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On the Change in Expectation of Life in Man during a Period of Circa 2000 Years

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probable error of the difference, or the odds are only about 3 to 1 against the 84 group actually coming out larger than the 93 group. In other words in every four random samples of this material we should find on the average the mode in one case (if judged by inspection) to fall in the 84 and not the 93 element! Thus large frequencies about the modal value are subject to large absolute probable errors, and unless we have investigated the probable error of the differences of such frequencies, we shall have no security for even having found the elementary range within which the mode really lies. In fact, if we want to find the mode satisfactorily we must take into account the frequency in elements lying outside the groups 52 and 84. Five groups will be better than three, seven than five, and so on. But where are we to stop? Clearly it will be best to take all the component frequencies, or *the mode can only be found with the maximum of accuracy when we deduce it like the mean from the whole series of observations*. It will rarely if ever lie at the mid-point of the group of *apparent* maximum frequency of observation, and very often will lie outside the range of this group altogether. It is quite fallacious to suppose it a constant of the distribution easily determined by inspection. To discover it involves some theory of the nature of the distribution of the frequency or some interpolation hypothesis; it cannot be found until the errors of random sampling have been smoothed by some such process.

For practical purposes the *median* is one of the easiest quantities to determine, and this can be found in a very few minutes from inspection of the measurements, i.e. count half the observations from either end of the frequency distribution, and this will land the counter part-way, say n individuals, into some elementary frequency group. Look out the individuals in the observation-book falling into this group and arrange them in order of size, the n th individual from the proper end of the group either gives the median value of the organ (total number of individuals odd) or we place the median value (total number of individuals even) mid-way between the n and $n+1$ th individuals. If the median has been found as well as the mean, then a quite good value of the mode may be deduced by remembering that the median lies between the mode and the mean and that the distance from the median to the mode is double the distance from the mean to the median; this is close enough for practical purposes in the majority of frequency distributions*. Unless the mode be determined in this manner or from a complete treatment of the frequency distribution the mere tabulation of modes by inspection seems of small value, and the reasoning upon modes so determined liable to lead to fallacious conclusions.

K. PEARSON.

V. On the Change in Expectation of Life in Man during a period of circa 2000 years.

It is well known that the expectation of life at each age has changed in England very sensibly during the last 50 years—Farr's table differs very considerably from Ogle's table. The same remark applies, if we compare the Registrar-General's life table for 1881–90 with that of J. P., F.R.S., based on the London bills of mortality for 1728 to 1757†. But an opportunity has occurred for comparing the expectation of life in man at an interval of nearly 2000 years. The change that has taken place in this period cannot fail to be one of the greatest interest from the standpoint of evolution.

Professor Flinders Petrie has drawn my attention to the fact that the ages at death of a certain number of Egyptian mummies in the Roman period have been recorded and are published

* *Phil. Trans.*, Vol. 186, A. p. 375. Formulae for determining the mode and the probable error of its determination from the moments directly are given in a paper: "On the Mathematical Theory of Errors of Judgment, with Special Reference to the Personal Equation," in type for the *Phil. Trans.* See also *R. S. Proc.* Vol. 68, p. 369.

† See *R. S. Proc.* Vol. 67, p. 169.

by Professor W. Spiegelberg of Strassburg in his work: *Aegyptische und griechische Eigennamen aus Mumienetiketten*, 1901.

I presume that the individuals whose ages are thus preserved would not belong in bulk to the lowest nourished classes of the Egyptian population, so that they do not represent in any way a selected short-lived class. If anything we may suppose them to belong to the rather better classes, and at a time when a fairly settled civil government was in existence. We may reasonably treat the material as a fair sample of what one of the most stable populations of 1900 to 2000 years ago could manage in the matter of longevity. Unfortunately the material is very sparse. Professor Petrie provides me with the following table:

