deuteron and neutron bombardment of molybdenum and found that the upper isomeric state has a half-life of 6.6 hours and the lower, one of more than 40 years. The discoverers, Perrier and Segrè, have suggested the name "technetium" (Tc) for element 43, and it seems certain that this name and symbol will be adopted.

A radioactive form of element 61 has been positively identified in the experiments of J. A. Marinsky, L. E. Glendenin, and others, on the Plutonium Project of the Manhattan District, who found that isotopes 61^{147} and 61^{149}, with half-lives of about 3.7 years and 47 hours, respectively, are formed in the fission of uranium. This element is a rare earth, and the chemical experiments on the tracer scale show that its behavior is very similar to that of the preceding element, neodymium. Experiments involving selective adsorption and elution on ion-exchange resins led to the unambiguous separation of the element from its neighbors. The availability of isotope 61^{147} in large amounts from fission makes it now possible to isolate the missing element 61 in weighable amounts, and I am confident that this will soon be done. The name which is to be eventually adopted for element 61 should be, and presumably will be, the one which Marinsky and Glendenin will suggest.

The discovery of radioactive element 85 (isotope 85^{211})

from bismuth plus 32-Mev alpha-particles, by D. Corson, R. Mackenzie, and Segrè, made it possible for these workers to investigate its properties. The general behavior is that of a metal, with little resemblance to the other halogens. It is precipitated by hydrogen sulfide in 6 *N* hydrochloric acid solution with various carriers, and the sulfide is insoluble in ammonium sulfide. Volatility at comparatively low temperatures is observed; a piece of bombarded bismuth loses most of the activity before melting (275°C.). There is no precipitation upon the addition of silver nitrate to a dilute nitric acid solution using iodide as carrier. These investigators have given the name "astatine" (At) to this element.

A radioactive form of element 87 resulting from the alpha branching decay of actinium has been discovered by M. Perey in France. This isotope, given the name AcK, has the mass 223 and decays by negative beta-particle emission with a half-life of about 21 minutes. The experiments of Perey have shown that the element behaves, as expected, like a heavy alkali metal; for example, it is carried by the compound, cesium perchlorate. Perey has given it the name "francium" (Fa).

Perhaps the most extensive application of the artificial radioelements in chemical work has been to the study of "exchange reactions." In exchange experiments the atoms of an element in one of its valence forms or types of chemical combination are labeled by admixture with some radioactive isotope of the element which is of the same form or chemical combination. To this system is added the element in another state of valence or form of combination, containing none of the radioactive isotope; the presence of radioactivity in this second chemical form, after it has been separated from the first, shows that an effective exchange of atoms between the two different states of the element has taken place. Experiments of this type give information on chemical bond types, the strength and reactivity of chemical bonds and the effect of solvents on these properties, the structure of ions and compounds, the mechanism of reactions, and the mechanism of catalysis. In addition, exchange reactions often offer an excellent and convenient method for the introduction of radioactive atoms into compounds.

The subject of exchange reactions is too complicated to make possible accurate, complete generalizations. It seems profitable, however, to make a few rough statements concerning homogeneous exchange reactions. If we consider exchanges of a given element between two sorts of molecules or ions in which it is held by electron-pair bonds to different numbers or kinds of other atoms, we may say in general that such exchange reactions do not proceed with appreciable rates except in those cases where there are reversible reactions which enable the exchanging atoms to reach equivalent states of chemical combination. For example, there is no exchange of atoms between phosphate and phosphite ions, sulfate and sulfite ions, sulfur and carbon disulfide, iodide ion and iodoform, etc. On the other hand, exchanges have been found between chloride and chlorate ion (due to the oxidation-reduction equilibrium), between lead nitrate and lead chloride (an extreme example of the ionization exchange mechanism), and between iodide ion and iodine (through the formation of a symmetrical intermediate, I_3^-). When the two exchanging molecules differ only in their net charge, another exchange mechanism—the transfer of an electron from one to the other—may become possible. For example, exchanges have been observed between Fe^{++} and Fe^{+++} and between MnO_4^{--} and MnO_4^-. It is no doubt true that some exchanges occur through a simple transfer of atoms between molecules during a collision; such a mechanism is a special case of exchange through the formation of an intermediate. In many cases the observation of exchanges of this sort suggests the existence of unstable intermediates which might not be known from other reaction studies.

