discontinuities, however, can be viewed as the result of separate cases of neobiogenesis. The same may be said of the discontinuities in the taxonomic arrangement of existing organisms. The difficulty of placing viruses, bacteria, certain "algae," sponges, and so on, in a fitting place in any taxonomic scheme based on a monophyletic hypothesis may stem from the possibility that the discontinuities are real and represent the existence of separate lines of descent from independent instances of neobiogenesis at different times in the history of the earth down to the present (*25*).

References and Notes

1. *Biopoesis* is used here in the same sense as at the 1957 Moscow conference on the origin of life, to refer to the whole process of the evolution of life from inorganic beginnings, whereas *neobiogenesis* is used to refer to the establishment of primitive organisms *de novo* from a complex organic environment already present from any source. The term *'spontaneous generation'* is associated with theories proposing the spontaneous origin of higher organisms—flies, frogs, rats, and so on—as well as microorganisms from lifeless matter. Its use is avoided in this discussion, except in a historical sense.
2. A. I. Oparin, *The Origin of Life* (Academic Press, New York, ed. 3, 1957).
3. H. C. Urey, *Proc. Natl. Acad. Sci. U.S.* **38**, 351 (1952).
4. S. L. Miller, *Ann. N.Y. Acad. Sci.* **69**, 260 (1957); ——— and H. C. Urey, *Science* **130**, 245 (1959).
5. S. W. Fox, A. Vegotsky, K. Harada, P. D. Hoagland, *Ann. N.Y. Acad. Sci.* **69**, 328 (1957); S. W. Fox and K. Harada, *Science* **128**, 1214 (1958); S. W. Fox, K. Harada, J. Kendrick, preprints, International Oceanographic Congress, United Nations, New York (1959).
6. P. H. Abelson, *Ann. N.Y. Acad. Sci.* **69**, 276 (1957); lecture before the International Oceanographic Congress, United Nations, New York (Sept. 1959).
7. Recently J. D. Bernal (preprints, International Oceanographic Congress, 1959) restated his hypothesis that small organic molecules —amino acids, purines, pyrimidines, and so on—appearing in the waters were concentrated by adsorption on estuarine and terrestrial clays and there polymerized into molecules of greater molecular weight. The latter were then released and, along with other complex organic compounds in the environment, interacted to form a protoplankton. Under such conditions life could originate, eventually, without requiring the presence of an organic "soup" throughout the hydrosphere. Abelson (International Oceanographic Congress, 1959) called attention to the random interaction of organic compounds in aqueous solution in vitro to form an unusable tarlike mass. Moreover, the presence of adsorbents would, he maintained, prevent the waters from attaining anything like the concentration of a "soup."
8. G. Wald, in his article "The origin of optical activity" [*Ann. N.Y. Acad. Sci.* **69**, 352 (1957)], proposes the view that the first organisms incorporated both enantiomorphous forms of optically active substances, but that the operation of the principle of natural selection on a molecular level established in living things the present isomers which "won the fight" over their antipodes.
9. M. Phillips, *J. Am. Chem. Soc.* **44**, 1489 (1923); S. Winstein and H. J. Lucas, *ibid.* **61**, 1576 (1939); S. Winstein and E. Grunwald, *ibid.* **70**, 828 (1948); A. Streitweiser, Jr., *Chem. Revs.* **56**, 675 ff. (1956).
10. K. Ziegler, *Brennstoff-Chem.* **33**, 193 (1953); Belgian patents Nos. 533, 362; 534, 792; 534, 888.
11. F. Eirich and H. Mark, *J. Colloid Sci.* **11**, 748 (1956).
12. G. Natta, *J. Polymer Sci.* **20**, 95 (1956).
13. F. Danusso, D. Sianesi, B. Calgagno, *Chim. e ind. (Milan)* **40**, 628 (1958).
14. G. Natta, P. Pino, G. Mazzanti, P. Longi, *Gazz. chim. ital.* **88**, 219 (1958).
15. G. Natta, *J. Inorg. & Nuclear Chem.* **8**, 589 (1958).
16. ———, *J. Polymer Sci.* **34**, 531 (1959).
17. F. Danusso, B. Calgagno, D. Sianesi, *Chim. e ind. (Milan)* **41**, 13 (1959).
18. A. Kornberg, *Proc. Natl. Acad. Sci. U.S.* **44**, 641 (1958); *Harvey Lectures Ser. 53 (1957–58)* (1959), p. 83; *Revs. Modern Phys.* **31**, 200 (1959).
19. W. S. Vincent, *Biol. Bull.* **117**, 388 (1959).
20. Aristotle, *De Generatione Animalium.*
21. T. Needham, *Phil. Trans. Roy. Soc. London*, **490** (1749).
22. L. Spallanzani, "Sappio di osservazioni microscopiche concernenti il systema della generazione dei sig. di Needham e Buffon" (Modena, 1765).
23. F. Pouchet, "Hétérogénie ou traité de la génération spontanée, basée sur de nouvelles experiences" (Paris, 1859); *Compt. rend.* **47**, 979 (1858); *ibid.* **48**, 148, 546 (1859); *ibid.* **57**, 765 (1863).
24. L. Pasteur, *Compt. rend.* **50**, 303, 674, 849 (1860); *ibid.* **51**, 348 (1860); *ibid.* **56**, 734 (1863); *Ann. chim. et phys.* **3**, 64 (1862).

