

# Mortality and Survival: Comparison of Eunuchs with Intact Men and Women in a Mentally Retarded Population

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**M**ALES tend to die at an earlier age than females in most species of animals for which data are available (Hamilton, 1948). The sex difference in viability of humans is perhaps the most important medical problem in many countries. In the United States, as of 1955, the average duration of life for all white Ss was almost 10% shorter in males than in females (Scheinfeld, 1958). Vulnerability of males will become an even more serious problem in the future, since males are less able than females to take advantage of improvements that promote longevity (Woodhall & Jablon, 1957).

It is clear that most of the major causes of death in humans occur more commonly, or at an earlier age, in males than in females (Ciocco, 1940) and that males are penalized by the great majority of those diseases which occur more frequently in one sex (Hamilton, 1948).

Testicular functions may contribute to the general vulnerability of males as well as to incite specific diseases (Hamilton, 1941, 1942, 1948). Castration has been found to prolong life significantly in some infra-human species, and strains within species, but not in all species or strains (Asdell, Doornebal, Joshi, & Sperling, 1967; Hamilton, 1965; Robertson, 1961; Talbert & Hamilton, 1965). Since the sequelae of gonadectomy vary with species and strains, the effect of orchiectomy upon duration of life should be ascertained directly in man for racial and other definable genetic groups.

Castration has been practiced since antiquity, and large numbers of boys were orchiectomized

as recently as the nineteenth century when *castrati* were common among singers in churches and operatic houses in Europe and among personnel in harems and imperial palaces (Heriot, 1956). In 1896 the Emperor of China was stated to have 3,000 eunuchs (Report, 1896). A prince or princess could have 30 eunuchs, nephews and young children of the Emperor 20 eunuchs, and cousins of the Emperor 10 eunuchs. The present writers have records of duration of life in 28 Chinese eunuchs and are recording the age at death of 77 black eunuchs who left the Imperial Palace upon dissolution of the Ottoman Empire in 1923.

Despite the large numbers of eunuchs available for study during and before the nineteenth century, little or nothing seems to have been published regarding the effect of orchiectomy upon duration of life in eunuchs. The present study is the first pertaining to the comparative viability of large numbers of eunuchs, intact men, and intact women. Supplementary findings are reported for a small series of oöphorectomized females.

In the twentieth century, eunuchism of healthy boys has been discontinued and orchiectomy is done chiefly in Ss with prostatic cancer, psychoses, or mental retardation. It was deemed preferable to study the mentally retarded rather than the psychotic or cancerous. All of the presently studied Ss were inmates of an American institution for the mentally retarded in Kansas.

## MATERIALS AND METHODS

Intact males and females, who provided control data for castrated males, were born over a

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period of 61 years, between 1871 and 1932. These were the earliest and latest years of birth of the eunuchs under study.

Intact women, who provided control data for oöphorectomized females, were born over a period of 41 years, between 1890 and 1931. These were the earliest and latest years of birth of the oöphorectomized women under study.

As of Jan. 1, 1965, lives of the males had bridged an interval of more than 93 years and those of the females 75 years. These long periods of time minimize effects peculiar to any one era in the type and quality of custodial and medical care and in the rules governing admission and retention of inmates.

The authors began their study of vital statistics in 1937 and have had partial success in recording information since then and in collection of data previously missing. In order to obtain information as complete as possible, records were kept of Ss paroled or transferred from the institution. Data for some Ss had to be excluded, however, when they failed to cooperate, moved to an unknown address, or died as a result of probable or actual violence.

Many important matters were not under the author's purview, e.g., criteria for admission and retention of inmates and the manner of selection of Ss for gonadectomy. The writers found no evidence of drastic shifts in criteria for admission and transfer of inmates prior to 1953. Thereafter, however, preference in retention of inmates was given to those in extreme need of care.

The procedures purportedly followed in

selection of Ss for orchiectomy and the benefits claimed to result from this operation have been described (Hawke, 1941). Experience with domestic animals and later with eunuchs apparently encouraged the belief that castrated males tend to be more tractable than intact males. Of the 2,245 institutionalized males listed in Table 1, 344 (15%) were orchiectomized.

Neither castration nor oöphorectomy was performed because of suspected malignancy which would have complicated studies of the effects of gonadectomy upon viability. The present study had the further advantages (a) that experimental and control groups could be formed with Ss comparable in many regards, such as in ethnic composition, matching for year of birth, and simultaneous residence in one institution for at least a year and for many years in most instances; and (b) that few of these mentally retarded eunuchs were influenced by awareness of their castrate status.

The main part of this study was of white Ss who represented the great majority of inmates and were chiefly of British, German, and Irish extraction. There were 1,799 intact males, 319 eunuchs, 1,768 intact females, and 23 oöphorectomized females (Table 1).

In order to increase the comparability of the intact male and female groups with the eunuchs, and of the intact with the oöphorectomized females, Ss had to satisfy a series of requirements for inclusion in this analysis. Table 1 lists the number of individuals rejected on the basis of each requirement. The first cause for rejection was inadequate infor-

Table 1. Listing of All Male Inmates Born from 1871 to 1932 and All Female Inmates Born from 1871 to 1932, which Were the Earliest and Latest Years of Birth of the Castrated Males and Oöphorectomized Females.

| Reasons For Exclusion From Study   | White        |                 |                |                         | Non-white    |                 |                |                         |
|--|--------------|-----------------|----------------|-------------------------|--------------|-----------------|----------------|-------------------------|
|  | Intact Males | Castrated Males | Intact Females | Oöphorectomized Females | Intact Males | Castrated Males | Intact Females | Oöphorectomized Females |
| 1. Inadequate information  | 68           | 2               | 16             | 0                       | 3            | 0               | 2              | 0                       |
| 2. Medical conditions that predispose to early death, e.g., Down's Disease | 62           | 12              | 11             | 0                       | 4            | 0               | 1              | 0                       |
| 3. Transient (institutionalized less than one year)                        | 226          | 8               | 168            | 0                       | 11           | 0               | 3              | 0                       |
| 4. Did not match eunuchs:  | 708          | —               | 690            | —                       | 64           | —               | 41             | —                       |
| a. Different year of birth   | 119          | —               | 146            | —                       | 44           | —               | 33             | —                       |
| b. Dead or left institution before age at orchiectomy of castrated males   | 335          | —               | 338            | —                       | 13           | —               | 7              | —                       |
| c. Admitted to institution after age at orchiectomy of castrated males     | 254          | —               | 206            | —                       | 7            | —               | 1              | —                       |
| Total excluded   | 1064         | 22              | 885            | 0                       | 82           | 0               | 47             | 1                       |
| Total included   | 735          | 297             | 883            | 23                      | 20           | 25              | 8              | 0                       |
| Total excluded and included  | 1799         | 319             | 1768           | 23                      | 102          | 25              | 55             | 1                       |

Note.—Table 1 lists the number of Ss included in this study and the number excluded because of failure to fulfill each of several requirements. Arrows indicate the respective numbers of intact females used in comparisons with intact males and with oöphorectomized females.

Table 2. Listing, by Decade of Birth, of White Ss under Study and of the Ratios of Intact/Castrated Males and of Intact/Oophorectomized Females.

| Males           |        |     |           |     |                               | Females |     |                                 | Females |    |                 |      |         |
|-----------------|--------|-----|-----------|-----|-------------------------------|---------|-----|---------------------------------|---------|----|-----------------|------|---------|
| Decade of Birth | Intact |     | Castrated |     | Ratio of Intact/<br>Castrated | Intact  |     | Ratio of Intact/Oophorectomized | Intact  |    | Oophorectomized |      | Females |
|                 | N      | %   | N         | %   |                               | N       | %   |                                 | N       | %  | N               | %    |         |
| 1871-79         | 11     | 1   | 7         | 2   | 1.6                           | 17      | 2   | 0                               | —       | 0  | —               | —    |         |
| 1880-89         | 28     | 4   | 11        | 4   | 2.5                           | 34      | 4   | 0                               | —       | 0  | —               | —    |         |
| 1890-99         | 84     | 11  | 33        | 11  | 2.5                           | 113     | 13  | 29                              | 9       | 3  | 13              | 0.7  |         |
| 1900-09         | 126    | 17  | 51        | 17  | 2.5                           | 168     | 19  | 65                              | 21      | 5  | 22              | 13.0 |         |
| 1910-19         | 174    | 24  | 107       | 36  | 1.6                           | 210     | 24  | 118                             | 38      | 9  | 39              | 13.1 |         |
| 1920-32         | 312    | 43  | 88        | 30  | 3.5                           | 341     | 38  | 98                              | 32      | 6  | 26              | 16.3 |         |
| Total           | 735    | 100 | 297       | 100 | 2.5                           | 883     | 100 | 309                             | 100     | 23 | 100             | 13.4 |         |

mation, chiefly because of departure of Ss from the institution and, to a minor extent, because of destruction of some institutional files by a fire in 1905.

The second cause for rejection was the presence of certain medical conditions which might markedly curtail life expectancy. These conditions were Down's disease, hydrocephaly, microcephaly, oxycephaly, phenylketonuria, tuberous sclerosis, cretinism, and Lawrence-Moon-Biedl syndrome.

The third requirement was residence in the institution for one or more years. Some persons had been admitted when moribund. They were not candidates for castration and, if included in this analysis, would have reduced unduly the values for duration of life in intact Ss. There were also transients who had little or no mental retardation and were incarcerated (because of unseemly behavior) for a short time before transfer to another institution. Such transients might be expected to survive better than the more permanent inmates who are mentally retarded. Transients, those who remained in the institution less than one year, are not to be confused with inmates who were included in the study and left the institution after one or more years.

Intact Ss who resided in the institution for one or more years had to fulfill additional requirements which increased their comparability with gonadectomized individuals. Each intact male and female had to be matchable with a eunuch, by exact year of birth, in order to avoid overweighting of the intact series with individuals of ages markedly different from those of the eunuchs.

