SOME ASPECTS OF THE METABOLIC PATTERN OF GROWTH

by

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"To the physiologist the phenomenon of growth suggests many ..... considerations, and especially the relation of growth itself to chemical and physical forces and energies".

D'Arcy W. Thompson (1942).
On Growth and Form, p. 243.

"What is Growth?" ..... "Let us go back to work and find out more about it and not pretend we know".

P. Weiss (1955).
In The Hypophyseal Growth Hormone, Nature and Actions, p. 16.

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INTRODUCTION

The complex study of growth has been explored from many directions by many different methods. These numerous approaches are necessary because growth may be studied at all levels of protoplasmic synthesis, at the cellular level, at the organ or tissue level or at the organismal level.

The aspect of growth to be considered in the present work was the composition of the body weight gain at different ages in rats. The problem of what components constitute an increase in body mass at certain intervals of time was approached from two directions. Firstly, a dynamic approach was employed to discover, by measurements of the balances of nitrogen, water and energy, the processes involved in the retention of these substances. Secondly, analyses of whole carcases of rats at different ages were planned to give direct information about the nature of the weight gained.

Definitions of growth depend largely on the approach of the investigator. There is, for instance, that of Schloss (1911), "a correlated increase in the mass of the body in definite intervals of time in a way characteristic of the species" and that of Brody (1945), "a relatively irreversible time change in the measured dimension". D'Arcy Thompson (1942) emphasizes particularly

the change of form which accompanies growth. The practical viewpoints of Hammond (1952) who for the sake of simplicity subdivides growth from development, and of Maynard (1947) who distinguishes between true growth and fattening, contrast strongly with the more philosophical, though rather nebulous, views of Hammett (1946) who defines growth as the "integrated expression of the activities of Initiation, Proliferation, Differentiation, Organisation and Constructive Substance Increase". Richards and Kavanagh (1945) define growth as a "fundamental attribute of living organisms, manifested by a change in size of the individual or in the number of organisms in a unit of environment", and Medawar (1945) also states that growth means change of size, continuing "the size of an organism is something definite, unambiguous and measurable". In contrast, there is the dictum of Weiss (1949) that "growth is not even a scientific term with defined and constant meaning". There is indeed much truth in the viewpoint that there is "no single problem of growth but as many as one wishes to create" (Zuckerman, 1950).

There are various dimensions in which growth can be measured, for instance, increase in the number of cells, increase in length, increase in weight, etc. Even when increase in weight is taken as the measure of

growth there is a variety of methods for its assessment (Pálsson 1955). The actual weight increment, the percentage increment and the weight gain per unit time have all been used to illustrate different approaches to the problem of growth. The growth of parts relative to the whole has received some attention on the basis of weight increase as well as of length (Huxley, 1932; Teissier, 1934). Brody (1945) has advocated the application of the principle of mass action to all phases of growth, although this has been criticized by Mayer (1949) on the grounds that it lacks generality because of the imprecise characterization of ageing. It may be argued, equally well, however, that there is no precise yardstick of the criteria for youth.

Despite a formidable array of mathematical analyses of growth curves in which growth has, for the most part, been taken as equivalent to an increase in weight, there has been a growing demonstration from various standpoints that mere mass is a rather inadequate measure for the growth of organisms. This is strikingly illustrated by the marked difference in weight values of the same caloric equivalent of fat and protein retained in the body (Mayer, 1949a; Gaunt, 1954), and the recent increase in interest in body composition (p.) tends to shift the emphasis from weight increase per se to the components of this weight increase.

It is against this background that in the present work growth is taken as referring to the metabolic processes underlying the gain in weight which is normally associated with increasing age. In the study of this aspect of growth information was required about the retention of nitrogen, water and energy at different ages and about the intake and output of these substances. It was planned to study the energy expenditure of rats at different ages and its relationship to body weight and food intake. The proposition has been made (Mayer, 1949a) that growth contains a change from protein synthesis to fat synthesis with consequent continually increasing energy content of the added tissue. In other words, the potential energy per unit weight increases during growth. It was suggested that the heat content of animals increased steadily without any point of inflection in the curve, unlike the sigmoid curve of body weight on age (p. 3). The examination of this proposition of Mayer (1949a) was the purpose of the following study. It was also desired to establish the normal pattern of growth before any study of abnormal conditions of growth was undertaken.

As has been indicated, the experimental work was divided into two parts.

PART I.

Measurements were made of energy, nitrogen and water exchanges in male rats during growth, using a closed-circuit respirometer for long-term studies. Studies of these exchanges were made continuously for 24 hours for 5 day periods, commencing at the age of 30 days. Estimations were done at intervals of 10 days up to the age of 115 days, i.e. 9 periods, each of 5 days. Data were thus obtained for days 30 - 35, 40 - 45, 50 - 55, 60 - 65, 70 - 75, 80 - 85, 90 - 95, 100 - 105, 110 - 115. Three series, each composed of 9 periods were undertaken.