25. The views expressed in this article have been the result of much pondering over a long period. They could hardly have come to fruition in my mind without the many stimulating discussions on a wide variety of subjects in which I was privileged to participate. Outstanding among these were the lectures and seminars which are the fare every summer at the Marine Biological Laboratory, Woods Hole, Mass., and the many conversations with friends with whom I could confidently discuss these somewhat unorthodox ideas. I wish to mention especially my colleagues B. P. Sonnenblick and G. Panson, my research assistant Paula Gottdenker, and Lionel Luttinger of the American Cyanamid Co. Their friendly but penetrating criticism taxed me again and again and helped me to a better expression of my thoughts. I cannot speak for the extent to which I have convinced those who have heard me, and I must take the responsibility for the ideas expressed in this article.

Somatic Radiation Dose for the General Population

The report of the Ad Hoc Committee of the National Committee on Radiation Protection and Measurements, 6 May 1959

At its meeting in November 1958, the executive committee of the National Committee on Radiation Protection and Measurements undertook to re-examine the problem of exposure of the population to man-made radiations from the point of view of somatic effects as distinct from genetic effects. This review was undertaken because of the widespread public concern over the possible effect of radiation from fallout on the population, and because of the possibility that there might be some new, definitive information regarding the somatic effects of chronic low-level radiation on man.

The NCRP was unaware of any new basic information on somatic effects of radiation, upon which it could with sound reason recommend specific changes in permissible exposures for individuals or for population groups. The NCRP felt that information relative to the question was essentially the same as that outlined in National Bureau of Standards Handbook 59. However, it appeared desirable to make a new and independent examination of the problem for the purpose of affirming the views of the NCRP. For this purpose, the NCRP established an Ad Hoc Committee to examine the question further.

At its inception, the National Committee on Radiation Protection and Measurements centered its activities primarily around the problem of radiation hazards associated with industrial and medical uses of radiation. During succeeding years, it became increasingly apparent that NCRP could not ignore its responsibility for making recommendations concerning radiation exposure of larger population groups. Cognizance was taken of this problem at various times—for example, in NBS Handbook 59 (issued 24 September 1954), on pages 78 and 79, in the paragraphs "Non-occupational Exposure of Minors" and "Number of Ex-

posed Individuals" as well as in the separate paragraph found at the end of the Handbook. On 8 January 1957, the preliminary statement released by NCRP setting forth its revised philosophy on the maximum permissible radiation exposure to man suggested a certain limit for average gonadal exposure of the population. The addendum to NBS Handbook 59, dated 15 April 1958, contained additional recommendations concerning the maximum permissible dose to individuals outside controlled areas, and attributable to normal operations within controlled areas, for both external radiation exposure and internally deposited radioactive materials. In its statement of 23 April 1959, the use of the same maximum permissible dose (MPD) was extended to individuals in the population-at-large.

The Ad Hoc Committee report, the NCRP believes, serves to reaffirm the broad policies of the NCRP with regard to basic permissible dose criteria, but the report is not to be regarded as containing specific recommendations by the NCRP.

The report takes the line of conservatism. The Ad Hoc Committee felt that there was no other choice until more and better information is available on the effects of low-level chronic radiation exposure. Although a conservative and possibly pessimistic assumption with regard to radiation effects has been made, this should not carry any implication that either the NCRP or the Ad Hoc Committee accepts such assumptions as established facts. These assumptions have been adopted in the interests of prudence.