The over-all ratio of 2.5 intact to 1 castrated male varied little in successive decades (Table 2). This ensured the exposure of similar proportions of castrated and intact individuals to variables throughout the years in epidemics,

Table 3. Variation in Different Years in the Number of Orchietomies Performed, in the Median Age at Operation, and in the Percentage of Male Inmates Who Were Operated.

| Calendar Year at Castration | N of Eunuchs |                   |                     | Median Age at Orchietomy | Percentage of Total N of Intact Males (of Same Age and in the Institution) Orchietomized That Year |
|-----------------------------|--------------|-------------------|---------------------|--------------------------|--|
|                             | Total        | Included in Study | Excluded from Study |                          |  |
| 1895                        | 7            | 7                 |                     | 13                       | 37   |
| 1898                        | 1            | 1                 |                     | 12                       | 33   |
| 1911                        | 1            | 1                 |                     | 24                       | 17   |
| 1923                        | 24           | 23                | 1                   | 30                       | 15   |
| 1927                        | 24           | 23                | 1                   | 23                       | 15   |
| 1931                        | 40           | 37                | 3                   | 19                       | 17   |
| 1933                        | 39           | 38                | 1                   | 19                       | 16   |
| 1934                        | 37           | 32                | 5                   | 20                       | 16   |
| 1935                        | 15           | 12                | 3                   | 18                       | 11   |
| 1936                        | 16           | 16                |                     | 21.5                     | 15   |
| 1937                        | 14           | 12                | 2                   | 17.5                     | 9  |
| 1938                        | 10           | 8                 | 2                   | 22                       | 13   |
| 1939                        | 2            | 2                 |                     | 25.5                     | 6  |
| 1940                        | 15           | 15                |                     | 20                       | 10   |
| 1941                        | 13           | 11                | 2                   | 19                       | 8  |
| 1942                        | 15           | 12                | 3                   | 18                       | 12   |
| 1943                        | 16           | 16                |                     | 19                       | 11   |
| 1944                        | 7            | 7                 |                     | 18                       | 7  |
| 1946                        | 8            | 8                 |                     | 17                       | 8  |
| 1947                        | 8            | 6                 | 2                   | 23                       | 9  |
| 1950                        | 10           | 10                |                     | 20                       | 11   |
|                             | 322          | 297               | 25                  |                          |  |

Note.—Of the 25 eunuchs listed as excluded from study, 3 died at orchietomy and were not listed in Table 1 since they did not survive as eunuchs. Data are for white males.

housing, diet, custodial care, therapy, and other matters.

Each intact S included in the study was alive and admitted to the institution by or before the year at orchietomy of the eunuch with whom he was matched for age at birth. This requirement was deemed necessary because of the marked variation in the ages of Ss at gonadectomy in different periods in the history of the institution (Table 3). This requirement avoided (a) underestimation of duration of life in intact males who died before their matched

S had been castrated, and (b) errors from inclusion of intact men who had lived longer than the eunuchs before admission to the institution, for example, an intact man admitted at 75 years of age.

These requirements were fulfilled by 735 intact males, 883 intact females, and 297 eunuchs.

Another portion of this study was of 23 oöphorectomized and 309 intact white women who fulfilled the same requirements employed to increase the comparability of intact males and females with eunuchs.

The third part of this study was of non-white Ss, 96% of whom were described as Negro. There were 20 intact males, 8 intact females, and 25 eunuchs, all of whom met the requirements described for white Ss (Table 1). These Ss were considered separately but no statistical comparison was made between oöphorectomized and intact females since only one woman had been oöphorectomized.

Slightly more than half of the number of Ss left the institution permanently (Table 4). Therefore, in comparisons of white Ss (those of eunuchs with intact males and females and of oöphorectomized with intact females), data were analyzed separately for those who remained in the institution and for those who left. No significant difference was found and data for institutional and ex-institutional Ss were combined.

A separate analysis was made of Ss born by 1920 who were known to be dead or to be alive as of Jan. 1, 1965. All of these individuals could have lived for 45 or more years.

Institutional records contained data for a limited number of Ss with regard to mental age as estimated from findings with the Revised Simon-Binet Test and type of mental deficiency as classified by the code established by the American Association for Mental Deficiency (Heber, 1961).

Purported primary causes of death were obtained from death certificates for white Ss dying at or after 1940, the year in which Dr. Hawke became responsible for certificates. Even after 1940 the purported causes of death were based almost completely upon clinical diagnoses with few autopsies performed.

The values for median  $l_x$  in Tables 8 and 12 represent the estimated average duration of life. The significance of differences ( $p$ ), between values for median  $l_x$ , was ascertained from com-

Table 4. Percentage of Ss under Study Who Left the Institution Permanently.

| Group             | Sex | Endocrine Status | % of Ss Who Left the Institution Permanently |
|-------------------|-----|------------------|--|
| White             | M   | Castrated        | 55   |
| White             | M   | Intact           | 52   |
| White             | F   | Intact           | 52   |
| White             | F   | Oophorectomized  | 61   |
| Non-white         | M   | Castrated        | 68   |
| Non-white         | M   | Intact           | 75   |
| Non-white         | F   | Intact           | 62   |
| Total, all groups |     |                  | 53   |

Table 5. Age of Orchiectomy of 297 White and 25 Non-white Eunuchs.

| White Ss   |       |    | Non-white Ss |       |    |
|------------|-------|----|--------------|-------|----|
| Age        | N     | %  | Age          | N     | %  |
| 8-14       | 27    | 9  | 8-14         | 5     | 20 |
| 8          | 2     |    | 8            | 1     |    |
| 9          | 2     |    | 12           | 1     |    |
| 10         | 2     |    | 13           | 2     |    |
| 11         | 4     |    | 14           | 1     |    |
| 12         | 7     |    | 15-19        | 6     | 24 |
| 13         | 3     |    | 16           | 2     |    |
| 14         | 7     |    | 17           | 2     |    |
| 15-19      | 127   | 42 | 19           | 2     |    |
| 15         | 14    |    | 20-29        | 12    | 48 |
| 16         | 25    |    | 21           | 2     |    |
| 17         | 25    |    | 22           | 3     |    |
| 18         | 28    |    | 24           | 1     |    |
| 19         | 35    |    | 25           | 1     |    |
| 20-29      | 80    | 27 | 26           | 2     |    |
| 20         | 13    |    | 27           | 2     |    |
| 21         | 14    |    | 28           | 1     |    |
| 22         | 11    |    | 30-39        | 1     | 4  |
| 23         | 9     |    | 32           | 1     |    |
| 24         | 7     |    | 40 or more   | 1     | 4  |
| 25         | 9     |    | 46           | 1     |    |
| 26         | 8     |    |              |       |    |
| 27         | 5     |    | Mean         | 21.32 |    |
| 28         | 2     |    | Median       | 21.   |    |
| 29         | 2     |    |              |       |    |
| 30-39      | 52    | 18 |              |       |    |
| 30         | 11    |    |              |       |    |
| 31         | 6     |    |              |       |    |
| 32         | 7     |    |              |       |    |
| 33         | 8     |    |              |       |    |
| 34         | 6     |    |              |       |    |
| 35         | 3     |    |              |       |    |
| 36         | 2     |    |              |       |    |
| 37         | 4     |    |              |       |    |
| 38         | 3     |    |              |       |    |
| 39         | 2     |    |              |       |    |
| 40 or more | 11    | 4  |              |       |    |
| 41         | 3     |    |              |       |    |
| 42         | 1     |    |              |       |    |
| 43         | 1     |    |              |       |    |
| 46         | 1     |    |              |       |    |
| 48         | 1     |    |              |       |    |
| 50         | 1     |    |              |       |    |
| 52         | 1     |    |              |       |    |
| 58         | 1     |    |              |       |    |
| 59         | 1     |    |              |       |    |
| Mean       | 22.30 |    |              |       |    |
| Median     | 19.   |    |              |       |    |

parisons of the distribution of  $\chi^2$  for deviations from each median  $1_x$ .

## RESULTS

Assurance of a considerable degree of similarity between eunuchs and intact males was provided not only by the previously described requirements for inclusion in this study but also by the items considered under the next two column headings.

### *Comparability of Castrated and Intact Males Except for the Presence or Absence of Testes*

*Apparent lack of uniformity in recommendation and in approval of castration, which suggests that there was no consistent or single policy which singled out a particular type of person for castration.*—The number and percentage of male inmates who were orchietomized varied greatly at different periods in the history of the institution (Table 3), apparently because of differences in degree of enthusiasm for the practice of castration. The closest approach to published documentation of the policies governing castration was stated only in general terms and did not appear until many years after most orchietomies had been done (Hawke, 1941). The recommendations of operation by the medical director and ward supervisors and approval by the governing board of the institution and parents of inmates were influenced by changes in personnel and in

opinions regarding the advisability of orchietomy. Dr. Hawke, who was the medical director, and other supervisors in the institution informed the writers that the same inmates were recommended for orchietomy at one time and not recommended at another time.