Probably the most important isotope from the standpoint of future possibilities is the radioactive C^{14}. This isotope, discovered by S. Ruben and M. D. Kamen at the University of California, has a half-life of some thousands of years and therefore, before the advent of the chain-reacting pile, was practically unavailable due to the difficulty of its production in the large amounts needed to produce substantial radioactivities. However, the intense neutron source in the piles makes it possible now to produce C^{14} in such quantity and high specific activity as to place it in a class along with the most available and suitable isotopes. It can be produced in either of two ways: the neutron irradiation of carbon, preferably enriched C^{13}, by the reaction $C^{13}(n,\gamma)C^{14}$, or the neutron irradiation of nitrogen by the reaction $N^{14}(n,p)C^{14}$. Both of these reactions take place with slow neutrons. The reaction with nitrogen is, of course, preferable from the standpoint of producing C^{14} of the highest specific activity, it being, in fact, possible to produce isotopically pure C^{14} in this manner. The radiation is of relatively low energy, making it necessary for its detection to employ instruments designed with this in mind, and, in the investigations, to pay close attention to the self-absorption problem.

A whole vista of opportunity is, of course, opened as a result of the availability of the C^{14} isotope. Organic chemists, biochemists, physiologists, and men of medicine have dreamed for years of the day when a radioactive isotope of carbon suitable for tracer investigations should become available. A few of the possibilities which have opened through its availability will be indicated presently, but this field is so vast that it is certain that the best ideas are yet to come.

A great deal has been said in comparison of the potentialities of radioactive C^{14} and the separated stable C^{13} in these fields. Actually, these isotopes complement each other, and it is very fortunate that both are available. There now exists the interesting possibility of tagging each of two different carbon atoms in a molecule or system and then *simultaneously* observing the course of each. Also, the separated C^{13} makes possible the production of radioactive C^{14} of higher specific activity from the reaction $C^{13}(n,\gamma)C^{14}$.

Another isotope which has great potentialities is the radioactive H^3, which has a half-life of about 30 years. This can be used in many of the ways indicated for the use of C^{14} if it is present in a molecule in a nonlabile position. The availability of the intense neutron sources makes possible its production in weighable amounts by means of the reaction $Li^6(n, \alpha)H^3$. The radiation consists of extremely low-energy beta-particles, and therefore its detection demands the use of very special instruments, it being necessary to introduce the material in the form of a gas into the inside of the Geiger-Müller counter, ionization chamber, or electroscope.

Besides radioactive C^{14} and H^3, such isotopes as the 14.3-day P^{32}, the 87-day S^{35}, the 180-day Ca^{45}, the 47-day Fe^{59}, the 250-day Zn^{65}, the 53-day Sr^{89}, the 8.0-day I^{131}, and many others have offered and will offer many opportunities for important research.

The first and most obvious application in organic chemistry for C^{14} would be in an examination of the mechanisms of many isomerizations and rearrangements of organic molecules. There are a number of reactions in which carbon atoms or groups of carbon atoms move from one part of a molecule to another, and the question of just how this migration is accomplished has been a subject for discussion among organic chemists for many years. By labeling the migrating groups in certain positions it should be possible to determine the precise sequence of events in such a reaction. In many types of rearrangments it is impossible to tell, by ordinary means, which carbon atoms are actually migrating. It is easy to see how, by a selective labeling of atoms, an unequivocal answer to these questions is obtained.

Not only is this type of information of interest for itself and the light it will throw upon the behavior of organic substances, but it is a necessary preliminary to the synthesis of tagged compounds of biological interest and to the examination by degradation of metabolic products derived from administered labeled materials.