Upon review of the Ad Hoc Committee's report, it was noted that while the report suggests a basis for expressing the maximum permissible somatic dose for the population, it does not contain specific recommendations immediately applicable as maximum permissible doses. It also appears likely that the maximum permissible doses that might be derived from the Ad Hoc Committee's report would not be widely different from the current recommendations of the International Commission on Radiological Protection even though they are expressed in reference to another base. This report is, therefore, being referred to NCRP subcommittee I on "Maximum Permissible Dose Criteria" for further consideration and the possible formulation of specific values to be recommended as the maximum permissible dose. Pending the possible formulation and approval of such recommendations, the NCRP recommends the use of the current recommendations of the ICRP concerning permissible doses for the population.

Report of Ad Hoc Committee

I. Introduction

The National Committee on Radiation Protection, in the past, has recommended maximum permissible doses of ionizing radiation for occupationally exposed persons and other special groups. Its recommendations regarding exposure of the whole population to radiation have been primarily concerned with the genetically significant dose. An increasing number of sources of man-made radiation, industrial and military, make it desirable to consider the setting of maximum permissible levels of somatic exposure for the general population. This becomes increasingly important in view of the fact that certain radioelements, such as strontium and iodine, are nonuniformly distributed in the body and result in much larger doses to specific body tissues than to the gonads. This Ad Hoc Committee was appointed to examine the problem and report to the National Committee on Radiation Protection.

The Ad Hoc Committee has considered the basic concepts and premises by which maximum permissible levels of ionizing radiation for the general population might be established and how these might be applied to radiostrontium and other widespread contaminants.

II. Dose-Effect Relationship at Low Doses

Radiation doses to which the general population is likely to be exposed in peacetime are very low. Furthermore, the rate of delivery from most sources is slow, so that a small dose is accumulated over a long period. Yet the existing data upon which present protection criteria are based are from experimental animals exposed at higher, and frequently from acute, doses. Similarly, human data that are available are also primarily from higher doses.

If we understood the exact mechanism of the interaction of radiation and biological tissue, and the subsequent chemical, physiological, and morphological events leading to the final effects, we could extrapolate back to very low doses and make confident estimates of the extent of human damage to be expected from such a dose. Lacking this information, we must rely on the character of the dose-effect curve at higher doses and estimate the effects of changes in intensity and spacing of the dose.

A proportional (linear nonthreshold) relation between dose and biological effect is usually taken to imply a single-event process, especially if this is supported by data showing dose rate independence. More accurately, the relationship is $\log S = -kD$ (where S is the proportion not effected, D is the dose, and k is a constant). At low doses, this is not distinguishable from a straight line. With such a dose-effect relationship, linear interpolation between the observed values and the origin is acceptable when the doses and the related effects are too low to be measured accurately with our present methods.

If the true relationship is curvilinear at low doses, or if there is a threshold dose below which no effect is produced, a more complex mechanism may be inferred and extrapolation to lower doses could be grossly misleading.

The committee concludes that the present data are still *insufficient to establish the character of the dose-response* curve for somatic effects. Nor is there sufficient knowledge of the mechanisms to serve as a guide in areas where the data are not available.

In the absence of such information, the committee believes that it is prudent to be conservative and choose a premise which, if in error, would be likely to overestimate the effect of low doses rather than underestimate it. The committee decided to adopt as an assumption that a proportional relationship between dose and effect exists, as briefly outlined above. This signifies that no threshold exists, and, by inference from some of the theoretical concepts, we will assume further that the radiation dose is completely cumulative and that the effect is independent of the rate at which the radiation is delivered.

The members of the Ad Hoc Committee of the National Committee on Radiation Protection and Measurements are: Austin Brues, Argonne National Laboratory; James Crow, University of Wisconsin; E. B. Lewis, California Institute of Technology; Karl Z. Morgan, Oak Ridge National Laboratory; W. S. Snyder, Oak Ridge National Laboratory, *alternate*; Clinton Powell, U.S. Public Health Service; Frederick Seitz, North Atlantic Treaty Organization; Forrest Western, U. S. Atomic Energy Commission; and Hymer L. Friedell, Western Reserve University, *chairman*. Lauriston S. Taylor, chairman of the National Committee on Radiation Protection and Measurements, prepared the introductory material.

If there is a threshold, there will be no effect at doses below this threshold value. If the true relation is curvilinear with an accelerating effect as the dose increases, such as would occur if the biological effect depended on multiple events or on a mixture of threshold and nonthreshold causes, the proportional assumption overestimates the effect at low doses. There is the possibility that the curve is concave in the opposite direction, but this seems very remote. Moreover, data that show a dose-rate dependence generally indicate that the effect is less with a low rate of delivery or with intermittent dosage than with the same total delivered in a short time. For these reasons, the committee believes that the proportional assumption is a conservative, and perhaps a stringent one.