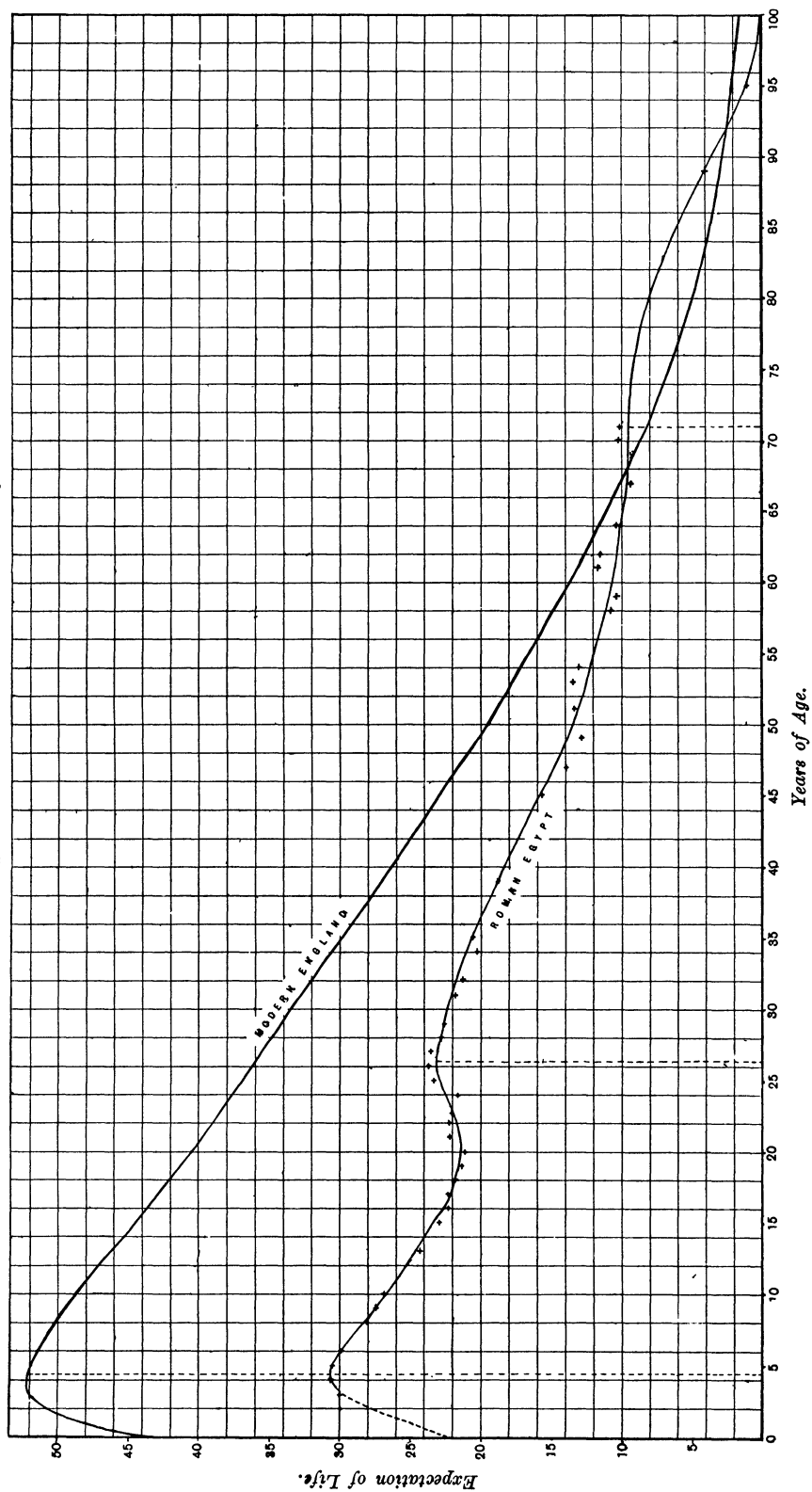
Age at Death	♂	♀	Age at Death	♂	♀
1½	1	1	33	2	1
1⅝	1	—	35	—	3
2	2	—	36	2	2
3	3	2	37	1	—
4	4	3	40	3	3
5	3	—	46	1	—
6	—	2	48	2	—
7	1	—	50	5	1
8	—	—	52	3	1
9	—	1	54	—	1
10	1	1	55	2	1
11	1	1	59	1	—
14	2	1	60	4	1
16	1	1	62	1	—
17	2	3	63	1	—
18	—	2	65	2	—
19	1	2	68	2	—
20	2	3	70	—	1
21	1	6	70·5	1	—
22	2	2	72	3	—
23	1	2	84	1	—
24	2	—	90	1	—
25	5	4	96	—	1
26	4	1			
27	1	1			
28	—	1		82	59
29	1	1			
30	1	2			
32	1	—			
				Total 141	

In dealing with this table I have not ventured to separate the ♂ and ♀ mortality, the numbers are far too insignificant. In the second place I have used expectation of life, and not a mortality table, because at any rate after two years of age we get up to a good age the means of more or less considerable numbers. Evidently there are hardly any entries in the first year of life, there is no fair representation of infantile mortality. Baby mummies, if they ever existed, have disappeared out of all due proportion.