Within each series, the animals used were littermates. In the first series, it was intended to use one rat throughout, but a second rat was substituted for 3 out of the 9 periods (p.72, Vol.2). In the second series, several rats were used because of technical difficulties with the metabolic apparatus. In the third series, two rats were studied on alternate periods and in this series, 44 out of 45 days ran consecutively without mishap. In the earlier two series there were occasional gaps in the scheme, either due to obvious instrumental breakdowns or to errors in the weight balance of components (p. 64) subsequently discovered.

In addition to these 3 series (totalling 135 days), two weanling rats (21 days old) were studied in the

metabolic apparatus for 5 consecutive days. The apparatus was also in use on numerous other occasions to give additional information (on urine solids (p. 73) 21 days, on moisture on funnel and frame (p. 65) 23 days and on "blank" runs (p. 75) 9 days). That is, in the present work the apparatus was in use for a total of 193 days.

PART II.

Analyses for water, nitrogen, fat and heat of combustion were made of the carcases of the rats on metabolic study and of the carcases of littermates of these rats. A total of 28 analyses at different ages were made, as follows:-

Number analysed	Age
1 litter (10 rats)	Newborn
1 litter (12 rats)	1 day
1 group (4 littermates)	20 days
1 group (3 littermates)	21 days
5 rats	30 days
5 rats	60 days
3 rats	80 days
6 rats	115 days
2 rats	143 days
1 rat	194 days
1 rat	242 days
1 rat	247 days

PART I.

METABOLIC STUDIES

REVIEW OF THE LITERATURE.

Metabolic rate during growth.

The metabolic rate is a measure of the energy or heat released by all the bodily activities under certain circumstances. The methods used are either direct measurement of the heat produced or indirect estimation of the energy equivalent of the fuel utilized to produce this energy. This involves measurement of respiratory gaseous exchange and urinary nitrogen. Oxygen consumption can be used to give an approximate estimate of the heat production.

Much of the previous work on metabolic rate in all species of animals has been concerned with basal values, which, though providing much useful information, have, nevertheless, many drawbacks, as has been emphasized by Morrison (1955) for adult female rats. In rodents, the circumstances under which basal values of heat production are estimated border closely on starvation. The measurement of basal metabolic rate involves the restriction of activity and the withholding of food for some time, usually over 12 hours. These artificial conditions in the adult animal may give an indication of the minimum heat produced under these relatively static circumstances. In the growing animal, however, in which the active synthesis of new tissue is a

main characteristic, the extent of catabolism imposed by these basal conditions renders invalid any estimate of normal events.

Total heat production is the sum of the basal heat production plus the energy cost of feeding and the heat generated by physical activity. Its measurement gives a much less artificial picture of metabolic processes in the growing animal and has thus been used in the present work.

The metabolic rate requires to be expressed on some reference basis in order to compare the heat produced by animals of different size in the same species or by animals of different species, either of the same or different sizes. There has been much argument about the best method of expressing metabolic rate (Benedict, 1915, 1938; Du Bois, 1927; Kleiber, 1947a, 1956). This has been mainly concerned with whether the standard of reference should be body weight, a power of body weight or body surface.

In the present work, when a reference standard for heat production has been required rather than absolute values, body weight has been used because it gives a simple and readily measured index of tissue metabolism taken as a whole (Kleiber, 1956). Body surface or a power function of body weight are of use in

interspecies comparisons, since they provide a more uniform measure of body size when there are large differences of size among species. Although in the present case there are differences in body size, the above reasoning does not apply, since the differences in size are complicated by the accompanying differences in age. The variety of formulae for surface area even for one species such as the rat, reviewed by Kleiber (1944) and by Brody (1945), has rendered difficult comparison of data in the literature and increased the complexity of their interpretation for later workers. It should be noted that since surface area varies as a power of body weight (approximately weight$^{0.75}$), surface area increases less rapidly than body weight. Therefore, as will be seen (p. 13), in early life basal metabolism is higher than that of the adult on a weight basis but lower on a surface area basis.

It has been proposed that basal metabolism should be expressed as a function of the total mass of active protoplasm (Rubner, 1902; Benedict, 1938). The inference was that much of the variation in weight among adults of the same species is due to accumulation of fat, which is a tissue relatively inactive in energy exchange. The use of the total mass of active protoplasm was criticized as a vague concept (Brody, 1945; Kleiber, 1947a), but it cannot be lightly dismissed at

the present time because of the high correlation recently demonstrated between B.M.R. and lean body mass (Keys, Brožek, Henschel, Mickelsen & Taylor, 1950; Behnke, 1953; Garn, Clark & Portray, 1953; Miller & Blyth, 1953; von Döbeln, 1956). It should not be forgotten that adipose tissue is not metabolically inert, though it is less active than other tissues (Shapiro & Wertheimer, 1956). Other standards of reference used which have a high correlation with basal metabolism have been total body nitrogen (Moulton, 1916; Zeuthen, 1953), extracellular fluid (Dahlström, 1950) and the other fluid compartments (Wedgewood, Bass, Klimas, Kleeman & Quinn, 1953). At first sight, these would appear to be more useful as standards than body weight because they are more homogeneous, with less variable components, but, as has been pointed out (Brožek & Grande, 1955), there is a danger in assuming that a statistically significant correlation implies a physiological causal relationship.