It is in this latter field of biochemistry that the carbon isotopes will have their greatest usefulness. The determination of the intermediary metabolism of the major structural and energy-transforming materials of living organisms such as fats, proteins, and carbohydrates, as well as the catalytic or organizing substances such as vitamins, hormones, and enzymes, will undoubtedly make great strides as a result of the availability of isotopic carbon and some of the other isotopes as well.

Turning to biological systems, we find a virtually unlimited field of important work for the organic chemist and workers in all branches of biology.

It is not out of the question that a complete understanding of the photosynthetic mechanism might give men the ability to synthesize food and fuel at will, using this principle. This could give rise to a literal harnessing of the sun's energy. With the aid of C^{14} this might be accomplished. A number of experiments have been performed with the 21-minute C^{11}, but this short half-life placed definite limits on the extent of progress which was possible. Nevertheless, Ruben, Kamen, and W. Z. Hassid were able to use radioactive C^{11} in a study of photosynthesis in which considerable progress was made. Radioactive carbon dioxide was fed to the unicellular green alga, *Chlorella,* and also to higher plants under various controlled conditions in both the light and the dark. The results obtained so far have been quite interesting. The higher plants and the algae absorb carbon dioxide in the dark. This process takes place concurrently with the release of CO_2 by respiration, so that the net effect is an evolution of carbon dioxide. Only by the tracer technique was it possible to demonstrate a simultaneous uptake and evolution of carbon dioxide. The dark uptake of carbon dioxide is very likely the first step in photosynthesis and can be represented by $RH + CO_2 \rightleftharpoons RCOOH$. Decarboxylation experiments have shown that the bulk of the radioactive carbon is in the carboxyl group. Attempts to identify the radioactive substances formed in the dark and in the light have been thus far unsuccessful. It is of considerable interest to note that formaldehyde, which has played a prominent role in many proposed mechanisms, was not identified from the radioactive carbon dioxide introduced. Experiments with the ultracentrifuge and diffusion methods indicate the average molecular weight of the radioactive molecules to be about 1,000, which explains the failure to identify them chemically with any small molecules.

The radioactive elements, in particular radioactive carbon, will, of course, receive widespread use in studying animal metabolism. In the highly intricate process of carbohydrate metabolism in man, present knowledge has been gained, for the most part, only as a result of painstaking analytical work by classical methods. In general, these methods are not capable of high precision and are not adapted for the determination of highly labile compounds. Thus, it is quite likely that many important details of the process under investigation have not been revealed. Almost certainly, the use of radioactive tracers will bring these details to light. Aside from circumventing many analytical difficulties, the use of labeled elements can yield important information not possible by other methods. It is very often the case in biological systems that reactions proceed under steady-state conditions. With radioactive tracers it is possible to follow the formation of a compound in the presence of a considerable amount of the previously synthesized compound or to measure synthesis while the net reaction constitutes breakdown. Such measurements will be of great value in determining the mechanisms of biological reactions. For example, B. Hastings and his collaborators at Harvard have used C^{11} in the study of glycogen formation in the liver and have found that the incorporation of carbon dioxide into organic molecules takes place here. Many carbon dioxide-incorporating reactions have been studied with C^{13} by H. G. Wood and C. H. Werkman. The present availability of C^{14} will make possible the elucidation of many mechanisms in the metabolism of carbohydrate and fat. Many biologists believe that artificial radioactivity has given biology and medicine what is probably the most useful tool for research since the discovery of the microscope, because almost all of the elements and compounds in biological systems can be tagged and their course through living systems studied.

The most simple and direct use of an element as a tracer is accomplished by its administration as a simple inorganic compound, in which case the distribution of the tagged element in the various structures of the plant or animal is determined by measuring the radioactivity of the samples of tissues and body fluids. A very large number of experiments of this type have been performed, principally to aid in the understanding of mineral metabolism. For example, the absorption of iron as related to anemia has been studied by G. H. Whipple and P. F. Hahn at the University of Rochester.

