the range of 0.3 to 0.5 percent Cr_2O_3. Rapid chilling and dilution of the solution at the end of the digestion is effective in arresting the reduction of sexavalent chromium due to the formation of a small amount of hydrogen peroxide during the period of oxidation. Potassium permanganate, if added, would reduce the hydrogen peroxide preferentially, leaving the chromium in sexavalent form (*4*).

Reference 1 did not stress the critical factors of time, temperature, and acidity of digestion or mention the possible source of error and low results due to prolonged digestion.

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19 July 1954.

Genetics of Homothallic Fungi

Advances in Genetics, vol. V, contains an important and interesting paper by Pontecorvo *et al.*, on the genetics of the fungus *Aspergillus nidulans* (*1*). In the paper, however, the authors refer to this organism as the first homothallic fungus ever investigated genetically. They also report the discovery of a new phenomenon which they term "relative heterothallism." The validity of these claims seems extremely doubtful in view of the extensive genetic studies that have been carried out with members of the genus *Glomerella*. These studies date from 1914, when Edgerton (*2*) reported the occurrence of cross-fertilization between strains of *Glomerella*. References to most of the papers published since that time may be found in a recent review of the genetics of this fungus (*3*).

Wild-type cultures of *Glomerella* isolated from nature, as well as many mutant forms derived from them, are self-fertile when propagated from single, uninucleate haploid cells. Such cultures are clearly homothallic according to Pontecorvo's definition of the term. In wild-type cultures, mutant nuclei arise that undergo preferential cross-karyogamy, and, as a result, ascospores from many of the perithecia produced by such cultures segregate in a 1:1 ratio for wild-type and mutant forms (*4*). The phenomenon of preferential cross-karyogamy (relative heterothallism) also occurs commonly when *Glomerella* cultures are mated (*5, 6*), and an analysis of genes controlling this phenomenon in matings in which neither, one, or both of the mated cultures were self-fertile has been published (*7*). As a result of these behavior patterns, *Glomerella* has been termed homothallic, partially heterothallic, and homothallic with heterothallic tendencies. That a similar paradoxical situation exists in *Aspergillus nidulans* seems evident from the fact that this fungus is claimed to be both clearly homothallic and relatively heterothallic in the same paper (*1*). The results with both *Glomerella* and *Aspergillus* appear to emphasize Olive's (*8*) observation that "it is not wise to conclude that any fungus is strictly or irrevocably homothallic."

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29 July 1954.

Taken literally, my statement that "Genetic analysis of a homothallic fungus (*Aspergillus nidulans*) has been carried out for the first time" was quite wrong. I am glad that Dr. Wheeler has pointed it out. Even in 1948 (*1*) when I first communicated the technique of recombinant selection to the International Congress of Genetics, there had been already several attempts at analysis of homothallic species. Thus, earlier than the work of Wheeler and his colleagues on *Glomerella*, the pioneer work of Winge on yeasts was more than 10 years old, and that of Gries (*2*) on *Sordaria* was more than 5 years old. Though my statement is literally very misleading, when read in its context it may convey what I meant, namely, that with the technique of recombinant selection, formal genetic analysis on a scale comparable to that of classical organisms, such as *Drosophila* and maize, has become practicable. The previous attempts mentioned above, though exceedingly interesting in other respects, have given meager results of strictly genetic interest. The need of picking individual asci, among which the great majority were not of crossed origin, made it impossible to cope with the large numbers of products of meiosis required for effective genetic analysis.

As to the second point on which Wheeler takes issue, that is, our claim of having discovered "relative heterothallism," I am not sure that his doubts are founded. Our findings were communicated to the Genetical Society in 1951 (*3*), that is, before Wheeler and McGahen's paper (*4*). Furthermore, on our definition of relative heterothallism—the formation by two self-fertile strains of crossed asci in excess of 50 percent—only one or perhaps two of the many matings reported in their paper could be examples of this phenomenon. We still have no clue of whether relative heterothallism is the consequence of preferential multiplication of ascogenous hyphae with nuclei of two kinds, or of actual preferential cross-karyogamy. It would be

wiser, therefore, not to equate relative heterothallism to preferential cross-karyogamy for the time being.