*Ss differed greatly in age at orchietomy, which suggests that no specific type of individual was selected on an endocrine basis.*—Orchietomies were done in children, in adolescents, and in young and old adults, with a range in age from 8 to 59 years (Table 5). Clearly, sexual maturation was not a require-

Table 6. Similarity in Percentages of Castrated and Intact White Males with Regard to Rating of Intelligence and Category of Mental Deficiency.

| Rating of Intelligence              | Intact Males |     | Castrated Males |     |
|-------------------------------------|--------------|-----|-----------------|-----|
|                                     | N            | %   | N               | %   |
| Normal                              | 4            | 1   | 1               | 1   |
| Borderline                          | 13           | 5   | 4               | 3   |
| Moronic                             | 60           | 22  | 38              | 25  |
| Imbecilic                           | 132          | 49  | 84              | 55  |
| Idiotic                             | 62           | 23  | 25              | 16  |
| Total                               | 271          | 100 | 152             | 100 |
| Classification of Mental Deficiency |              |     |                 |     |
| 89.00                               | 73           | 30  | 51              | 40  |
| 89.1X                               | 9            | 4   | 7               | 6   |
| 89.44                               | 29           | 12  | 13              | 10  |
| 81.1X                               | 20           | 8   | 19              | 15  |
| 32.44                               | 10           | 4   | 0               | 0   |
| Miscellaneous                       | 101          | 42  | 37              | 29  |
| Total                               | 242          | 100 | 127             | 100 |

Table 7. Comparison of Two Subgroups of Intact White Males: 146 for Whom Castration Was Never Recommended and 19 Recommended for Orchietomy but Never Operated on.

|                                     | Ss Not Recommended For Castration |    | Ss Recommended For Castration |    |
|-------------------------------------|-----------------------------------|----|-------------------------------|----|
|                                     | N                                 | %  | N                             | %  |
| Rating of intelligence              |                                   |    |                               |    |
| Borderline                          | 3                                 | 4  | 1                             | 10 |
| Moronic                             | 16                                | 22 | 2                             | 20 |
| Imbecilic                           | 36                                | 49 | 4                             | 40 |
| Idiotic                             | 18                                | 25 | 3                             | 30 |
| Classification of mental deficiency |                                   |    |                               |    |
| 89.00 <sup>a</sup>                  | 28                                | 37 | 4                             | 44 |
| 81.1X <sup>b</sup>                  | 4                                 | 5  | 0                             | 0  |
| Miscellaneous                       | 44                                | 58 | 5                             | 56 |
| Residence in institution            |                                   |    |                               |    |
| Never paroled                       | 86                                | 63 | 13                            | 69 |
| Temporarily paroled                 | 21                                | 15 | 1                             | 5  |
| Transferred to other institutions   | 28                                | 21 | 4                             | 21 |
| Unapproved permanent departure      | 1                                 | 1  | 1                             | 5  |

<sup>a</sup>89.00—All types

<sup>b</sup>81.1X—Cultural-familial mental retardation of undetermined genetic mechanism

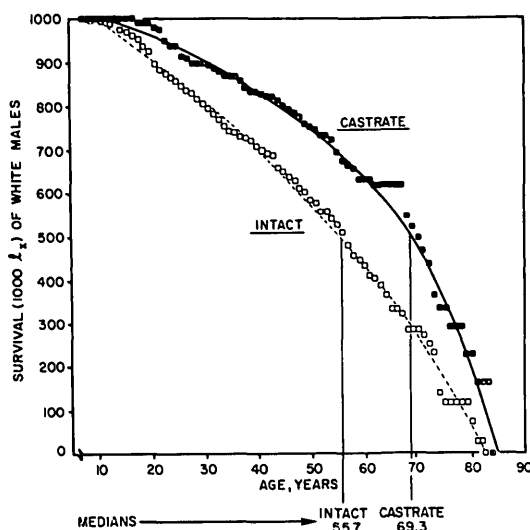


Fig. 1. Survival curves for intact and castrated white males. Data from  $1_x$  columns of Table 8.

ment for operation. Neither was a decrease in responses to testicular secretions in older Ss sufficient cause to forego castration. Further evidence that Ss differed widely in endocrine status is the variation in median age at orchietomy from as much as 30 years in 1923 to as little as 13 years in 1895 (Table 3).

*There was no difference in viability of individuals operated in years when many vs. few Ss were castrated.*—If long-lived persons had been selected for castration, preferential selection of long-lived individuals might have been most marked in years when a small percentage of the male inmates were operated on. To test

this possibility, comparison was made of two matched subgroups of eunuchs included in this study. One subgroup consisted of 82 males operated on in years when 15-17% of the male inmates were orchietomized. The other subgroup consisted of 63 males operated on in years when 6-11% of the male inmates were castrated. The two subgroups did not differ in survival.

*Intact and castrated white males under study were comparable in ratings of intelligence, in categories of mental deficiency, and in percentage of Ss permanently paroled* (Tables 4 & 6).—Similar proportions of intact and castrated

Table 8. Life Tables for 735 Intact and 297 Castrated Males, Mentally Retarded White Ss Who Lived to at Least 8 Years of Age, the Youngest Age at Orchietomy.

| Age   | Intact White Males  |                |                    |                |     | Castrated White Males |                     |                |                    |                |     |     |
|-------|---------------------|----------------|--------------------|----------------|-----|-----------------------|---------------------|----------------|--------------------|----------------|-----|-----|
|       | 1000 l <sub>x</sub> | d <sub>x</sub> | 1000q <sub>x</sub> | e <sub>x</sub> | L+D |                       | 1000 l <sub>x</sub> | d <sub>x</sub> | 1000q <sub>x</sub> | e <sub>x</sub> | L+D |     |
|       |                     |                |                    |                | N   | %                     |                     |                |                    |                | N   | %   |
| 8-9   | 1000                | 0              | 0                  | 44.62          | 198 |                       | 1000                | 0              | 0                  | 54.80          | 2   |     |
| 9-10  | 1000                | 0              | 0                  | 43.62          | 258 |                       | 1000                | 0              | 0                  | 53.80          | 4   |     |
| 10-11 | 1000                | 2              | 2.00               | 42.62          | 319 | 100                   | 1000                | 0              | 0                  | 52.80          | 6   | 100 |
| 11-12 | 998                 | 9              | 9.02               | 41.71          | 370 |                       | 1000                | 0              | 0                  | 51.80          | 10  |     |
| 12-13 | 989                 | 10             | 10.11              | 41.08          | 438 |                       | 1000                | 2              | 2.00               | 50.80          | 16  |     |
| 13-14 | 979                 | 9              | 9.19               | 40.50          | 490 |                       | 998                 | 4              | 4.01               | 49.90          | 19  |     |
| 14-15 | 970                 | 10             | 10.31              | 39.87          | 592 |                       | 994                 | 5              | 5.03               | 49.10          | 25  |     |
| 15-16 | 960                 | 9              | 9.38               | 39.28          | 660 | 99                    | 989                 | 4              | 4.04               | 48.35          | 39  | 95  |
| 16-17 | 951                 | 10             | 10.52              | 38.65          | 704 |                       | 985                 | 5              | 5.08               | 47.54          | 62  |     |
| 17-18 | 941                 | 9              | 9.56               | 38.05          | 725 |                       | 980                 | 4              | 4.08               | 46.78          | 84  |     |
| 18-19 | 932                 | 10             | 10.73              | 37.41          | 731 |                       | 976                 | 5              | 5.12               | 45.97          | 111 |     |
| 19-20 | 922                 | 10             | 10.85              | 36.81          | 731 |                       | 971                 | 5              | 5.15               | 45.21          | 146 |     |
| 20-21 | 912                 | 9              | 9.87               | 36.21          | 710 | 95                    | 966                 | 5              | 5.18               | 44.44          | 156 | 93  |
| 21-22 | 903                 | 10             | 11.07              | 35.57          | 712 |                       | 961                 | 6              | 6.24               | 43.67          | 170 |     |
| 22-23 | 893                 | 10             | 11.20              | 34.96          | 708 |                       | 955                 | 5              | 5.24               | 42.94          | 180 |     |
| 23-24 | 883                 | 9              | 10.19              | 34.35          | 697 |                       | 950                 | 6              | 6.32               | 42.16          | 189 |     |
| 24-25 | 874                 | 10             | 11.44              | 33.70          | 694 |                       | 944                 | 5              | 5.30               | 41.43          | 195 |     |
| 25-26 | 864                 | 10             | 11.57              | 33.08          | 694 | 91                    | 939                 | 6              | 6.39               | 40.64          | 203 | 94  |
| 26-27 | 854                 | 10             | 11.71              | 32.46          | 687 |                       | 933                 | 6              | 6.43               | 39.90          | 210 |     |
| 27-28 | 844                 | 10             | 11.85              | 31.84          | 684 |                       | 927                 | 6              | 6.47               | 39.16          | 213 |     |
| 28-29 | 834                 | 10             | 11.99              | 31.22          | 678 |                       | 921                 | 6              | 6.52               | 38.41          | 215 |     |
| 29-30 | 824                 | 11             | 13.35              | 30.59          | 678 |                       | 915                 | 6              | 6.56               | 37.66          | 217 |     |
| 30-31 | 813                 | 10             | 12.30              | 30.00          | 676 | 88                    | 909                 | 7              | 7.70               | 36.90          | 228 | 93  |
| 31-32 | 803                 | 11             | 13.70              | 29.37          | 664 |                       | 902                 | 7              | 7.76               | 36.19          | 234 |     |
| 32-33 | 792                 | 10             | 12.63              | 28.77          | 652 |                       | 895                 | 6              | 6.70               | 35.46          | 241 |     |
| 33-34 | 782                 | 11             | 14.07              | 28.13          | 643 |                       | 889                 | 7              | 7.87               | 34.70          | 249 |     |
| 34-35 | 771                 | 11             | 14.27              | 27.52          | 627 |                       | 882                 | 7              | 7.94               | 33.97          | 254 |     |
| 35-36 | 760                 | 11             | 14.47              | 26.91          | 605 | 81                    | 875                 | 8              | 9.14               | 33.24          | 254 | 92  |
| 36-37 | 749                 | 11             | 14.69              | 26.30          | 584 |                       | 867                 | 7              | 8.07               | 32.54          | 250 |     |
| 37-38 | 738                 | 11             | 14.90              | 25.69          | 571 |                       | 860                 | 8              | 9.30               | 31.80          | 251 |     |
| 38-39 | 727                 | 11             | 15.13              | 25.07          | 557 |                       | 852                 | 8              | 9.39               | 31.10          | 250 |     |
| 39-40 | 716                 | 12             | 16.76              | 24.45          | 541 |                       | 844                 | 8              | 9.48               | 30.39          | 249 |     |
| 40-41 | 704                 | 11             | 15.62              | 23.85          | 527 | 72                    | 836                 | 8              | 9.57               | 29.67          | 240 | 84  |
| 41-42 | 693                 | 12             | 17.32              | 23.22          | 525 |                       | 828                 | 8              | 9.66               | 28.95          | 238 |     |
| 42-43 | 681                 | 12             | 17.62              | 22.62          | 519 |                       | 820                 | 9              | 10.98              | 28.23          | 231 |     |
| 43-44 | 669                 | 12             | 17.94              | 22.02          | 494 |                       | 811                 | 8              | 9.86               | 27.54          | 225 |     |
| 44-45 | 657                 | 13             | 19.79              | 21.41          | 472 |                       | 803                 | 9              | 11.21              | 26.81          | 220 |     |

Note.—1000 l<sub>x</sub>=number surviving per 1000 alive.

d<sub>x</sub>=number dying at each year.