Radiophosphorus has been the most widely used of all the artificially prepared radioelements as a tracer for metabolic studies in biological systems. The distribution of administered phosphorus in human and animal tissues has been extensively studied. It has been observed, for example, that the retention of a single dose of disodium phosphate varied in different tissues in the following decreasing order: bone, muscle, liver, stomach plus small intestines, blood, kidneys, heart, lungs, and brain. In other experiments a selective accumulation of radiophosphorus in leukemic tissues was found to occur. This was important in that it indicated that the leukemic tissues could be subjected to a greater degree of beta-particle irradiation than the normal tissues, which in turn indicated the application of radiophosphorus as a potentially valuable therapeutic agent.

The synthesis of the biologically important organic phospholipids has been studied by G. Hevesy and co-workers in Copenhagen and I. L. Chaikoff and his associates in California. Compounds like these are now considered to be vital links in the complex, low-temperature oxidation mechanisms characteristic of living systems. Chaikoff and associates have shown the importance of the liver in such synthesis and transport: how the turnover of these substances through the liver can be altered by the administration of choline and certain amino acids and how newly synthesized molecules are absent altogether from the blood when the liver is removed. Using surviving tissue slices, they have demonstrated the dependence of the synthesis upon the proper functioning of certain respiratory enzyme systems. The first real insight into the mechanism of the action of insulin on carbohydrate metabolism has come from studies, by J. Sacks at Michigan with P^{32}, on the effect of this hormone on the turnover of phosphorus compounds in muscle. All of these studies, of which only a few were mentioned, would have been impossible without the use of a labeling agent.

Extensive metabolic studies have been made with the use of radioactive iodine as an indicator. The pioneering work in this field was done by S. Hertz and his co-workers in Boston and J. G. Hamilton and co-workers at California. The thyroid gland, through its synthesis of the iodine-containing hormone, thyroxine, controls the metabolic rate of the entire organism. Nevertheless, the quantities of iodine compounds produced and distributed are so small that even the finest micromethods are hardly adequate for the task of studying these processes. With the use of radioactive iodine the analytical difficulties can be largely overcome, and, in addition, types of measurements can be made which are not possible from chemical analysis. Among these is the measurement of the uptake of orally administered radioiodine by the intact thyroid glands of normal human subjects and by those of patients suffering from various types of thyroid disorder. The course of the uptake may be followed simply by placing a Geiger counter in the vicinity of the throat. The thyroids of patients with hypothyroidism were shown to accumulate iodine at a slow rate, while there was a relatively large uptake of administered iodine in the thyroid glands of patients with nontoxic goiters. In contrast to these behavior patterns, the thyroids of patients with hyperthyroidism were shown to take up administered radioiodine at a remarkably rapid rate and also to discharge the iodine from the gland in a rapid fashion. It is seen from these studies that an aid toward diagnosing the condition of the thyroid gland is available.

A large amount of work on iodine metabolism has been done by Chaikoff, I. Perlman, and M. E. Morton at the University of California. They were able to follow in some detail the distribution of organic iodine compounds from the thyroid gland through the blood to peripheral tissues in various states of thyroid activity; to demonstrate that, to a limited extent, tissues other than the thyroid gland are able to synthesize thyroxine; and, by using isolated surviving tissues, to tie in the synthesis of an organic compound with the energy-producing enzyme systems.

B. C. Smith and E. H. Quimby at Columbia have used the gamma radiations from intravenously injected $Na^{24}Cl$ to determine the rate of passage of sodium into the extracellular phase of the tissues in cases of peripheral vascular disease and thus determined the competency of the circulation—another example of use for diagnosis.

Many more possibilities for the use of radioactive isotopes in biochemical and physiological work might be suggested, but those given above are typical.

The study of the mechanism of action of antibiotic substances, many of which act by means not completely understood at present, will be possible. For example, the synthesis of radioactive penicillin or streptomycin might give rise to a method for investigating the mechanisms by which these great substances operate. The mechanism of action of antibodies might also be investigated by the use of tracers.