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26 August 1954.

Radioactivity of the Human Being

We have obtained some data in this laboratory which supplement, and to some extent clarify, the article by A. T. Krebs [*Science* **119**, 429 (1954)]. The gamma-ray emission from living subjects has been studied using a differential high-pressure ionization chamber apparatus (*1*). Three groups of subjects have been examined: (i) 11 male and 3 female medical students, resident locally, aged 19 to 20 yr; (ii) 11 males of widely scattered residence (mostly in England), aged 26 to 41 yr (average, 34 yr); and (iii) 4 males, resident locally, aged 60 to 79 yr (average, 70 yr). No individual in these groups had any known occupational or therapeutic exposure to radioactive materials. If in each case we assume that the gamma-ray emission may be attributed entirely to potassium-40, then we may express our results in terms of the percentage by weight of potassium in the body. The following average percentages were obtained: group (i), $(0.21_5 \pm 0.01)$; group (ii), $(0.21_2 \pm 0.01)$; and group (iii) $(0.21_5 \pm 0.02)$. Shohl (*2*) quotes 0.21_5 percent from chemical measurements. Edelman *et al.* (*3*), from measurements of "exchangeable" potassium (said to be approximately 5 percent less than total), found an average of 0.18_3 percent for 33 males and an average of 0.16 percent for 14 females. All these results are inconsistent with the figure of 280 g of potassium per body (corresponding to 0.4 percent) quoted by Krebs from Grosse and Libby (*4*).

For the purpose of comparison with Krebs' Table 2, we may express our findings in terms of the equivalent mass of radium, which, distributed throughout the body, would produce the response observed with our apparatus. Thus, for a 70-kg man, the observed gamma activity is equivalent to that which would be emitted by approximately 140×10^{-10} g of radium in equilibrium with its decay products. Hursh and Gates (*5*) determined the actual radium content of cremation ashes and deduced an average figure of 1.2×10^{-10} g for the radium content of the body. This burden, if typical of persons living outside areas of high natural radioactivity, would contribute only about 1 percent of the gamma-ray emission observed by us.

It appears, therefore, that most of the gamma-ray emission from the "unexposed" subjects tested by us may be attributed to the potassium content of the body. Within the rather wide limits of experimental error and biological variability, we find no significant change in total gamma-ray emission over the age range of 19 to 70 yr.

Krebs concludes that "the amounts of radioactive substances deposited in the body, however, exercise an irradiation burden on the body close to the accepted tolerance figures." It would be interesting to be given the magnitude of the tolerance figures that Krebs has in mind and to know whether any distinction is made between the dose to the general soft tissues of the body, including the gonads, and the dose to limited parts of the body, such as osteocytes. The latter will depend markedly upon the presence of bone-seeking radioactive elements. In Table 1 we give estimations of the dose rates to these two types of body tissue from "natural" sources and compare them with the permissible levels for large populations, given by the International Commission on Radiological Protection (*6*), and with other relevant dose data. The table lists the dose rates from cosmic rays, local gamma rays (Leeds situation), body potassium and body radiocarbon, calculated by us in an earlier publication (*7*) and now expressed in millirads per week. Dose rates to osteocytes from radium burdens uniformly distributed throughout the skeleton are also included, based on calculations by Spiers (*8*) and converted to milli-

Table 1. Dose rates to body tissues.

Radiation-source	Tissues affected	Dose per week	
		(mrad)	(mrem)
General irradiation			
Cosmic radiation	Soft tissues, including gonads	0.32	0.32
Local gamma radiation (Leeds)		1.12	1.12
Postasium-40		0.35	0.35
Carbon-14		.02	.02
		1.8	1.8
Radium in body			
1.2×10^{-10} g (Hursh and Gates)	Osteocytes	0.1	1.0
140×10^{-10} g (Krebs)	Osteocytes	11	110
100×10^{-10} g (I.C.R.P. maximum permissible level for large populations)	Osteocytes	8	80