The Ad Hoc Committee emphasizes that this conservative assumption was adopted not because any definitive conclusions were reached as to the true nature of the dose-effect relationship but because the committee would prefer to err on the side of overcaution rather than in the opposite direction. With this assumption (nonthreshold linear dose-effect relationship), or, for that matter, any nonthreshold assumption, it follows that even the smallest dose would involve some risk. This means that the exposure should be kept as low as feasible and that no level of radiation is warranted unless the benefits balance or outweigh the assumed risk.

This also means that if a maximum permissible dose is determined, it will necessarily be at an arbitrary level where, in the judgment of those choosing the level, the risk is acceptable as compared to the benefits. Every effort should be made to maintain the actual dose as far below the permissible level as possible.

III. Should the Population Dose Differ from that for Occupationally Exposed Groups?

The committee believes that the dosage permitted for the general population should be substantially less than that permitted for occupationally exposed or other special groups. Some of the reasons are:

1) The general population is much larger, and if exposed to the same dosage there will be the risk of a correspondingly larger number of individuals with injurious effects.

2) Employment involving occupational hazard to exposure is voluntary, and the extent and nature of the exposure can, in principle, be foreseen by the individual accepting any risk that may be involved.

3) Industrial workers are relatively carefully screened. Generally, those least able to meet any peculiar hazard may be channeled into other activities.

4) In industry there can be specific evaluation and control of the hazards by radiation monitoring and other studies.

5) Children and embryos may be particularly sensitive. These can generally be excluded from groups receiving the maximum permissible occupational dose.

6) The number of years of exposure to radiation for occupational reasons will be much less than the number of years of exposure to environmental sources of radiation.

7) If industrial hazards exist, it is obvious that any of these hazards (one of which is radiation) should not be spread beyond the individuals in that particular occupation. If the hazards to the outside nonindustrial population are not reduced as compared to those within the industry, the risk to the total population could be unacceptably high because of the contributions from all the occupational hazards in the society.

For these reasons, the committee believes that it is appropriate to set lower maximum permissible doses for general population groups than for persons exposed to radiation for occupational reasons.

IV. Bases for Establishing a Maximum Permissible Dose

On the basis of the assumption discussed in section II, any realistic recommendations of maximum permissible dose must be reached by balancing biological risks against the reasons for accepting exposures to radiation. It is highly improbable that such a balance can be made with accuracy, not only because of our limited knowledge, both of benefits and of risks, but also because of difficulties in comparing social, economic, and other benefits with radiation risks. Nevertheless, since decisions will be made, if only by default, it is desirable to make the best evaluations possible at the present time.

As a first approach, there are several possible scales on which the risks from low levels of radiation dose may be related to human experience. The committee believes that all of these are meaningful and has tried to consider them in its deliberations.

1) *Relating the population dose to the level established for occupationally exposed groups.* This could be done by taking an arbitrary fraction of the occupational dose and using this as the maximum permissible dose for the general population.

2) *Relating population dose to the estimated effects of radiation and to other risks of life.* The estimated effects of the exposure of the public to low doses of radiation can be assessed in principle in three ways: (i) by their estimated absolute incidence; (ii) by their estimated incidence relative to the spontaneous incidence of the same biological effects, *e.g.* leukemia; and (iii) by comparison with the effects of other population risks not associated with radiation.

3) *Relating the population dose to the natural background radiation level.* If any risks are associated with natural background radiation, they are accepted as a normal factor of life. Ordinarily no effort is made to reduce them, and ordinarily no consideration is given to differences in background levels in determining where one shall reside.

The committee recommends, pending more precise information, that maximum permissible doses for the general population should be related to the average natural background level of radiation. One reason is that this level can be determined relatively easily and is relatively stable in time. A more important reason is that this is a level to which the human population has been exposed throughout its history. The further we get from this level, the less confidence we have that any effects will be similar in kind and quantity to those the population has experienced from natural background radiation and has been able to tolerate in the past.

V. Recommendations Regarding Permissible Doses to the Population

It is not the responsibility of this Ad Hoc Committee to recommend specific levels of maximum permissible dose to the population. It hopes that as more data become available, both as to benefits and risks, a maximum permissible dose representing a proper balance between these can be found. Meanwhile, it believes that the maximum permissible dose of man-made radiation (excluding medical and dental sources) should not be substantially higher than the background level of natural radia-

tion without a careful examination of the reasons for higher values. For this purpose it may be convenient to take the background level arbitrarily to be 100 millirem per year.