1000q<sub>x</sub>=number dying per 1000 alive at each year.

e<sub>x</sub>=years of expectation of life at each year.

L+D=number known alive + number known dead at each year.

% (of Ss for whom information is available) who could have lived to this age.

Table 8. (Continued)

| Age   | Intact White Males  |                |                    |                |     | Castrated White Males |                     |                |                    |                |     |    |
|-------|---------------------|----------------|--------------------|----------------|-----|-----------------------|---------------------|----------------|--------------------|----------------|-----|----|
|       | 1000 l <sub>x</sub> | d <sub>x</sub> | 1000q <sub>x</sub> | e <sub>x</sub> | L+D |                       | 1000 l <sub>x</sub> | d <sub>x</sub> | 1000q <sub>x</sub> | e <sub>x</sub> | L+D |    |
|       |                     |                |                    |                | N   | %                     |                     |                |                    |                | N   | %  |
| 45-46 | 644                 | 12             | 18.63              | 20.84          | 461 | 63                    | 794                 | 9              | 11.34              | 26.11          | 213 | 87 |
| 46-47 | 632                 | 13             | 20.57              | 20.22          | 450 |                       | 785                 | 9              | 11.46              | 25.40          | 208 |    |
| 47-48 | 619                 | 13             | 21.00              | 19.64          | 446 |                       | 776                 | 10             | 12.89              | 24.69          | 198 |    |
| 48-49 | 606                 | 12             | 19.80              | 19.05          | 437 |                       | 766                 | 10             | 13.06              | 24.01          | 192 |    |
| 49-50 | 594                 | 14             | 23.57              | 18.42          | 426 |                       | 756                 | 10             | 13.23              | 23.32          | 183 |    |
| 50-51 | 580                 | 13             | 22.41              | 17.86          | 421 | 57                    | 746                 | 10             | 13.40              | 22.62          | 170 | 58 |
| 51-52 | 567                 | 14             | 24.69              | 17.25          | 417 |                       | 736                 | 9              | 12.23              | 21.92          | 164 |    |
| 52-53 | 553                 | 14             | 25.32              | 16.68          | 410 |                       | 727                 | 7              | 9.63               | 21.19          | 158 |    |
| 53-54 | 539                 | 14             | 25.97              | 16.10          | 404 |                       | 720                 | 8              | 11.11              | 20.39          | 149 |    |
| 54-55 | 525                 | 14             | 26.67              | 15.51          | 395 |                       | 712                 | 8              | 11.24              | 19.61          | 140 |    |
| 55-56 | 511                 | 15             | 29.35              | 14.92          | 389 | 53                    | 704                 | 9              | 12.78              | 18.83          | 135 | 46 |
| 56-57 | 496                 | 15             | 30.24              | 14.36          | 385 |                       | 695                 | 9              | 12.95              | 18.07          | 131 |    |
| 57-58 | 481                 | 15             | 31.18              | 13.79          | 376 |                       | 686                 | 11             | 16.04              | 17.30          | 128 |    |
| 58-59 | 466                 | 15             | 32.19              | 13.22          | 364 |                       | 675                 | 11             | 16.30              | 16.57          | 129 |    |
| 59-60 | 451                 | 16             | 35.48              | 12.64          | 355 |                       | 664                 | 11             | 16.57              | 15.84          | 126 |    |
| 60-61 | 435                 | 16             | 36.78              | 12.09          | 353 | 48                    | 653                 | 13             | 19.91              | 15.10          | 123 | 41 |
| 61-62 | 419                 | 16             | 38.19              | 11.53          | 350 |                       | 640                 | 13             | 20.31              | 14.39          | 118 |    |
| 62-63 | 403                 | 16             | 39.70              | 10.97          | 348 |                       | 627                 | 15             | 23.92              | 13.68          | 113 |    |
| 63-64 | 387                 | 17             | 43.93              | 10.40          | 344 |                       | 612                 | 15             | 24.51              | 13.00          | 109 |    |
| 64-65 | 370                 | 17             | 45.95              | 9.85           | 343 |                       | 597                 | 16             | 26.80              | 12.32          | 108 |    |
| 65-66 | 353                 | 17             | 48.16              | 9.30           | 339 | 46                    | 581                 | 17             | 29.26              | 11.64          | 104 | 35 |
| 66-67 | 336                 | 18             | 53.57              | 8.75           | 332 |                       | 564                 | 18             | 31.92              | 10.98          | 101 |    |
| 67-68 | 318                 | 17             | 53.46              | 8.22           | 330 |                       | 546                 | 20             | 36.63              | 10.32          | 99  |    |
| 68-69 | 301                 | 19             | 63.12              | 7.65           | 329 |                       | 526                 | 20             | 38.02              | 9.70           | 98  |    |
| 69-70 | 282                 | 18             | 63.83              | 7.13           | 327 |                       | 506                 | 21             | 41.50              | 9.06           | 97  |    |
| 70-71 | 264                 | 19             | 71.97              | 6.59           | 324 | 44                    | 485                 | 23             | 47.42              | 8.43           | 93  | 31 |
| 71-72 | 245                 | 19             | 77.55              | 6.06           | 320 |                       | 462                 | 23             | 49.78              | 7.83           | 93  |    |
| 72-73 | 226                 | 19             | 84.07              | 5.53           | 320 |                       | 439                 | 25             | 56.95              | 7.21           | 92  |    |
| 73-74 | 207                 | 20             | 96.62              | 4.99           | 319 |                       | 414                 | 26             | 62.80              | 6.62           | 91  |    |
| 74-75 | 187                 | 20             | 106.95             | 4.47           | 319 |                       | 388                 | 28             | 72.16              | 6.03           | 91  |    |
| 75-76 | 167                 | 21             | 125.75             | 3.94           | 318 | 43                    | 360                 | 29             | 80.56              | 5.46           | 90  | 30 |
| 76-77 | 146                 | 20             | 136.99             | 3.44           | 315 |                       | 331                 | 30             | 90.63              | 4.89           | 88  |    |
| 77-78 | 126                 | 22             | 174.60             | 2.90           | 315 |                       | 301                 | 31             | 102.99             | 4.33           | 88  |    |
| 78-79 | 104                 | 21             | 201.92             | 2.41           | 315 |                       | 270                 | 33             | 122.22             | 3.77           | 87  |    |
| 79-80 | 83                  | 22             | 265.06             | 1.90           | 315 |                       | 237                 | 35             | 147.68             | 3.22           | 87  |    |
| 80-81 | 61                  | 22             | 360.66             | 1.40           | 315 | 43                    | 202                 | 36             | 178.22             | 2.69           | 87  | 29 |
| 81-82 | 39                  | 23             | 589.74             | 0.91           | 315 |                       | 166                 | 37             | 222.89             | 2.17           | 87  |    |
| 82-83 | 16                  | 16             | 1000.00            | 0.50           | 315 |                       | 129                 | 39             | 302.33             | 1.65           | 87  |    |
| 83-84 | 0                   | —              | —                  | —              | 315 |                       | 90                  | 40             | 444.44             | 1.14           | 87  |    |
| 84-85 |                     |                |                    |                |     |                       | 50                  | 42             | 840.00             | 0.66           | 87  |    |
| 85-86 |                     |                |                    |                |     |                       | 8                   | 8              | 1000.00            | 0.50           | 87  | 29 |
| 86-87 |                     |                |                    |                |     |                       | 0                   | —              | —                  | —              | 87  |    |

Note.—1000 l<sub>x</sub>=number surviving per 1000 alive.

d<sub>x</sub>=number dying at each year.

1000q<sub>x</sub>=number dying per 1000 alive at each year.

e<sub>x</sub>=years of expectation of life at each year.

L+D=number known alive + number known dead at each year.

% (of Ss for whom informatin is available) who could have lived to this age.

white males were also paroled temporarily, transferred to other institutions, and left the institution without approval.

*Similarity of males recommended for orchietomy (but not operated) and other intact males.*—From the intact males under study, a subgroup of 19 males, recommended for castration but not operated on, was matched with 136 intact males never recommended for operation. These two subgroups of intact males did not differ in survival. They also showed little

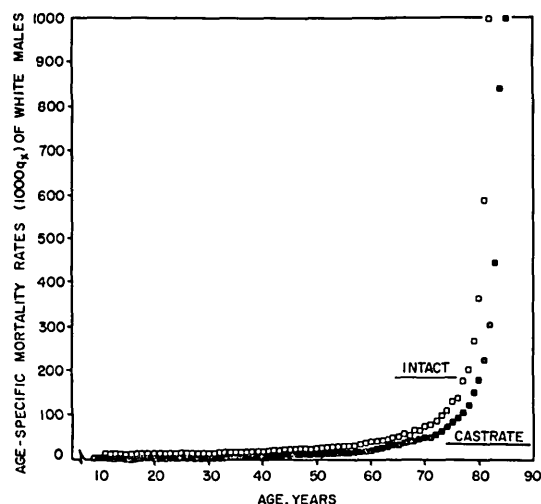
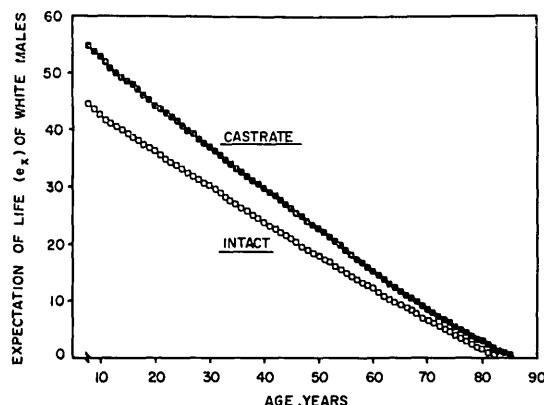
difference in intelligence, in the percentage of Ss in the various categories of mental deficiency, or in qualifications required for parole (Table 7).

