Reproduction and Obesity*

By E. M. Widdowson, D.Sc.

The title of this symposium is a sign of the times. If this Congress had been held 5 years ago there is little doubt that we should have been considering reproduction in relation to undernutrition, not to obesity. Both undernutrition and overnutrition can influence the capacity to reproduce successfully. The effects vary from one species to another and from one stage of reproduction to another. In some ways their influence is the same and in others the very reverse. Of the two, undernutrition is probably the more harmful and for one of the functions of reproduction it may even be an advantage to be too fat.

Professor McCance has already mentioned the organism *Tokophrya*, which lives on another unicellular organism, *Tetrahymena*. *Tokophrya* reproduces by budding off small daughter cells. If a *Tokophrya* has just the right amount of food it will produce the maximum number of embryos, that is about 12 in 24 hours. If it has too little food—say 2 or 3 *Tetrahymena* per 24 hours—it produces only 2 embryos over that time, and if it is completely starved it produces none. If, on the other hand, it is given an excess of food—say 35 *Tetrahymena* per 24 hours—it again only produces 2 embryos, and if it is allowed to feed without interruption for 24–48 hours, which it will do if given the chance, it grows to 120 times its original size and reproduction stops altogether.[38] Thus, undernutrition and overnutrition have the same effect. The deposition of too much storage material within the cell appears to prevent nuclear growth and division, and, in the absence of food, growth is impossible and nuclear division also ceases.

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In mammals reproduction is so much more complicated than in unicellular organisms that there are many different ways in which obesity or undernutrition can influence it. Female rats which have become very fat after puncture of the hypothalamus refuse to mate, even though they have a normal sex cycle.[4] This appears to be part of their general inactivity, and hereditarily obese mice behave in the same way, although they have histologically normal ovaries.[27]

Stockmen blame fatness for sterility in their animals bred for "show" purposes and there seems little doubt that there is some foundation for this belief,[35] although sound scientific evidence is singularly lacking. It has been suggested that the fat removes estrogens from the circulation by dissolving them[44] or blocks the production of progesterone.[17] There is, however, much more evidence that fertility of the female can be increased by improving the rations of livestock[36,37] than that too much food depresses it. Whether overnutrition or mild undernutrition of the male has any effect on sperm production is still an open question.[11,46]

Some clinicians blame obesity for their patients' sterility,[30] but others have been much more impressed with the fertility of fat women.[34] Some have reported that during a period of severe food shortage fewer babies are born,[1,40] whereas others have concluded that undernutrition is without effect on fertility.[28] So many psychological and physiological factors are involved, however, that even if the birth rate is reduced during a famine, it is difficult to be sure that the undernutrition has been the cause. Whatever the truth of this aspect of reproduction and nutrition, all are agreed that the obese woman is more prone to some disorders of pregnancy than the thin one, particularly hypertension, albuminuria, edema, and other evidences of toxemia.[26,34] Fetal mortality is stated by some to be

