antigen by *in vitro* procedures. For other viruses and rickettsiae, there are not yet available simple and reliable technics for the detection of specific antigens early in the disease process. Recovery and identification of the infectious agent and the demonstration of a specific antibody response after the early stages of the disease constitute the mainstays of laboratory diagnosis. Both have the disadvantages of requiring considerable effort and time and therefore tend to yield information only of retrospective value. Recent advances in tissue culture methods have simplified the diagnostic problem in some virus diseases, particularly in poliomyelitis. In this disease, tissue culture has largely replaced the experimental animal as a means for recovery and identification of the virus and measurement of specific antibodies. In addition, the newer tissue culture technics have made feasible the propagation of varicella and herpes zoster viruses, possibly also common cold virus, and have resulted in the recovery of a number of seemingly new infectious agents.

Although effective chemotherapeutic agents are now available for all rickettsial diseases and for those diseases caused by the psittacosis-lymphogranuloma venereum group of agents, there is still no good evidence that substances, useful in man, have been found for other virus infections. However, vigorous efforts in this direction continue and some substances capable of inhibiting the reproduction of certain animal, bacterial, or plant viruses under experimental conditions are now known. The effects of proflavine on phage multiplication appear to be best understood. The compound is thought to prevent the final assembly of the mature virus particle but does not affect the earlier production of either phage proteins or nucleic acid. However, despite its effect upon the bacterial virus, proflavine fails to provide any benefit to the infected bacterial host which proceeds to die at the expected time. Inhibitors of plant virus multiplication have received relatively little detailed study, partly because of technical difficulties, and it is doubtful that the effects of any can yet be described in mechanistic terms. In the animal virus field a variety of substances of widely dissimilar nature have been investigated intensively but only in a few instances, for example, with mumps and influenza viruses, have kinetic studies on inhibitor activity been undertaken. Chief interest appears to be in compounds that may act as inhibitors of required biosynthetic processes. Various so-called antimetabolites such as analogues of amino acids and derivatives of benzimidazole, cause effects in some virus infections that may prove to be of importance.

The Radioactivity of the Human Being

A. T. Krebs
Army Medical Research Laboratory, Fort Knox, Kentucky

THE amount of radioactive substances deposited naturally in the normal human being has become one of the key figures in recent discussions on "tolerance" dose, "permissible" dose and "damaging" dose in repeated, as well as in single, total body exposures to ionizing radiations. Its magnitude, originally reported by Krebs (*1–3*) as close to the accepted permissible body content of 1×10^{-7} gram radium element permanently fixed in the body, became uncertain, when Hursh and Gates (*4*), in 1950, found values 100 to 1000 times smaller than the accepted permissible content. While the reasons for this discrepancy were under discussion, Sievert (*5*), in 1951, using a special gamma-ray sensitive device for measurements on the intact living body as a whole, reported an average radioactivity of the human being close to the values given by Krebs and, thus, close to the permissible content. In connection with present considerations on the extension to man of the findings from experimental whole body irradiation studies (*6*), a critical review of the present situation seems adequate in order to come to an understanding of the reported values.

The data on total body radioactivity of the human being so far reported are presented in Fig. 1. They were obtained by Krebs in the study of 17 cases in the age range 50 to 91 yr, by Hursh and Gates in 25 cases in the age range 33 to 85 yr, and by Sievert in 12 cases in the age range 15 to 58 yr. Krebs measured his samples with an especially developed alpha-particle counter and with the emanation method. His values are given in amounts of radioactive substance equivalent to radium and/or radium element. Hursh and Gates used exclusively the emanation method and reported their findings in radium element. Sievert measured the radioactivity of the living individual with

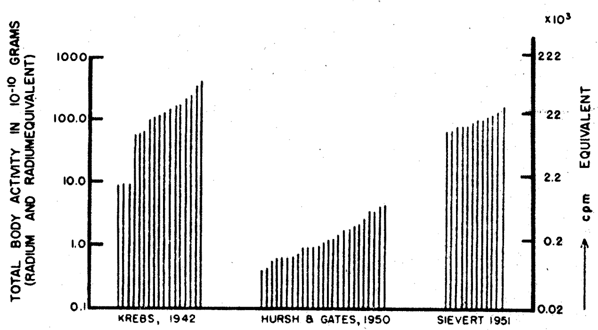

FIG. 1. Radioactivity of the normal human being.

