NOTES ON BIOLOGICAL AND MEDICAL CONSIDERATIONS

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1. Considerations common to external and internal radiation.

a. Any consideration of military effectiveness of radioactive materials must take into account the very wide spread between dosages necessary to produce casualties within a short time (hours) and those which will produce disability or death after a lapse of time (days, weeks, months, years).

b. Consideration must also be given to the very low limits of tolerance to continued or repeated radiation. Dosages which would be without demonstrable effect for exposure over short periods of time (hours, days) may produce permanent damage, or even death, if continued for longer periods (weeks, months). This has bearing on the manner in which radioactive materials might be used, and particularly on panic effect of distribution of such materials.

c. An important consideration concerning a potential military weapon is the ease with which its effects may be neutralized or counteracted by appropriate medical treatment. Discovery of an effective treatment for lewisite poisoning, for example, considerably diminished any possible usefulness of this agent in warfare. In the case of radioactive materials no treatment at present known has any marked effect upon the physiological actions of these substances, and there is no known method for exerting any pronounced effect upon the rate of elimination of such substances from the body. In general, therefore, the effects of radiation, or of intake of radioactive substances, are to be considered as irreversible, except in so far as the body's own mechanisms are able to deal with them.

d. While there is a wide range of radioactive isotopes, with extremes of physical and chemical properties, selection of those for work on biological and medical considerations must, to a large degree, be based on such practical questions as those of availability.

2. Considerations concerning external radiation.

a. Except for panic effects, and for some effectiveness with reference to denial of terrain (cities, etc.) any possible military effectiveness of alpha and beta emitters for external radiation would be so limited as to be almost negligible. Consideration of military usefulness of external radiation is accordingly limited almost entirely to gamma rays.

b. Use of gamma emitters for external radiation does not introduce any serious problems concerning dispersion. Dusting of relatively large particles on the ground can be relied upon to produce the calculated hazards.

c. Given a choice of materials, length of time that occupation of terrain would be hazardous may be controlled by selection of materials according to half-life.

d. More accurate information than is at present available is needed on the points as listed hereunder. The obtaining of this information does not offer any insuperable difficulties:

(1) Tolerance dosages, both for continued and single exposure. For military purposes, this information is needed as a basis for estimating how long civilian and military personnel may remain in contaminated areas. Present estimates of tolerance dosages, even if sound for protection of laboratory personnel, etc., would probably require revision for military purposes, to permit a certain amount of calculated risk.

(2) Relation of dosage, either from continued or from single exposure, to time required for production of casualties, defined in terms of disability or death.

e. Experimental work on the effects of continued exposure to contaminated terrain should, in so far as is possible be carried out on large animals (pigs, goats, sheep, cattle), in order to simulate the effects upon man.

3. Considerations concerning **internal** radiation.

a. Any consideration of the possible use of radioactive materials to produce internal radiation (i.e., radiation from substances after their entrance into the body) introduces much greater complications, and a much larger number of variables. Some of these are listed as follows:

(1) Method of dissemination. For the most part, substances to be taken into the body would require dissemination in particulate clouds, i.e., as aerosols. Satisfactory methods for such dissemination, on a large scale, have not as yet been developed. Such clouds would be effective both on the surface of the body (external radiation), and after entrance into the body (internal radiation) chiefly by inhalation. Since inhalation would be easily prevented, by the use of appropriate filters, high concentrations, for surprise and panic effects, would be desirable.

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(2) Particle size. Sufficient work has been done on particle size to establish the range of size desirable, both from the standpoint of the stability of clouds, and from that of behavior in the respiratory tract. Materials of large size, which are filtered out in the upper respiratory tract, will be discharged from the body, or may be swallowed, and either lost in the excreta or absorbed from the gastro-intestinal tract. On the other hand, very small particles (cf. cigarette smoke) will be lost by exhalation.

(3) Portal of entry. The chief portal of entry into the body will be by way of the respiratory tract. Contamination of food and water, however, may conceivably lead to absorption of large amounts of radioactivity through the gastro-intestinal tract.

(4) Locus of deposition in the body. Many radioactive minerals will be deposited in the bones, where, owing to the slowness of turnover, they may remain in considerable quantities throughout the lives of the individuals. In the case of radium it is well known that substances may be retained in the bones for years before finally giving rise to disability and even death. The same situation may be expected in the case of other minerals, particularly those that are able to substitute in the apatite lattice of the bone mineral. In general, the turnover of the elements in the soft tissues is sufficiently rapid to enable the body to rid itself rather rapidly of such elements as are deposited in these tissues.

(5) Types of radiation. All types of radiation - alpha, beta, and gamma, may be effective from the standpoint of internal radiation, and the effectivenss must be studied in relation to other variables, such as half-life, locus of deposition, physiological actions.

(6) Half-life. For internal radiation, consideration of the life of the radioactive isotope is especially important. Except for panic effect, and for compelling evacuation of terrain, a long-lived substance, which would be deposited in the bone, in doses insufficient to produce immediate physiological effects, would have little military value. On the other hand disability and death from such substances would manifest themselves in later years, long after the possibility of influencing the immediate situation had disappeared. In general, such considerations would lead to the use of relatively short-lived isotopes, for their immediate effects, rather than of long-lived substances.

(7) Physiological effects. While the gross physiological effects of internal radiation, both acute and chronic, are known, much more work needs to be done on this subject, taking into account all of the variables considered above. Acute effects of internal radiation, leading to early disability (days), are chiefly upon the gastro-intestinal tract, leading to bleeding, and upon the blood-forming organs, leading to their destruction. Acute death is generally result of the latter effects.

b. Because of the complexities introduced by internal radiation, and because these have not had intensive study at dosage levels of interest from the military standpoint, the greater amount of effort, in the laboratory and in later field trials, will be needed on these aspects of the potentialities and limitations of radiological warfare.

c. Since internal radiation depends upon entrance of radioactive materials into the body, and since this in turn depends largely upon such considerations as particle size and method of dissemination, work on the biological and medical aspects of internal radiation must be closely coordinated with that on munitions development.