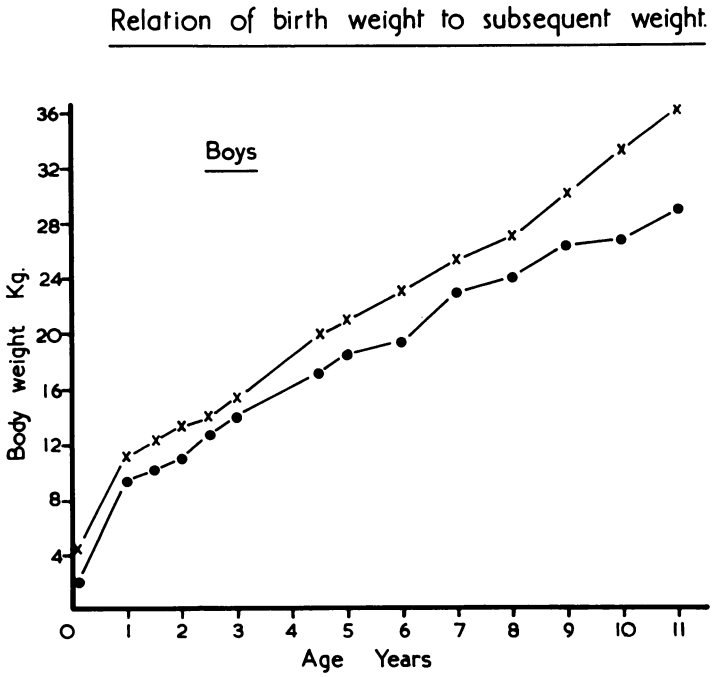

Figure 1

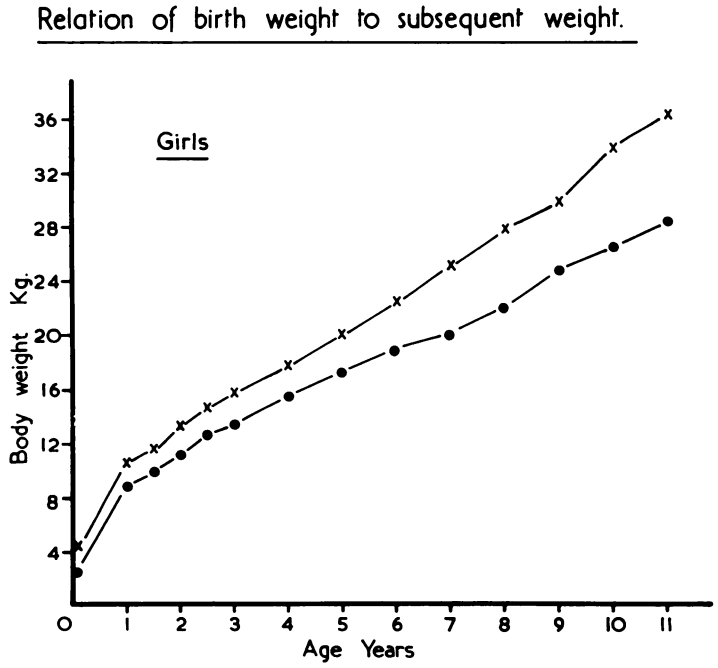

Figure 2

high,[15,26] but others have not found it to be so.[34]

There is no doubt that the fat mother tends to have a large fat baby, whether she will later develop diabetes or not.[9,15,24,26,34] Contrariwise, in a community which is suffering from a shortage of food the average birth weight of the babies is less than it is in the same community when it is well-nourished.[1,10,41]

Once a fat mother has safely brought forth a living baby, the tide turns in her favor, or certainly in favor of her offspring. She tends to produce more milk than the thin woman[39] or the undernourished one.[10] One reason for this probably is that her breasts have grown bigger, for the quantity of milk secreted appears to be directly related to the amount of mammary tissue,[25] and this is also true of the cow.[16] The big baby of the fat mother is hungry and ready to take more than the average amount of milk.[43] The child grows fast and is at all ages heavier than a child with a smaller birth weight. Illingworth and coworkers[21,22,23] have demonstrated quite clearly that the subsequent weight of children of all ages depends on the whole upon their birth weight (Figs. 1 and 2) and Mossberg[32] has shown that obese children have often been big babies at birth. A big baby born of a fat mother seems to be endowed with something which makes it continue to eat in proportion to its size. This may be growth hormone,[48] but whatever it is, it keeps these children ahead of their fellows. They eat a little more; they may or may not get fat during the growth period, but whether they do or not, they tend to reach puberty at an early age and a heavy weight.[3,5,12,32,33] This is also true of animals. An animal which grows fast and is heavier than average for its age will also attain puberty early,[7,36] and one whose diet is restricted so that its growth rate is slower than normal will attain sexual maturity late and its weight will be low at that time.[6]

As growth ceases, the big girl, with an appetite bigger than that of her companions, will continue to eat just that little bit extra each day and, as the surplus calories can no longer be expended on rapid growth, they will be laid down as fat. The bonny young woman