TABLE 1. Radioactivity of tissue from uranium miners (St. Joachimsthal) (Behounek and Fort, 1941).

Age of miner (in yr)	Activity per gram of fresh tissue (in 10^{-14} g)			
	Emanation method*		Alpha activity method†	
	Lung	Vertebra	Lung	Vertebra
34	9.7	533	316	432
37	13.5	290	256	518
40	12.7	403	154	109
44	3.5	312	27	210
46	8.5	377	71	410
46	8.2	290	71	660
49	15.0	460	22	50
50	5.8	534	22	395
62	10.3	367	174	315

* Records only radium element.
† Records all alpha emitting radioactive substances.

special gamma-ray sensitive ionization chambers. His values are presented in gamma radium equivalent, which means in amounts of radioactive substance the magnitude of which is equivalent to the gamma radiation emitted by the proper amount of radium element. In evaluating and comparing, with these facts in mind, the presented data, the question immediately arises regarding the principles and the characteristics of the different methods used for the determination of the activities.

The normal emanation method, one of the most outstanding procedures in classical radioactivity studies, measures the amount of radium element in the sample. It does not detect other possibly present, nonemanating radioactive substances. Even short-lived emanations, such as thoron with a half-life of about 54 sec, which indicate the presence of active compounds, can be measured only with specially constructed experimental attachments. Thus, it already becomes evident that the particular method used determines the type and the amount of radioactive material that will be reported.

The methods based on gamma-radiation measurements record the activities of practically all gamma-ray emitting elements in the tissue and in the body, independent of location and distribution. The values obtained with these methods will always be higher than the pure radium element values, since man incorporates from his environment into his body not only radium but also other gamma-ray emitting radioactive substances. Since Sievert's device measures the activity of the living body as a whole, it offers another great advantage in comparison with methods that measure only the activity of certain tissue and body parts and require calculation of the total body activity

TABLE 2. Radioactivity of the human being.

1. Total body radioactivity

a. Normal cases

Investigator	No. of cases	Age (yr)	Activity range (in 10^{-10} g)	Average activity (in 10^{-10} g)
Hursh and Gates, 1950	25	33–85	.38–4.3*	1.5*
Sievert, 1951	12	15–58	67–165†	103†
Krebs, 1942	18	50–91	10–400†	140†
b. Occupationally exposed cases				
Sievert, 1951	12	25–64	90–680†	

* Radium element
† Radium equivalent

2. Tissue radioactivity

a. Normal cases

Investigator	Tissue	No. of cases	Age (yr)	Activity in 10^{-15} g radium equivalent
Krebs, 1939/42	Muscle	6	47–88	10– 300
	Lung	9	18–88	60– 6500
	Vertebra	5	47–75	700– 4600
b. Occupationally exposed cases				
Krebs, 1942	Lung	17	38–68	20– 9000
Behounek and Fort, 1941	Lung	21	34–62	225– 5550
	Vertebra	10	34–62	500–20,000

3. Natural radioactivity of body, after Grosse and Libby (*8*)

Element	Potassium	Carbon	Radium	
Amount per body (in g)	280	14,400	8×10^{-9}	4×10^{-9}
Nature of emitted particle	Beta	Beta	Alpha	Alpha
cpm from total amount	380,000	150,000	18,000	9000
Reference	Sherman	Sherman	Vernadsky	Evans, R. D.

by multiplying the tissue activities with estimated tissue and organ weights.

The investigations based on particle counting and particle ionization measuring methods will give values close to the upper limits of the radioactivity of the body. These methods record especially all alpha-particle emitting elements accumulated in the body under the individually given conditions. They include the main radioactive elements and their decay products, the uranium, thorium, and actinium families. These values should contribute decisively to the picture of the internal irradiation burden to which man is subjected.

