Age.	$i=0$.	$i=\cdot03$.	$i=\cdot04$.	$i=\cdot05$.
30	3·1464	4·5002	5·1881	6·1767
50	5·0909	6·3154	6·8336	7·4329
70	11·3708	13·0714	13·6844	14·3199
90	29·0875	31·8114	32·7722	33·6255

I am, Sir,
Your most obedient servant,

P. GRAY.

London, 2nd Sept., 1867.

_ A short note on the problem which forms the subject of this letter will be found in vol. v., p. 348.

VALUE OF A POLICY—FORMULÆ—MILNE.

To the Editor of the Assurance Magazine.

Dear Sir,—There is a theorem which I suppose must be in the heads of many actuaries, but I cannot find it in any of the books. It is that the values of a policy, as it runs on, are proportional to the falls in the value of the annuity. That is, if a_x be the value of an annuity of £1 at the age x, the age of creation of the policy, the values of the policy at the ages y and z are as $a_x - a_y$ to $a_x - a_z$. That this theorem is not commonly expressed seems due to the value at the age y being usually written $1-\frac{1+a_y}{1+a_x}$ instead of $\frac{a_x-a_y}{1+a_x}$.

I shall be curious to see whether any one will produce a statement of this simple form. I find it occasionally very useful to take out from the table, without any writing, that the policy-value of $1+a_x$ at death is $a_x - a_y$ at the age y, the age x being that of commencement. When a formula represents two different results, it is a useful exercise of ingenuity to deduce one result directly from the other. Now $a_x - a_y$ is the value to (x) of a counter-survivorship—as we may call it—of the following kind. The executors of the first who dies pay an annuity of £1 to the survivor; and $(a_x - a_y) \div (1+a_x)$ is the whole-life premium which (x) should pay to be put in this position. How, from the nature of this contract, does it follow that one payment of this premium, over and above the annual premium which (x) should pay, admits (y) to a policy of £1 at the premium for the age (x)?

Easy forms, corollaries from common forms, are things for *second editions.* A person who is engaged in a great effort, and has a heavy system of tables to look after, does not watch offshoots. Now none of the best known works—except only those of Price and Morgan, which lay no stress on formulæ—have arrived at second editions: this may be said of Baily, G. Davies, Milne, and David Jones.

It is much to be regretted that Milne did not, in his later years, occupy himself with a reconstruction of the algebraical part of his work. But it is hardly known how completely he abandoned the subject. In May,

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1839, he wrote to me as follows:—"I am far from taking an interest now in investigations of the values of life contingencies; I have long since had too much of that, and been desirous of prosecuting inquiries into the phenomena of nature, which I have always regarded with intense interest."

Long before the above date, Milne had gained an unusually minute knowledge of natural history. When my colleague—as he then was—Macculloch, was putting together his dictionary of political economy, he was puzzled to know the character of some animal whose skin formed an article of commerce imported, I think, from Spain. He applied to zoologists without result: he brought away the impression that they did not take any interest in animals useful to man; and very sarcastic he was—and an unequivocal Scotch tongue is a very effective instrument of sarcasm—upon their imputed feeling in this respect. He knew that his friend Milne had paid attention to natural history, and applied to him in hope of reference to some source of knowledge. Milne immediately gave him all he wanted about the animal, and a great deal more, without book and with perfect precision.

The second quarter of our century was distinguished by the growth in England—and abroad also—of attention to especial points of scientific history, with complete research, and publication of documents, or at least of full reference. Four men are conspicuous; Stephen Peter Rigaud, of Oxford; George Peacock, of Cambridge; Francis Baily, Actuary, and of the Stock Exchange; and Joshua Milne, Actuary of the Sun Life Office. To these might be added John Drinkwater-Bethune, whose scientific biographies are special researches, though full materials were not published. Of the four men first named, two were academics, with large public libraries at their command; accordingly they left but few books. The two commercial men had to collect their own libraries; and they left two very remarkable sale catalogues on their own *amateur* subjects. Baily's library was astronomical, and not rich in life contingency. Nor was Milne's: I suspect he had parted with nearly all that was curious and that especially helped him in his historical articles. But in this collection of more than two thousand lots, representing perhaps six thousand volumes, we find a powerful force of general mathematics, Newton, Euler, D'Alembert, Lagrange, &c., and a very large collection of natural history, medicine, music, &c. I picked up two books connected with music, of which I never heard of other copies for sale: Solomon de Caus, and the collection of Meibomius. At the same time, it looks odd that in the library of the historian of life contingencies *Kerseboom* should be missing, and the contemporary anatomist *Cassebohm* should be present in several works.

There is a very good word coming into use to express the full treatment of one separated point; such a thing is a *monograph.*

The branches of science are becoming so extensive that histories will not be written again for a long time. But monographies will, I hope, abound; and the time may come when there shall be so many of them that somebody may abbreviate the total into a history, referring to the monographers for further detail and for evidence, and laying all responsibility on their shoulders.

Yours truly,

A. DE MORGAN.