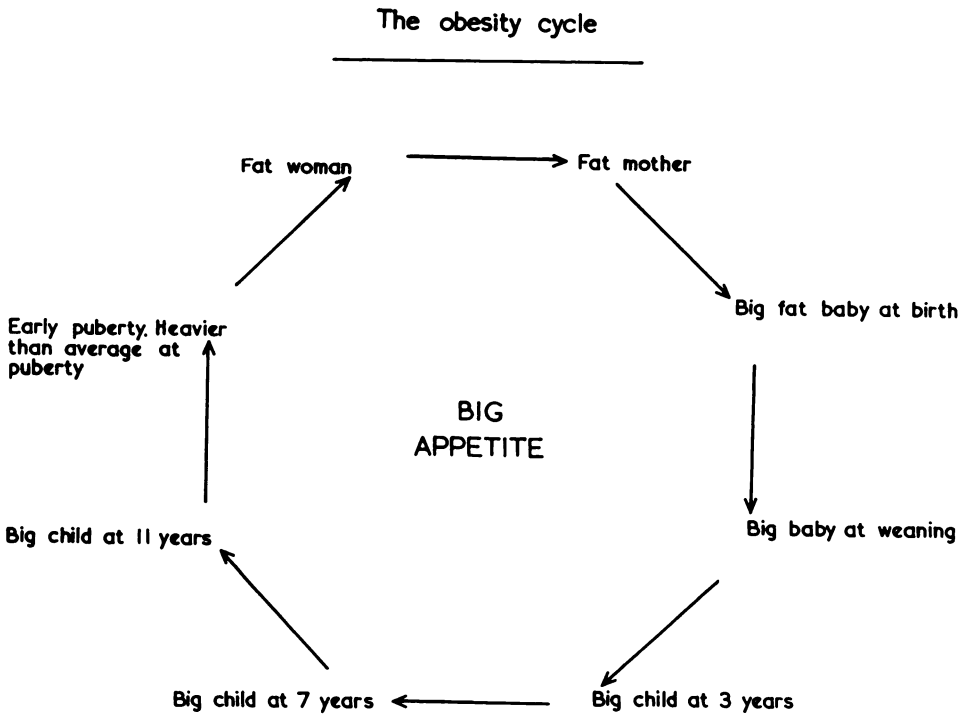

Figure 3

now only has to get married (and there seems no reason to suppose that she is less likely to do so than her thinner friend) and the obesity cycle is complete. (Fig. 3).

So far we have considered the effect of obesity on reproduction. Now I propose to look at the relationship from the other angle—the effect of reproduction on obesity. In many species it is physiological for the mother to lay down extra fat and nitrogen within her own body during pregnancy. The female rat starts to eat more food by the second day after mating, long before the fetuses can be making any measurable demands upon her.[8] She weighs more after delivery of her young than she did before she was pregnant,[2,8,46] and with each succeeding pregnancy she gains a little more weight.[8] This weight is not all lost during lactation, but no more weight is gained.[8] Morse and Schmidt[31] showed that nitrogen was retained by the rat during pregnancy and Spray[42] that both fat and protein contributed to the gain in weight (Fig. 4). Pregnant sows also store nitrogen in their own bodies during pregnancy,[13,29] but the outstanding example of the mother laying down material in her body during pregnancy is the grey Atlantic seal. The mother comes out of the sea on to the breeding territory on the shore a few days before calving, and at that time she is very fat. The newborn seal weighs about 30 pounds, and it grows to 84 pounds in two weeks—a growth rate of about 4 pounds a day. This growth is made entirely on milk, and entirely at the expense of the mother's body, for during the whole of this time the mother has nothing whatever to eat, and she loses about 200 pounds of her own weight during these two weeks.[14] Incidentally, the bull seals also put on a great deal of fat before breeding time, and they too go without food for several weeks while they are lying on the shore waiting for the females to bring forth their young and rear them and be ready for mating again about 14 days after the birth of the calf.