#### *Adrenal Cortical Secretions Do Not Substitute For Testicular Function in Eunuchs*

The adrenal cortices secreted abnormally large amounts of sex hormones after ablation of testes or ovaries in certain strains of mice and guinea-pigs (Woolley, 1949). In eunuchs, however, adrenal cortical secretions rarely if

Table 9. Ss Born 1871-1920 Inclusive, and Known to be Dead or Alive as of Jan. 1, 1965, Exclusive of Deaths from Violence.

| White Ss                     |                                  |                                     |    |           |                                 |        |       |        |       |       |
|------------------------------|----------------------------------|-------------------------------------|----|-----------|---------------------------------|--------|-------|--------|-------|-------|
| Status                       | Total N<br>(Dead<br>or<br>Alive) | Known Dead and<br>Mean Age at Death |    |           | Significance (p) of Differences |        |       |        |       |       |
|                              |                                  |                                     |    |           | Mean Age at Death               |        |       | % Dead |       |       |
|                              |                                  | N                                   | %  | Mean±S.E. | CM-IM                           | CM-IF  | IM-IF | CM-IM  | CM-IF | IM-IF |
| Intact males (IM)            | 332                              | 233                                 | 70 | 38.2±1.06 | 0.001                           |        | 0.27  | <0.001 |       | 0.006 |
| Castrated males (CM)         | 161                              | 69                                  | 43 | 48.4±2.10 |                                 |        | 0.40  |        |       | 0.002 |
| Intact females (IF)          | 318                              | 187                                 | 59 | 39.4±1.11 |                                 |        |       |        |       |       |
|                              |                                  |                                     |    |           |                                 | OF-IF  |       |        | OF-IF |       |
| Intact females (IF)          | 126                              | 64                                  | 51 | 33.9±1.36 |                                 |        |       |        |       |       |
|                              |                                  |                                     |    |           |                                 | <0.001 |       |        | 0.56  |       |
| Oöphorectomized females (OF) | 11                               | 4                                   | 36 | 56.2±4.69 |                                 |        |       |        |       |       |
| Non-white Ss                 |                                  |                                     |    |           |                                 |        |       |        |       |       |
| Intact males (IM)            | 2                                | 1                                   | 50 | 38.0±0.00 |                                 |        | 0.65  |        |       | 1.00  |
|                              |                                  |                                     |    |           | 1.00                            |        |       | 1.00   |       |       |
| Castrated males (CM)         | 10                               | 5                                   | 50 | 38.0±4.93 |                                 |        |       |        |       |       |
|                              |                                  |                                     |    |           |                                 | 0.65   |       |        | 1.00  |       |
| Intact females (IF)          | 2                                | 1                                   | 50 | 32.0±0.00 |                                 |        |       |        |       |       |

Fig. 2. Age-specific mortality rates for intact and castrated white males. Data from  $q_x$  columns of Table 8.Fig. 3. Expectation of life in intact and castrated white males. Data from  $q_x$  columns of Table 8.

ever replaced the sex hormones supplied by testicular secretions, as shown unequivocally by quantitative measurements of secondary sex characters and other items which either depend upon or reflect androgenic stimulation (Hamilton, 1958; Hamilton, Bunch, & Mestler, 1962; Hamilton, Bunch, Mestler, & Imagawa, 1956; Hamilton & Mestler, 1963).

#### Survival of Castrated and Intact White Males

Survival of these two populations is shown in Figure 1. The difference between their curves was significant ( $p=0.01$ ), beginning at 25 years of age and continuing throughout life.

In the life table, columns  $l_x$ ,  $d_x$ ,  $q_x$ , and  $e_x$  are of particular importance (Table 8). The median  $l_x$  was 13.5 years later in castrated than in intact males. This difference was significant ( $p = 0.002$ ).

Better survival of eunuchs than of intact males characterized those born between 1871 and 1899 and between 1910 and 1919. Therefore this difference was representative of more than one period in the history of the institution.

#### Deaths of Castrated and Intact White Males

Table 9 lists data for Ss born by 1920 and known to be dead or to be alive as of Jan. 1, 1965. Among eunuchs, compared with intact males, the percentage who were dead was significantly less and the mean age at death was significantly higher.



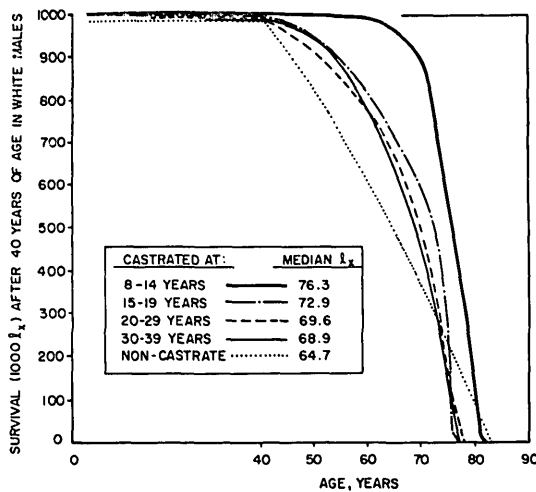


Fig. 4. Relationship between age at castration and survival of white males who lived to 40 or more years of age.

Table 10. Data for White Males Alive at 40 Years of Age upon Whom the Survival Curves in Figure 4 Were Based.

| Group | Age of Orchietomy (Years) | N of Ss | Estimated Median Length of Life <sup>a</sup> | Dead N | %  |
|-------|---------------------------|---------|--|--------|----|
| 1     | 8-14                      | 18      | 76.3±1.36                                    | 4      | 22 |
| 2     | 15-19                     | 72      | 72.9±5.13                                    | 7      | 10 |
| 3     | 20-29                     | 61      | 69.6±2.50                                    | 11     | 18 |
| 4     | 30-39                     | 49      | 68.9±2.05                                    | 18     | 37 |
| 5     | Intact                    | 320     | 64.7±0.99                                    | 109    | 34 |

<sup>a</sup>Estimates of significance ( $p$ ) between lengths of life among the various possible comparisons are as follows:

| Between Groups | $p$    |
|----------------|--------|
| 1-2            | 0.30   |
| 1-3            | 0.004  |
| 1-4            | 0.003  |
| 1-5            | <0.001 |
| 2-3            | 0.10   |
| 2-4            | 0.08   |
| 2-5            | <0.001 |
| 3-4            | 0.85   |
| 3-5            | <0.001 |
| 4-5            | 0.002  |

#### Age-Specific Mortality Rates and Expectation of Life in Castrated and Intact White Males

Within each group, age-specific mortality rates were calculated from the number of Ss dying at a particular year of age  $\div$  the total number of Ss alive at that age (Fig. 2 & Table 8).

The mean number of years of expected life at successive ages is shown in Table 8 and Figure 3. As one example of the difference

between castrated and intact males, the mean expectation of life at 8 years of age was  $54.80 \pm 1.78$  years in eunuchs and  $44.62 \pm 2.07$  years in intact males. Based on values for standard errors, the difference between the curves for castrated and intact males in Figure 3 was significant between 8 and 45 years ( $p < 0.001$  to  $p = 0.05$ ).

#### Relationship of Age at Castration to Survival After 40 Years of Age in White Males

Figure 4 compares survival curves and median ages at death for intact males and for groups of males castrated at successive ranges of age. Data were limited to Ss who had lived 40 or more years, since some males had been orchietomized at 39 years of age. The number of Ss in each age group and other data are shown in Table 10.

The median  $l_x$  of Ss castrated at 20-39 or at 15-39 years of age was significantly higher than that of intact men (69.3 and 70.7 years, vs. 64.7 years for intact men,  $p < 0.001$  and  $< 0.001$ ).

To ascertain if an early age at castration increased longevity after 40 years of age, as suggested by the  $l_x$  curves in Figure 4, a linear relationship was established among median  $l_x$ 's in groups operated on at 8-14, 15-19, 20-29, and 30-39 years of age. It was necessary to use variance estimates for each group derived from distribution of ages at death of Ss dying over 40 years of age because many Ss contributing to the determination of the median  $l_x$ 's were still alive. Use of variance estimates was justified because of the absence of significant differences in magnitude of variances among the successive decades of age at death after 40 years of age. The variance was also unrelated to the size of the sample of those already dead in the successive decades from 40-79 years of age. The resultant linear regression equation for the 200 Ss alive at age 40 was  $y = 77.559 - 0.27866x$ , where  $x$  = age at castration and  $y$  = age at death. The criterion used was the null hypothesis that the slope of the linear regression line was zero; symbolically,  $b = 0$ . But  $b = -0.27866$ , and was significantly different from zero ( $p = 0.008$ ). For survivors after the age of 40 years there was a loss of 0.28 years of potential life for each year of delay in orchietomy from 8 to 39 years of age. For the array of median  $l_x$ 's shown in Table 10, men who had been castrated at 8-14 years were significantly longer-lived after age 40 than men

operated on either at 20-29 years (6.7 years,  $p = 0.004$ ) or at 30-39 years (7.4 years,  $p = 0.003$ ) and longer-lived than those never castrated (11.6 years,  $p < 0.001$ ). Survival after age 40 in those castrated at 15-19 years was significantly different only from intact males (8.2 years,  $p < 0.001$ ). Survival after age 40 was not significantly different between those orchiectomized at 20-29 years and those operated on at 30-39 years (0.7 years,  $p = 0.85$ ), but was significantly different from intact males (4.9 years,  $p < 0.001$ ). Ss castrated at 30-39 years of age were significantly longer-lived after age 40 than intact males (4.2 years,  $p = 0.002$ ).

The authors examined 14 adults who had been castrated when 8-14 years old. All had an immature penis and eunuchoid proportions of axial and appendicular skeletons. This was convincing evidence that these Ss had been operated on before sexual maturation.