Another possible use of tracers is, of course, in the study of cancer. Here, in addition to the possibilities cited in connection with the use of radioactive indicators in the investigation of mechanisms, there is the therapeutic possibility of effecting the selective deposition of the radioactive material in the cancerous tissue, as has been mentioned in the case of leukemia. It has occurred to many investigators that it should be possible in the future to synthesize some compound containing a radioactive substance, this compound having the property of being selectively absorbed by the cancerous tissue so that the radioactive rays can act directly at this spot without harmful effects on the body's healthy tissue.

Another possibility, which may sound quite startling, is that of tagging bacteria with radioactive C^{14}. This appears to be feasible and to open great possibilities in the study of disease. In fact, Chaikoff and A. Kaplan have made a beginning by tagging the tuberculosis bacillus with radioactive phosphorus in some experiments which have not yet been brought to completion.

In addition to the therapeutic uses of radioactive substances which have already been mentioned, therapeutic value has been established in the work of J. H. Lawrence and associates, who have had some success in the application of radioactive P^{32} to the temporary control of the blood diseases, polycythemia vera and leukemia. A large number of other therapeutic uses will surely be found, since it will be possible to apply alpha-particles, beta-particles, and gamma-rays to this purpose. It is worth pointing out that all of these radiations are represented in isotopes which can be produced in quantity, so that it is quite likely that the use of radium and its descendants in this type of therapy will soon be superseded by the artificial radioactive elements.

Availability of large quantities of radioactivities has also opened the possibility of their use in industry and industrial processes. Radioactive indicators may soon be used to follow the course of products and impurities in large industrial processes. Applications should be found in the testing of the efficiency of distillation apparatus, in testing for leaks, and in many other ways. The intense sources of gamma-rays will find application in the field of radiography, in looking for imperfections in metal products, studying the path of fast-moving parts, etc.

With respect to chemical problems of direct interest to industries, many examples could be cited. Among these may be mentioned studies, with C^{14}, of the mechanism of catalytic cracking, isomerization, and alkylation of hydrocarbons, which are of profound interest to the oil industry.

The future seems to hold unlimited possibilities for the application of radioactive tracers to scientific problems. It is certain that the applications made thus far are just the beginning of what is going to become an extremely large and successful field of research.

Local Committees, Chicago Meeting, AAAS

From April 7 to 9 officers of the AAAS will meet with representatives appointed from the various educational and cultural institutions in the Chicago area to serve on five committees that will direct local preparations for the 114th meeting of the AAAS, to be held in Chicago December 26–31, 1947. These committees, of about 12 members each, will handle problems of reception and entertainment, procurement and distribution of equipment, registration, and publicity, and will help to raise funds to defray expenses incurred by the work of the local committees.

Honorary chairmen, serving in an advisory capacity for the local committees, include: Paul M. Angle, secretary, Chicago Historical Society; Charles C. Caveny, dean, Chicago Undergraduate Division, University of Illinois; Walter H. Chute, director, John G. Shedd, aquarium; H. C. Coffman, president, George Williams College; V. R. Edman, president, Wheaton College; H. K. Gloyd, director of Museum, Chicago Academy of Sciences; Clifford C. Gregg, director, Chicago Natural History Museum; Henry T. Heald, president, Illinois Institute of Technology; Robert M. Hutchins, chancellor, University of Chicago; A. C. Ivy, University of Illinois; Paul A. Jenkins, executive secretary, Chicago Technical Societies Council; K. Richard Johnson, head of Science Department, National College of Education; T. Lehmann, president, Elmhurst College; L. R. Lohr, president, Museum of Science and Industry; Lee Medsker, dean, Wright Junior College; Comerford J. O'Malley, president, De Paul University; Franklyn B. Snyder, president, Northwestern University; Edward J. Sparling, president, Roosevelt College.

The Chicago Convention promises to be one of the largest on record. At least 60 affiliated and associated societies and sections are planning to meet with the Association.