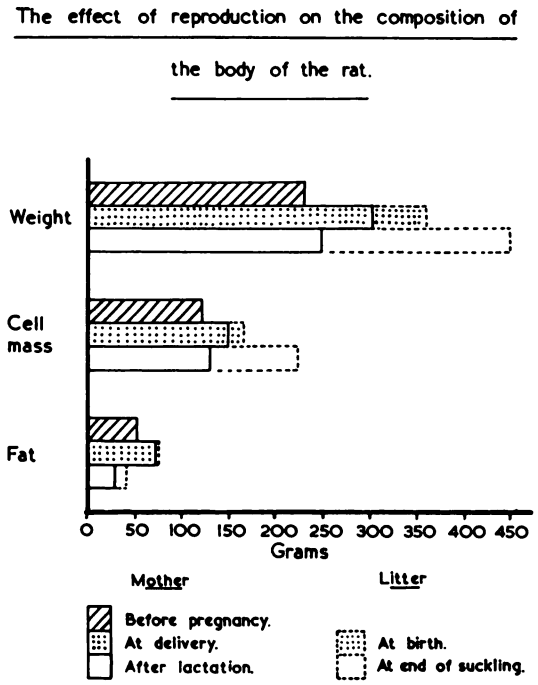

Figure 4

The human mother also normally stores more nitrogen and possibly also more fat in her own body during pregnancy than is required for the development of her baby.[18,19,20] In order to do this she must eat more food, and sometimes she carries this to excess and becomes very fat. Sheldon[39] has investigated the problem of maternal obesity and has found that some women put on weight with each succeeding pregnancy, while others put on a great deal of weight after one particular pregnancy. Sometimes the obesity does not develop until immediately after delivery or during lactation. In any case, this maternal obesity is always due to over-eating, and I would like to suggest that the woman who becomes fat during pregnancy or lactation has been travelling round the obesity cycle all her life. She was herself a big baby at birth and she will produce a big baby and lactate well.[39] She is always potentially fat, but the obesity first becomes gross when she herself reproduces.

One point remains to be considered: the effect of obesity on the length of reproductive life. We have been told today that obesity shortens the expectation of life. How does it affect reproductive life? The overweight woman or animal begins her reproductive life early. Does she wear out early? In mice an

unlimited supply of food seems to shorten reproductive life,[45] but in women, as far as I know, we have no evidence one way or the other. I can only conclude by quoting the words of the psalmist, "They shall bring forth fruit in old age; they shall be fat and flourishing." (Ps. 92. 14.)

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Philosophy in Medicine

"Galen desired that every true physician should be also a philosopher. Philosophical enquiry in medicine is apt to be regarded as an arduous eccentricity for which few physicians in our time have had either the opportunity or the inclination. Yet it is a worth-while pursuit, for a knowledge of the history of ideas has a moderating influence. It helps to keep a balance between undue dogmatism on the one hand and undue scepticism on the other; and above all in revealing the thoughts and expounding the works of some of the greatest minds in human history, it inculcates a humility which is the surest shield against intellectual arrogance."
—Sir Henry Cohen. *Proceedings of the Royal Society of Medicine* 48: 155, 1955.

Testing for "Guts"

"There were enthusiasts who believed that the nutritional state of a child could be measured by the length of time for which he could hang by his hands from an overhead bar or by the strength he could record on the dial of a dynamometer as he squeezed a spring grip or pulled a handle. The fallacies were fairly soon obvious. The 'hanging bar' test measured not only muscular power but tenacity of purpose and that very ill-defined quality, 'guts.' The dynamometer measured not only strength but skill and knack in the use of muscles. For that reason, the nutritionists abandoned these tests. . . . In our view that abandoning of functional tests was premature, for these adventitious qualities, 'guts,' 'muscular knack,' and 'fitness,' though hard to define and often hard to explain, were certainly parts of total health in that the person who had them in a high degree was certainly a better human being than the person who lacked them."
—*The Medical Press* 232: 533, 1954