Examination of 50 adults who had been castrated at 15-19 years of age and 100 adults orchiectomized at or after 20 years of age showed variation in size of penes and in skeletal proportions among those operated on at 15 or 16 years of age but large penes and normal skeletal proportions in those orchiectomized at or after 17 years of age. It was concluded that sexual maturation had occurred prior to operation at or after 17 years of age.

To ascertain in another way if castration at an early age prolonged life markedly, an analysis was made of Ss born by 1920 and of known fate on Jan. 1, 1965, comparing eunuchs with intact males matched for age at birth and alive at the age when eunuchs were orchiectomized (Table 11). The percentage dead in intact males was significantly greater than in eunuchs castrated prepubertally at 8-14 years or operated on at 15-19 years.

Mean age at death of the known dead was significantly higher in castrated than in intact males both for those orchiectomized prepubertally (at 8-14 years) and for those operated on before or within a few years after puberty at 15-19 or at 20-29 years (Table 11).

Mean age at death was significantly higher in Ss orchiectomized at 8-14 years (75.8 years) than in those operated at 20-39 years (47.0 years) ( $p < 0.001$ ).

The mean number of years lived *after* age at orchiectomy was greater in eunuchs than in matched intact males. This difference was most marked when the testes were removed prepubertally (64.2 *vs.* 38.4 years,  $p = 0.02$ ), but was also significant with orchiectomy after sexual maturation, i.e., at 15-29 years (18.0 *vs.* 10.8 years,  $P < 0.001$ ).

*Survival of Castrated White Males and Intact White Females*

Figure 5 shows survival of the 297 eunuchs and a matched series of 883 intact females. The median  $1_x$  in these mentally retarded Ss was 69.3 years in eunuchs and 62.6 years in intact females. The difference was not significant ( $p = 0.07$ ).

But in data for Ss born by 1920 and of known fate in 1965, the percentage of known dead was significantly lower in eunuchs than in intact females (Table 9).

*Survival of Castrated and Intact Non-White Males*

In this small series of non-white Ss the median  $1_x$  was 3 years higher in castrated than in intact males (Table 12). The difference was not significant but the effect of orchiectomy was in the same direction as in white males.

Table 11. White Ss born 1871-1920 Inclusive, and Known to be Dead or Alive as of January 1, 1965, Exclusive of Deaths from Violence.

| Age at<br>Castration | Total N<br>(Dead or Alive) |       |                        | Known Dead and Mean Age at Death |    |           |              |    |           |                |    |           | Significance ( <i>p</i> ) of Differences |           |           |           |           |           |
|----------------------|----------------------------|-------|------------------------|----------------------------------|----|-----------|--------------|----|-----------|----------------|----|-----------|--|-----------|-----------|-----------|-----------|-----------|
|                      | Cas-<br>trated             |       | Intact<br>Fe-<br>males | Castrated Males                  |    |           | Intact Males |    |           | Intact Females |    |           | Mean Age at Death                        |           |           | % Dead    |           |           |
|                      | Males                      | Males |                        | N                                | %  | Mean±S.E. | N            | %  | Mean±S.E. | N              | %  | Mean±S.E. | CM-<br>IM                                | CM-<br>IF | IM-<br>IF | CM-<br>IM | CM-<br>IF | IM-<br>IF |
| 8-14                 | 12                         | 66    | 73                     | 4                                | 33 | 75.8±1.57 | 45           | 68 | 34.5±2.63 | 38             | 52 | 34.9±2.56 | <0.001                                   | 1.00      | 1.00      | 0.05      | 0.39      | 0.08      |
| 15-19                | 55                         | 162   | 181                    | 17                               | 31 | 36.4±3.87 | 99           | 61 | 29.4±1.17 | 88             | 49 | 31.2±1.26 | 0.04                                     | 0.52      | 0.79      | <0.001    | 0.03      | 0.03      |
| 20-29                | 45                         | 207   | 208                    | 20                               | 44 | 40.6±2.82 | 123          | 59 | 33.6±1.03 | 104            | 50 | 35.9±1.15 | 0.01                                     | 0.29      | 0.90      | 0.10      | 0.63      | 0.07      |
| 30-39                | 38                         | 159   | 178                    | 19                               | 50 | 53.8±2.36 | 89           | 56 | 48.0±1.28 | 89             | 50 | 46.0±1.16 | 0.06                                     | 0.04      | 0.62      | 0.64      | 1.00      | 0.33      |
| 40-59                | 11                         | 43    | 36                     | 9                                | 82 | 64.7±5.00 | 36           | 84 | 57.1±1.79 | 31             | 86 | 59.5±1.67 | 0.10                                     | 0.38      | 0.55      | 0.76      | 0.90      | 0.98      |

### Survival of White and Non-White Males

White and non-white eunuchs had similar mean and median ages at castration (Tables 8 and 12) but differed significantly in the extent to which eunuchs outlived intact males (median  $l_x$  of 13.5 years in whites and 3 in non-whites,  $p = 0.01$ ).

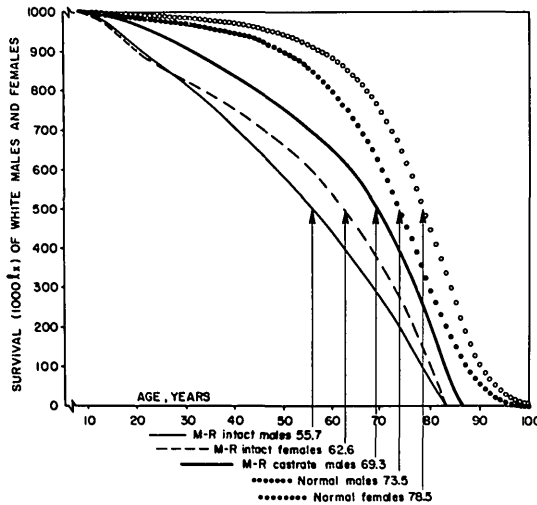


Fig. 5. Survival curves for white Ss. Comparisons of (a) mentally retarded (M-R) groups of intact and castrated males (data from  $l_x$  columns of Table 8) and intact females (data from a similarly prepared life table); and (b) mentally normal groups of intact males and females (data for all recorded deaths in Kansas for 1949-1951 and U. S. Bureau of Census for 1950, calculated for Ss who lived to be 8 or more years of age).

The median  $l_x$  was 6.7 years older in white than in non-white eunuchs 69.3 vs. 92.6) and 9.9 years younger in white than in non-white intact males (55.7-65.6 years).

It is presumed that functional testes curtailed viability to a greater extent in white than in non-white males and that prolongation of life upon removal of the testes was greater in white than in non-white males. This presumption is only tentative because of the small number of non-white males under study.

### Survival of Castrated Non-White Males and Intact Non-White Females

The limited data for Ss born by 1920 and of known fate in 1965 may be consulted in Table 9.

### Survival of Oöphorectomized and Intact White Females

The year of birth of 23 oöphorectomized and 309 intact white females and the ages at oöphorectomy are listed in Table 13. Survival is shown in an abbreviated partial life table (Table 12). There was no difference between these two populations in median  $l_x$ . For Ss born by 1920 and of known fate in 1965, the percentage dead was lower, but not significantly so, in oöphorectomized than in intact females (Table 9). Mean age at death was significantly higher in oöphorectomized than in intact females (Table 9).

Table 12. Abbreviated Partial Life Tables for 23 Oöphorectomized and 390 Intact White Females and for 20 Intact Non-white Males.

| White                                      |      |     |  |      |    | Non-white                                |     |      |   |     |     |
|--|------|-----|--|------|----|--|-----|------|---|-----|-----|
| Intact Females<br>Median $l_x$ = 65.2 yrs. |      |     | Oöphorectomized<br>Females<br>Median $l_x$ = 65.2 yrs. |      |    | Intact Males<br>Median $l_x$ = 62.6 yrs. |     |      | Castrated Males<br>Median $l_x$ = 65.6 yrs. |     |     |
| 1000 $l_x$                                 | L+D  |     | 1000 $l_x$   | L+D  |    | 1000 $l_x$                               | L+D |      | 1000 $l_x$                                  | L+D |     |
| Age  | N    | %   | N  | %    |    | Age                                      | N   | %    | N   | %   |     |
| 13   | 1000 | 186 | 100  | 1000 | 1  | 100                                      | 8   | 1000 | 1000  | 1   | 100 |
| 15   | 1000 | 234 | 100  | 1000 | 4  | 100                                      | 10  | 1000 | 1000  | 1   | 100 |
| 20   | 968  | 275 | 98   | 1000 | 10 | 100                                      | 15  | 997  | 997   | 4   | 80  |
| 25   | 932  | 281 | 95   | 1000 | 17 | 94                                       | 20  | 989  | 992   | 9   | 82  |
| 30   | 896  | 279 | 91   | 997  | 18 | 95                                       | 25  | 967  | 983   | 15  | 83  |
| 35   | 857  | 276 | 89   | 984  | 19 | 95                                       | 30  | 919  | 968   | 19  | 83  |
| 40   | 815  | 251 | 81   | 963  | 17 | 85                                       | 35  | 878  | 911   | 17  | 71  |
| 45   | 768  | 208 | 67   | 923  | 16 | 73                                       | 40  | 840  | 848   | 15  | 62  |
| 50   | 714  | 177 | 57   | 854  | 15 | 65                                       | 45  | 791  | 780   | 11  | 46  |
| 55   | 653  | 142 | 46   | 763  | 11 | 48                                       | 50  | 730  | 712   | 12  | 48  |
| 60   | 583  | 112 | 36   | 648  | 7  | 30                                       | 55  | 654  | 648   | 10  | 40  |
| 65   | 503  | 99  | 32   | 506  | 7  | 30                                       | 60  | 559  | 594   | 9   | 36  |
| 70   | 411  | 92  | 30   | 337  | 6  | 26                                       | 65  | 442  | 510   | 8   | 32  |
| 75   | 306  | 92  | 30   | 137  | 5  | 22                                       | 70  | 302  | 412   | 8   | 32  |
| 80   | 187  | —   | —  | 38   | —  | —  | 75  | 135  | 302   | 7   | 28  |
| 85   | 53   | —   | —  | 1    | —  | —  | 80  | 0    | 182   | 7   | 28  |
|  |      |     |  |      |    |  | 85  | —    | 48  | —   | —   |

Note.—No life table was prepared for non-white females, who are only 8 in number.