There is a definite difference between the amount of radium and the amount of radioactive substances to be found in tissue, as may be seen from the values obtained by Behounek and Fort (*7*), when measuring one and the same tissue with two different methods (Table 1). There is however, no consistency in the ratio of these two values. The ratio of radium content to radioactive-material content changes from case to case, depending on the history of the case and on the physiological state of the individual as well as on the rate of accumulation and excretion for the individual radioactive element in the body.

It should be kept in mind, therefore, in any discussion of the problem that the emanation method gives the amount of radium element present in the body; the gamma-ray sensitive methods measure the activity in gamma radium equivalent; and the alpha sensitive methods preferentially record the radioactivity of the body in alpha radium equivalent. In the earlier publications on the radioactivity of normal and abnormal tissue, this was clearly stated and emphasized; later and even in recent publications this distinction was lost in the discussion of details.

Application of these criteria to the radioactivity values presented in Table 2 leads, therefore, to the following conclusions. Measurements of the radioactivity of the human body with methods that record radium element *per se* show, in general, the lowest values. Measurements with particle-counting devices and/or with alpha and gamma radiation sensitive ionization setups give higher values, since these methods record, besides radium element, other radioactive substances that are accumulated and deposited in the body from its environment during the years.

There is no definite, discrete value of the radioactivity of the human being. Like all other biological values, this value also covers a range rather than showing one proper figure (*9*). The amounts of radium element to be found in the body seem to be well below the accepted permissible radium content of 1×10^{-7} g per body. The amounts of radioactive substances deposited in the body, however, exercise an irradiation burden on the body close to the accepted tolerance figures. They are, nevertheless, much lower than the toxic amounts found so far in radium-poisoning cases. The question, insofar as these findings and the knowledge gained in radium-poisoning cases can be extended to total body irradiation studies on man, by applying the time-intensity law, requires special considerations.

References

1. A. Krebs. *Fundamenta Radiol.* **5**, 89 (1939).
2. ———. *Z. Altersforschung* **4**, 53 (1942).
3. ———. AMRL-Report #109. Fort Knox, 1953.
4. J. B. Hursh and A. A. Gates. *Nucleonics* **7**, 46 (1950).
5. R. M. Sievert. *Arkiv Fysik* **3**, 337 (1951).
6. F. C. McLean, J. H. Rust, and A. M. Budy. *Military Surgeon,* **112**, 174 (1953).
7. F. Behounek and M. Fort. *Strahlentherapie* **70**, 487 (1941).
8. A. V. Grosse and W. F. Libby. *Science* **106**, 88 (1947).
9. F. W. Spiers and P. R. J. Burch. *Biological Hazards of Atomic Energy*, A. Haddow, Ed. (Oxford Univ. Press, New York, 1952), p. 203.

News and Notes

Entomologists Meet

THE 1953 Annual Meeting of the Entomological Society of America was held at the Hotel Biltmore, Los Angeles, Calif., Dec. 7–10, 1953, with nearly 700 entomologists registered. The president for 1954, Dr. H. H. Ross of the Illinois Natural History Survey, was installed, and the election of Dr. George C. Decker, of the same organization, as president-elect was announced. The next Annual Meeting will be held at Houston, Tex., Dec. 6–9, 1954.

The recent meeting was the first since the Society's reorganization resulting from the consolidation of the American Association of Economic Entomologists (1889–1952) and the former Entomological Society of America (1906–1952). Dr. E. G. Linsley, of the University of California, Berkeley, spoke on the role of taxonomy in the new Society and predicted that increased encouragement for taxonomic studies could be expected. The great value of taxonomic work was one of the views also stressed by Dr. C. E. Palm, of Cornell University, the retiring president, in his address, "The growing responsibility of entomology to human welfare." A concluding thought of his address was expressed in his appraisal of the future progress of entomology as a profession: "The key to future gains, and our ability to serve, lie in the support and conduct of basic research in broadest terms for all aspects of entomology. The entomologist can no longer withdraw from his obligation to share his knowledge about insects with the public who must be informed if it is to support him adequately."

The resistance of insects to insecticides was discussed by several speakers, including Dr. Palm, who in his address suggested that the occurrence of resistant strains of insects may well be responsible for the growing support of basic physiological research, which despite its importance has been neglected too often in the past. Drs. R. B. March, R. L. Metcalf, and L. L. Lewallen, of the University of California