In the practical application of maximum permissible levels to the general population, it is necessary to consider a number of factors, some of which are noted in the following discussion.

It is not feasible at the present time to monitor the population dose solely by measuring the dose to individuals. Moreover, any control measures to be effective must be directed at levels of radiation and of radioactive materials in the environment. Thus, it is contemplated that maximum permissible levels for such environmental factors as food, water, and air will be set for certain areas in such a manner that the radiation dose to typical persons in those areas from all sources (excluding natural background, medical, and dental sources) will not exceed the appropriate maximum permissible level. For this purpose the committee recommends that it should be allowable to average doses over a suitably long period of time, *e.g.* one year, and over population groups approximating the size of a state or major city. Because of variability of dose levels with location, it is expected that the average dose to the total population would be considerably less than the maximum permissible level.

Some radioisotopes are distributed through the body in such a fashion as to give an approximately uniform distribution of radiation dose to all of the body tissues. However, from certain radioisotopes, such as those of strontium and iodine, radiation doses are much higher in some tissues than in others. In general, the maximum permissible level should apply to the tissue receiving the greatest dose—bone in the case of strontium, thyroid for iodine. If several sources of radiation are involved, the total dose to the tissue from all such sources should not exceed the maximum permissible level.

It is recognized that for some radioisotopes, environmental levels may conceivably result in higher radiation doses to children than to adults. In such cases, permissible levels should apply to radiation doses received in the age ranges of highest dose, rather than to the population group as a whole.

The committee emphasizes that the final criterion in environmental control is the level of radiation dose to human tissues, and that environmental levels are used only as indicators and means of control. At the present time permissible levels for the environment may be derived from permissible levels of dose to humans only by making certain assumptions involving such factors as movement of radioisotopes in the environment, relationships between environmental and dietary concentrations, and biochemical behavior in the body. Recommended maximum permissible concentrations in the environment will require revision as new information on such factors becomes available, or as indicated by actual experience with environmental situations.

Since any maximum permissible level based on the considerations discussed above is a relative standard designed to keep the average radiation dose to the population as low as feasible, it follows that *a level recommended for one set of conditions may not be appropriate for another.* For example, maximum permissible concentrations in foods designed to limit the release of radioactive materials into the environment may appropriately be much lower than levels at which the foods may be considered unfit for use; and maximum permissible concentrations in air designed to limit the release of materials into the environment may be much lower than levels at which it would be wise to evacuate an area in case of accidental release of larger quantities of such materials.

VI. Discussion

This committee has not made any recommendations regarding medical and dental radiation. The reason is that in this case the individual exposed to the risk and the one receiving the benefit are the same. The balancing of the risk is largely a medical problem. Furthermore, there are circumstances when going beyond any preassigned maximum permissible level may be thoroughly justified. It is axiomatic that every reasonable precaution should be exercised to keep the radiation dose as low as possible.

The Ad Hoc Committee was not asked for comments regarding genetically significant radiation. With the assumption of an effect proportional to the dose, which is the same as is generally assumed for genetic effects with low doses, some of the genetic and somatic considerations become very similar. Some sources of radiation, such as radioactive cesium, give about the same dose to the gonads as to other parts of the body. For others, such as radiostrontium, the gonad dose is exceedingly small in comparison with the bone dose.

The committee would like to note that if the National Committee on Radiation Protection chooses a maximum permissible dose of man-made radiation, exclusive of medical and dental sources, in the general vicinity of the background level, there will be an order of agreement with the recommendations of other groups that have studied the problem. The previous recommendation of the National Academy of Sciences Committee and the National Committee on Radiation Protection for a maximum average-per-capita-dose to the gonads of 10 roentgens of man-made radiation per 30 years is roughly three times the background level, and these recommendations include the estimated contribution from medical and dental radiation. We note the maximum permissible dose of whole-body exposure for a single individual recommended for the general population by the International Commission on Radiological Protection and the NCRP, although expressed in terms of a fraction of the permissible occupational exposure, is approximately five times the background. For long-range planning purposes, the International Commission on Radiological Protection has suggested a permissible average level for the whole population in the general vicinity of the background dose (a man-made radiation level of 1.7 times background, if background is taken to be 100 millirem per year).