Table 13. Year of Birth and Age at Oophorectomy of 23 Oophorectomized and 309 Intact White Females Matched for Year of Birth.

| Year of Birth | Intact Females | Oophorectomized Females |              |
|---------------|----------------|-------------------------|--------------|
|               | N              | Age at Operation        | Age at Death |
| 1921          | 17             | 13                      | 40           |
| 1908          | 11             | 15                      | a            |
| 1918          | 15             | 15                      | —            |
| 1931          | 6              | 15                      | a            |
| 1917          | 21             | 16                      | a            |
| 1914          | 15             | 17                      | —            |
| 1929          | 19             | 17                      | a            |
| 1913          | 13             | 18                      | a            |
| 1914          | 2              | 19                      | a            |
| 1926          | 18             | 20                      | a            |
| 1912          | 14             | 21                      | —            |
| 1922          | 24             | 21                      | a            |
| 1923          | 14             | 21                      | a            |
| 1911          | 11             | 23                      | a            |
| 1907          | 16             | 24                      | —            |
| 1909          | 14             | 24                      | —            |
| 1919          | 10             | 24                      | 43           |
| 1910          | 16             | 25                      | —            |
| 1905          | 13             | 28                      | 58           |
| 1896          | 12             | 35                      | 63           |
| 1901          | 11             | 43                      | 61           |
| 1890          | 12             | 44                      | a            |
| 1897          | 5              | 46                      | —            |

a Not known to be dead or alive as of Jan. 1, 1965.

### Purported Causes of Death in White Ss

The chief difference that distinguished intact males from either eunuchs or intact females was the high incidence of death from infections, particularly among the young and middle-aged (Table 14). Deaths from tuberculosis but not from pneumonia were more common in intact men than in eunuchs. Mean age at death from infections was also lower in intact than in castrated males.

There was no significant difference between castrated and intact males in the incidence of deaths attributed to cardiovascular disease, to cancer, or to trauma (Tables 14 and 15), although in eunuchs there was a trend to a higher percentage of deaths from cancer and to a lower percentage of deaths from trauma. Mean age at death from trauma was higher in castrated than in intact males (Table 15).

### DISCUSSION

A report is made at this time because there has been a marked trend since 1953 to transfer inmates from a single institution for the men-

Table 14. Purported Causes of Death from All and Selected Infections, Cancer, Cardiovascularrenal Diseases. Data Based on Certificates of Death for White Ss Exclusive of Those Who Died from Trauma.

| Purported Causes of Death | Status | Total |                   | Mean, Yrs.        | Median | Age At Death |                   |            |      |                 |                   |
|---------------------------|--------|-------|-------------------|-------------------|--------|--------------|-------------------|------------|------|-----------------|-------------------|
|                           |        |       |                   |                   |        | 14-34 Yrs.   |                   | 35-54 Yrs. |      | 55 or More Yrs. |                   |
|                           |        | N     | %                 |                   |        | N            | %                 | N          | %    | N               | %                 |
| All deaths                | IM     | 170   | 100.00            | 41.3 <sup>j</sup> | 41     | 74           | 43.5 <sup>s</sup> | 53         | 31.2 | 43              | 25.3              |
|                           | CM     | 74    | 100.00            | 47.8 <sup>k</sup> | 46     | 21           | 28.4 <sup>t</sup> | 28         | 37.8 | 25              | 33.8 <sup>v</sup> |
|                           | IF     | 133   | 100.00            | 38.4 <sup>l</sup> | 36     | 63           | 47.4 <sup>u</sup> | 46         | 34.6 | 24              | 18.0 <sup>w</sup> |
| All infections            | IM     | 74    | 43.5 <sup>a</sup> | 34.9 <sup>m</sup> | 32     | 44           | 59.5              | 20         | 37.7 | 10              | 23.3              |
|                           | CM     | 20    | 27.0 <sup>b</sup> | 44.0 <sup>n</sup> | 44     | 8            | 38.1              | 7          | 25.0 | 5               | 20.0              |
|                           | IF     | 51    | 38.3              | 31.4 <sup>o</sup> | 27     | 34           | 54.0              | 13         | 28.3 | 4               | 16.7              |
| Tuberculosis              | IM     | 35    | 20.6 <sup>c</sup> | 30.1              | 28     | 27           | 36.5              | 5          | 9.4  | 3               | 7.0               |
|                           | CM     | 6     | 8.1 <sup>d</sup>  | 27.2              | 25     | 5            | 23.8              | 1          | 3.6  | 0               | 0                 |
|                           | IF     | 21    | 15.8              | 29.2              | 26     | 15           | 23.8              | 6          | 13.0 | 0               | 0                 |
| Pneumonia                 | IM     | 23    | 13.5              | 43.3 <sup>p</sup> | 44     | 8            | 10.8              | 9          | 17.0 | 6               | 14.0              |
|                           | CM     | 9     | 12.2              | 55.1 <sup>q</sup> | 51     | 1            | 4.8               | 4          | 14.3 | 4               | 16.0              |
|                           | IF     | 18    | 13.5              | 32.7 <sup>r</sup> | 29.5   | 12           | 19.0              | 3          | 6.5  | 3               | 12.5              |
| All cancers               | IM     | 7     | 4.1               | 44.6              | 47     | 2            | 2.7               | 4          | 7.5  | 1               | 2.3               |
|                           | CM     | 7     | 9.5 <sup>e</sup>  | 45.1              | 45     | 2            | 9.5               | 3          | 10.7 | 2               | 8.0               |
|                           | IF     | 3     | 2.3 <sup>f</sup>  | 42.3              | 47     | 1            | 1.6               | 1          | 2.2  | 1               | 4.2               |
| Cardiovascular Diseases   | IM     | 50    | 29.4 <sup>g</sup> | 51.1              | 52     | 11           | 14.9              | 17         | 32.1 | 22              | 51.2              |
|                           | CM     | 22    | 29.7 <sup>h</sup> | 51.6              | 54     | 5            | 23.8              | 7          | 25.0 | 10              | 40.0              |
|                           | IF     | 60    | 45.1 <sup>i</sup> | 45.2              | 45     | 17           | 27.0              | 25         | 54.3 | 18              | 75.0              |

p=0.001: k-l, n-o

p=0.005: q-r

p=0.008: j-k

p=0.009: g-i

p=0.01: t-u

p=0.02: a-b, v-w

p=0.03: c-d, m-n

p=0.04: p-r, s-t

p=0.05: e-f, h-i

p=0.07: p-q

tally retarded, thereby exposing them to a greater variety of environments and increasing the difficulties in maintenance of records.

There is little reason to anticipate material change in the present data for males between 25 and 40 years of age during which years the eunuchs were significantly more viable than intact males. Only 4% of the combined series of castrated and intact males were born too late to be 35 years of age by Jan. 1, 1965, and only 17% too late to be 40 years old.

Better survival of castrated than of intact males continued to be at least as marked between 41 and 70 years of age as between 25 and 40 years of age (Fig. 1). Survival after 70 years of age has been estimated on the basis of relatively few Ss (Table 8).

Important judgments in the present study are (a) the comparability of intact and castrated males except for the consequences of orchietomy; (b) the validity of the prolongation of life after castration; (c) the suitability of mentally retarded Ss for this type of study; and (d) the applicability to the mentally normal Ss of the finding that orchietomy prolonged life in the mentally retarded.

*Comparability of castrate and intact males except for the consequences of orchietomy.*—The absence of a rigid policy governing recommendations for castration, great differences from year to year in enthusiasm for the practice of castration, and marked variation in the age of Ss at castration, all strongly suggest that no particular type of person was selected for operation. Direct evidence of the comparability of castrated and intact Ss was afforded by measurements of intelligence, classification by

type of mental deficiency, and other data. Further direct evidence was obtained from comparison of males never recommended for castration with males recommended for orchietomy but never operated on.

*Validity of the increase in length of life due to castration.*—Several differences between intact and castrated males were highly significant. The reality of these findings was further evident in that progressive delay in age at castration was associated with progressively shorter survival and lower mean age at death.

Further proof that orchietomy prolonged life was the fact that the percentage of known dead was lower in eunuchs than in intact females. This appears to be the first demonstration that a group of young males can be assembled (on the basis that they are eunuchs) who will outlive intact females. It is probably impossible to devise any way to select a group of males that would outlive females if the males were not orchietomized.

As discussed below, orchietomy also prolonged life in other species. The percentage increase in life-span after castration was even greater in cats and in salmon than in white eunuchs (Hamilton, 1965; Robertson, 1961).

*Suitability of mentally retarded Ss for this type of study.* Intact males tend to be shorter lived than intact females in the mentally retarded as in the mentally normal populations (Fig. 5). Therefore the effects of gonadectomy upon sex differences in survival can be studied in mentally retarded populations.