In the diagram I have indicated by a small cross each expectation of life that it was possible to calculate, and I have further placed upon the diagram the English expectation of life based upon the average of male and female*. Now if we neglect infancy and extreme old age we really get a very fair sweep showing the general trend of the Egyptian mortality. I have very roughly adjusted the data representing them by the continuous curve. No elaborate adjustment was

* Ogle's Table, 1871—80.

Comparison of Expectation of Life at an Interval of 2000 years.



permissible, but from this adjustment, or even without it, the following results are clearly obvious :

(i) That up to the age of 68 the English expectation of life is greater, and in the earlier part of life immensely greater, than that of 2000 years ago.

In the course of those centuries man must have grown remarkably fitter to his environment, or else he must have fitted his environment immeasurably better to himself. No civilised community of to-day could show such a curve as the civilised Romano-Egyptians of 2000 years ago exhibit. We have here either a strong argument for the survival of the physically fitter man, or for the survival of the civilly fitter society. Either man is constitutionally fitter to survive to-day, or he is mentally fitter, i.e. better able to organise his civic surroundings. Both conclusions point perfectly definitely to an evolutionary progress.

(ii) The Egyptian curve differs fundamentally from the English in exhibiting apparently three maxima instead of one. These maxima must arise from the mortality curve itself being multinodal.

The first maximum is at about 4.5 years of age and corresponds to the English at about 4 years of age*. This is associated with the point where the especial dangers of infantile and childhood mortality have been surpassed.

The second Egyptian maximum occurs between 26 and 27 and possibly marks the period where the dangers of youthful mortality have been surmounted. The mortality of youth in our English case is a rather small component (greater for the French) and is centred at 22.5 years, becoming insignificant at 35.

I take it that this was much emphasised in Ancient Egypt, and reached its maximum considerably earlier. The third Egyptian maximum is less definite, because there are so few cases of extreme longevity to base the means upon. But it seems to me, looking at the points between 60 and 70, clearly impossible for the expectation of life curve to approach the axis without a point of inflexion and a maximum somewhere about 71—possibly earlier, even as early as 65, but the data are not sufficient to determine the point at all closely†. If this third maximum really exists, it would probably mean that the “mortality of middle life” which in the case of England is centred about 41.5 and ceases about 70 was much more definitely marked in Egypt. [See my paper in the *Phil. Trans.*, Vol. 186, p. 408, and especially Plate 16.] That the expectation of life for a Romano-Egyptian over 68 was greater than for a modern English man or woman is what we might expect, for with the mortality of youth and of middle age enormously emphasised only the very strongest would survive to this age. Out of 100 English alive at 10 years of age 39 survive to be 68; out of 100 Romano-Egyptians not 9 survived.

Looking at these two curves, we realise at a glance either the great physical progress of man, which enables him far more effectually to withstand a hostile environment, or the great social and sanitary progress he has made which enables him to modify that environment. In either case we can definitely assert that 2000 years has made him a much “fitter” being. In this comparison it must be remembered that we are not placing a civilised race against a barbaric tribe, but comparing a modern civilisation with one of the highest types of ancient civilisation.

That a man of 25 years to-day lives on an average 15 more years than a man of 25 years did 2000 years ago is surely very strong evidence that man has progressed substantially in this period.

K. PEARSON.

* I have turned down the Egyptian curve in a perfectly arbitrary manner by a broken line to indicate to the reader, looking at the diagram, that the infantile mortality is practically unrecorded.

† I am inclined to think the Egyptian curve for a considerable period must be concave to the horizontal axis, instead of throughout convex as in the case of the English.