VII. Summary: Conclusions

On the basis of the general principles outlined previously, and examination of some of the problems posed by widespread man-made contamination by various radioelements, the committee makes the following recommendations for the guidance of those concerned with the establishment of tolerable somatic levels for widespread radiation:

1) The committee believes that present evidence is not sufficient to establish the dose-response curve for somatic effects at low doses. In the absence of such information, the committee has chosen to make the cautious *assumption* that there is a proportional relation between dose and effect and that the effect is independent of dose rate or dose fractionation.

2) On this, or any other nonthreshold assumption, it follows that even the

smallest dose is associated with some risk. Under these circumstances, the exposure of the population to any increase in radiation should not occur unless there is reason to expect some compensatory benefits.

3) Because of our present limited information, an accurate estimate of the hazard and the benefits of a specific level of radiation is not possible. Therefore, pending more precise information, we *recommend* that the population permissible dose for man-made radiation be based on the average natural background level.

Although it is not our responsibility to determine the exact level, we believe that the population permissible somatic dose from man-made radiations, excluding medical and dental sources, should not be larger than that due to natural background radiation, without a careful examination of the reasons for, and the expected benefits to society from a larger dose.

It is expected that, because of fluctuations in time and location, the population average dose will be considerably less than the maximum permissible dose.

4) For purposes of computation, it should be permitted to average the amounts over a suitably long period of time, *e.g.* one year, and a reasonable sized population.

5) For radiation sources, such as radioactive strontium and iodine, which deliver radiation predominantly to one organ or tissue, the maximum permissible dose should be established for the tissue or organ that is expected to receive the most radiation.

6) It is not possible at present to monitor the population dose solely by measuring the dose to individuals. Furthermore, any effective control over radiation levels must be directed at the levels of radiation and radioactive materials in the environment. This means that maximum permissible levels will need to be established for such factors as food, water, and air. The levels should be set so that the typical person in the area will not receive more than the established permissible dose when all sources are combined.

7) It is recognized that setting environmental levels involves assumptions and conversion factors to translate these into human body levels. These factors may be expected to change with new information, so the environmental levels may be expected to require continuous revision even though the maximum permissible limits to the body are not changed.

8) Recommendations regarding a maximum permissible level for medical and dental exposures to the patient are not given because for somatic effects of radiation the possible harm and prospective benefits occur in the same individual in contrast to radiation involving genetic material. The committee urges that continual caution be exercised to maintain radiation for medical and dental purposes at the lowest feasible level.

9) Finally, the committee wishes to emphasize that under one of the primary assumptions made in this report (nonthreshold linear dose response), the biological effect does not suddenly change from harmless to harmful if any permissible dose is exceeded. Any permissible level which may be chosen is essentially arbitrary and every effort should be made to keep the radiation dosage as far below the permissible level as feasible. On the assumption noted above, any radiation dose should be thought of as being tolerated only to obtain compensatory benefits.

Cornelius Packard Rhoads, Leader in Cancer Research

In announcing the death of Cornelius Packard Rhoads, which occurred on 13 August 1959, the Sloan-Kettering Institute described him as "one of the principal pioneers in the development of treatment of cancer by drugs." This was a modest statement indeed. He was, in fact, one of the chief architects of the modern era of cancer research. His attraction to this field was a natural one, from his early training in surgery and pathology and his later connection with the Rockefeller Institute for Medical Research. Two appointments that Rhoads received in 1940 were decisive factors in the shaping of his career. At that time he became professor of pathology at the Cornell University Medical College and director of the Memorial Center for Cancer and Allied Diseases. In 1945 he was appointed director of the newly established Sloan-Kettering Institute for Cancer Research, a research affiliate of Memorial Center. Five years later he relinquished the directorship of Memorial Center to concentrate his energies on the research programs of the Sloan-Kettering Institute.

Rhoads' personal contribution to medicine and medical education, and particularly to cancer research, was a tremendous one. Until his death he continued in his appointment as professor of pathology in the department of biology and growth of the Sloan-Kettering Division of Cornell University Medical College. As a member of the National Research Council he served during World War II as a member of its subcommittee on blood substitutes, as a member of its committee on war gas casualties, and as chairman of its blood procurement service. Later he was a member of the Council's committee on veterans' medical problems and committee on atomic casualties. He was a member of the National Research Council's advisory committee on chemical-biological coordination and a member-at-large of its Division of Medical Sciences.

Rhoads served as chairman of the committee on growth of the National Research Council—a group which for several years provided valuable guidance and inspiration for the development of modern cancer research. He