The mentally retarded Ss have also been shown to exhibit the morphological and phys-

Table 15. The Incidence of Traumatic Deaths in White Ss.

|            |        | All Ages |        |                   |        | 14-34 Yrs. |                   | 35-54 Yrs. |      | 55 or More Yrs. |                   |
|------------|--------|----------|--------|-------------------|--------|------------|-------------------|------------|------|-----------------|-------------------|
|            | Status | N        | %      | Mean              | Median | N          | %                 | N          | %    | N               | %                 |
| All deaths | IM     | 185      | 100.00 | 40.2 <sup>a</sup> | 39     | 85         | 45.9 <sup>f</sup> | 56         | 30.3 | 44              | 23.8              |
|            | CM     | 78       | 100.00 | 47.5 <sup>b</sup> | 45     | 22         | 28.2 <sup>g</sup> | 30         | 38.5 | 26              | 33.3 <sup>i</sup> |
|            | IF     | 137      | 100.00 | 38.1 <sup>c</sup> | 36     | 66         | 48.2 <sup>h</sup> | 47         | 34.3 | 24              | 17.5 <sup>j</sup> |
| Traumatic  | IM     | 15       | 8.1    | 27.7 <sup>d</sup> | 24     | 11         | 12.0              | 3          | 5.4  | 1               | 2.3               |
|            | CM     | 4        | 5.1    | 42.2 <sup>e</sup> | 45     | 1          | 4.5               | 2          | 6.7  | 1               | 3.8               |
|            | IF     | 4        | 2.9    | 29.2              | 27.5   | 3          | 4.5               | 1          | 2.1  | 0               | 0                 |

Note.—The total number of individuals in Table 15 is larger than in Table 14 due to inclusion of persons with traumatic deaths.

p < 0.001: b-c  
p = 0.003: a-b  
p = 0.008: g-h  
p = 0.01: f-g, i-j  
p = 0.04: d-e

iological effects of gonadectomy observed in the mentally normal Ss. In both types of Ss, orchietomy prevented development and maintenance of male secondary sex characters and the occurrence of sex-differing conditions such as male pattern baldness and acne (Hamilton, 1941, 1942, 1958; Hamilton & Mestler, 1963). For this type of study the mentally retarded are preferable to the mentally normal in one regard: few of the former were influenced by awareness of their castrated status. The writers examined 93 inmates who had been either orchietomized or vasectomized. Many remembered a surgical operation but only 7 men thought that these two types of surgery might produce different effects.

For these several reasons, mentally retarded Ss seem to be suitable for the present study.

*Applicability to the mentally normal of the finding that orchietomy prolonged life in the mentally retarded.*—Longer survival as a result of orchietomy in the mentally retarded may be expected to have a counterpart in mentally normal men, since castration increased the duration of life in normal males of other species and, as previously mentioned, orchietomy markedly depressed values for male secondary sex characters in both the mentally retarded and the mentally normal.

It must be recognized, however, that the loss of highly valued organs and functions such as the testes and some reproductive behavior has great psychological impact upon intelligent men (Bremer, 1959). In ordinary populations, operative procedures and mutilations of various sorts are known to have a deleterious effect on longevity (Homans, 1901).

Turning to other considerations, the present study supports the views that androgenic secretions of the testes may shorten the duration of life in man and be responsible in part for lesser viability in intact males than in intact females (Hamilton, 1948, 1965).

The present study also provides additional evidence that gonadal functions may play a more important role than heterozygosity of the sex chromosomes in sex-associated differences in survival (Hamilton, 1965). As reviewed elsewhere, however, the effects of gonadectomy upon duration of life vary not only with sex but also with the individual, strain, species, domestication, inbreeding, nutrition, and other factors (Hamilton, 1965). A statistically

demonstrable prolongation of life by orchietomy, which has now been observed in white men, has also been reported for outbred cats, salmon, and two kinds of rats (Asdell et al., 1967, Hamilton, 1965; Robertson, 1961; Talbert & Hamilton, 1965), but not for mice and other kinds of rats (Mühlbock, 1959) or meal moths (Hamilton & Johansson, 1955).

In white Ss, eunuchs were more viable than intact women, even though both groups lacked testes. At present it seems unwise to assume that ovarian estrogens reduced longevity since the evidence now available is that estrogens increased the duration of life in rats (Asdell et al., 1967). Instead, consideration may be given to the androgens known to be secreted by human ovaries as a result of findings such as the subnormal values for sebum after oöphorectomy (Hamilton & Mestler, 1963). Sebaceous secretions are dependent upon androgenic stimulation (Hamilton, 1941).

It is possible that ovarian androgens may reduce the life-span of some females in species such as *Homo sapiens*. Exceptionally high values for sebum have been reported in females with certain diseases, e.g., acne and breast cancer (Hamilton, Terada, & Mestler, 1964; Krant, Brandrup, Greene, Pochi, & Strauss, 1968). Persistent secretion of large amounts of androgens can result from presence of androgens in young female rodents for as short a time as one day (Weisz & Lloyd, 1965).

Postulated deleterious effects of ovarian androgens are in keeping with the reduction in life-span which followed administration of testosterone propionate to castrated and ovariectomized rats (Asdell et al., 1967).

A relationship between ovarian function and duration of life has been apparent in some but not all investigations. Ovariectomy prolonged life in cats, salmon,  $C_3H$  mice, and one type of rat (Hamilton, 1965; Mühlbock, 1959; Robertson, 1961; Talbert & Hamilton, 1965), but reduced life-span in other rats (Asdell et al., 1967). Actuarial data for a large number of women indicated that oöphorectomy had not promoted longevity, but many of these operations were done because of suspected pathology (Soc. Actuaries, 1951). An increased incidence of cardiovascular disease upon deprivation of ovarian functions has been claimed and denied (Williams & Novak, 1963), but even if true would not prove that the mortality rates were increased for all causes of death. In

the present study the number of oöphorectomized women was too small and the post-operative experience too limited to warrant conclusions.

Mechanisms whereby gonadal functions may influence longevity have been discussed elsewhere (Asdell et al., 1967; Hamilton, 1948, 1965).

The duration of life and purported causes of death in castrated and intact male cats may be considered here since autopsies or biopsies were done on the majority of these 458 outbred cats (Hamilton, Hamilton, & Mestler, 1969). Table 16 shows that the effects of orchiectomy in man and cat were similar in several regards: (a) longer mean duration of life; (b) greatest prolongation of life with castration before sexual maturation; (c) lower incidence of deaths from infections and older mean age at death from this cause; (d) higher incidence of deaths from cancers (not significant in man); (e) no decrease in frequency of deaths attributed to cardiovascular diseases; and (f) evidence that androgens may be more important than the Y chromosome in high mortality rates of males postnatally.

The finding of a greater loss of life from infections in intact males than in intact females or gonadectomized Ss is supported by other studies. Exposure of germfree mice to infections resulted in much higher mortality rates in males than in females (Outzen & Pilgrim, 1967). Females, in comparison with males, developed a stronger and more prolonged immune response to antigens (Graff, Lappé, & Snell, 1969; Terres, Morrison, & Habicht, 1968), exhibited more phagocytosis (Nicol, Bilbey, Charles, Cordingley, & Vernon-Roberts, 1964), and had higher circulating titers of macroglobulins (Butterworth, McClellan, & Allansmith, 1967). Testicular secretions reduced the immune response in mice (Graff et al., 1969).

Finally, the present study and that of out-

bred cats focuses attention on the nature of the irreversible loss of capacity for survival in males castrated after sexual maturation.

SUMMARY

The main part of this study was of mentally retarded white Ss: 735 intact males, 883 intact females, and 297 eunuchs. All lived for one or more years in the same institution and satisfied several requirements that increased the comparability of these groups.

Survival was significantly better in eunuchs than in intact males, beginning at 25 years of age and continuing throughout life. The median  $l_x$  (the estimated average duration of life) was 69.3 years in eunuchs, 55.7 years in intact males. For Ss born by 1920 and of known fate in 1965, the percentage dead was significantly lower in eunuchs and the mean age at death significantly higher.

Eunuchs also significantly outlived intact females, as shown by the percentage dead in Ss born by 1920 and of known fate in 1965. This is considered to be evidence that orchiectomy prolonged life, since it seems impossible to select males who would outlive females in the absence of orchiectomy.

In Ss born by 1920 and of known fate in 1965, the mean age at death was significantly higher with either prepubertal or postpubertal castration than in intact males. Males castrated at 8-14 years of age (before sexual maturation) were longer lived than males castrated at 20-39 years of age (after sexual maturation). Castration between 8 and 39 years of age was associated with reduction of 0.28 years in age at death for every year of delay before orchiectomy. That progressive lowering of age at castration was associated with progressive lengthening of life after 40 years of age was considered to be further evidence of an effect of orchiectomy upon survival.

Purported causes of death, recorded on death certificates, showed that the incidence of death

Table 16. Similarities in Sequelae of Orchiectomy in Man and in Outbred Cats. Data for Man Were Exclusive of Deaths Due to Trauma. Data for Cats were for Animals Examined or Autopsied at Death and Excluded Deaths Due to Trauma, Poisoning, and Panleukopenia.

| Age At Death |       |        |       |        | Longer Survival<br>With Castration<br>Before Sexual | Percentage of<br>Deaths Due to | Percentage of<br>Deaths Due to | No Difference Between CM<br>and IM in Percentage of |        |   |
|--------------|-------|--------|-------|--------|---|--------------------------------|--------------------------------|---|--------|---|
|              |       |        |       |        | Maturation  | Infections                     | Cancers                        | Deaths From Cardiovascular<br>Diseases              |        |   |
| Mean         |       |        |       |        |   |                                |                                |   |        |   |
| <i>p</i>     |       |        |       |        | <i>p</i>  | <i>p</i>                       | <i>p</i>                       |   |        |   |
| Man          | CM>IM | 0.008  | CM>IM | 0.002  | +   | CM<IM                          | 0.02                           | CM>IM   | N.S.   | + |
| Cat          | CM>IM | <0.001 | CM>IM | <0.001 | +   | CM<IM                          | 0.04                           | CM>IM   | <0.001 | + |

from infections was less in castrated than in intact males and that death occurred at an older age.

Limited study was made of mentally retarded non-white Ss: 25 eunuchs, 20 intact males, and 8 intact females. The median  $1_x$  was 65.6 years in castrated and 62.6 in intact males. This difference in median  $1_x$  was not significant but the tendency to a high median  $1_x$  in eunuchs was in harmony with the data for white eunuchs.

The difference between eunuchs and intact men with regard to duration of life was significantly more in whites than in non-whites (13.5 vs. 3 years). The detrimental effects of testicular function upon viability, and the benefit from orchiectomy, may prove to be more in white than in non-white males.

During more than 30 years given to this study, this work has depended upon the cooperation and help of many persons, including C. C. Hawke, L. D. Bunch, a succession of superintendents and librarians at the institution where most of the Ss lived, and others engaged in vital statistics and social work: Myrtle Cox, Irvin Franzen, M. A. S. Halleba, Marvin Larson, Muriel Lewis, and Helen Williard.

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