The changes in the ratio of the fluid compartments of the body during growth and in their associated mineral salts (McCance & Widdowson, 1956) may prove to have some bearing on the changes in basal metabolic rate. During growth, the extracellular fluid (E.C.F.) undergoes a gradual process of contraction relative to the intracellular fluid (I.C.F.) and there is a rise

in the N/K ratio in the body. Development may thus be associated with a gradual increase of protein and a decrease of water and potassium per unit volume of cell. Alteration of hydration of cells has been shown, in kidney slices, to affect their consumption of oxygen, namely, that as the metabolic rate increases, the I.C.F. decreases and the E.C.F. increases (Robinson, 1950). The findings of McCance & Widdowson and Robinson cannot be directly connected, but they serve to illustrate the point that changes at the cellular level in water content and oxygen consumption may in some way be reflected in changes in oxygen consumption of the whole organism.

In mature animals of different body size, basal metabolism expressed in terms either of body weight or of body surface has been shown to diminish with increasing age (Benedict, 1938). During the growth of many animals including man, the graph of basal metabolic rate (B.M.R.) on age rises to a peak and then gradually declines (Du Bois, 1916; Benedict & Talbot, 1921; Deighton, 1924; Wood, 1926; Du Bois, 1927; Riddle, Nussman & Benedict, 1932; Brody, 1945; Quenouille, Boyne, Fisher & Leitch, 1951).

A similar pattern is found in rats. Although information on the metabolic rate in the early stages

of development is limited, it seems that the high oxygen consumption per unit weight of the rat ovum (Boell & Nicholas, 1939; Smith & Kleiber, 1950) diminishes till it reaches the level of the maternal tissues at mid-term. Then there is presumably an increase, since the metabolic rate at birth per unit weight is greater than the adult value (Gulick, 1937; Kleiber, Cole & Smith, 1943).

There seems to be agreement that in early post-natal life, the oxygen consumption, for both basal and resting values, and the metabolic rate on a surface area basis rises to a peak and then declines, although the time of this maximum is variously estimated at before one month (Grad, 1953; Miller & Conrad, 1956), at 40 days (Kleiber, Smith & Chernikoff, 1956) and at 45 days post-partum (Kibler & Brody, 1942). A continuous decline in B.M.R. has been described by workers who commenced estimations on rats at different ages after birth, namely at 13, 35 and 39 days respectively, (McCashland, 1951; Davis & Hastings, 1934; Mitchell & Carman, 1926). The different values from several laboratories arise mainly from the differences in technique but also from differences in strain of animals. However, a marked lability of B.M.R., i.e. considerable variation from day to day within a short period, has been described in growing rats (Hamilton, 1933b).

From data in rats approaching maturity a decrease in B.M.R. with increasing age has been conclusively shown (Hill & Hill, 1913; Benedict & MacLeod, 1929b; Houssay & Artundo, 1929; Landelius & Ljungkvist, 1934; Sherwood, 1936; Schopbach, Keeler & Greenberg, 1943). These estimates are of the same order of magnitude as values for the B.M.R. of young mature rats (Lewis & Luck, 1933; Horst, Mendel & Benedict, 1934b; Kranz & Carr, 1935; Greenbaum, 1953; Noach, 1953). However, there is a lack of agreement in the data on older animals. A continued decline in B.M.R. with age has been reported by some (Sherwood, 1936; Davis, 1937) but by others a rise (Benedict & MacLeod, 1929b; Belasco and Murlin, 1941). A rise in total heat production has also been described (Black & Murlin, 1939). No convincing explanation has been advanced for this possible rise in total heat production with age. It has been attributed to an increase in activity resulting from thwarted sexual impulses and to a greater dissipation of heat from the food ingested, because in old age there is almost complete absence of retention of energy for growth (Black & Murlin, 1939). The increase in B.M.R. with age is even more puzzling; one possible explanation could be the existence of a low-grade pneumonia which is common in old laboratory rats (Griffith & Farris, [illegible].

The reasons for the changes in B.M.R. during the main period of growth have aroused more speculative enquiry than systematic study. Although several causes of the variations in B.M.R. at different ages have been cited in explanation, no definite answer has yet been given. The problem has been approached from different angles.

The low rate of basal metabolism on a surface area basis in the newborn, relative to later stages of life, is probably due, in part, to incompleteness of neuromuscular development (Krogh, 1916). On the other hand, hormonal influences may be in action. The significant finding that injection of growth hormone causes a reduction in B.M.R. (Lee, Teel & Gagnon, 1929; Kleiber & Cole, 1939) could give rise to speculation that in early infancy intrinsic growth hormone is present in greater abundance than at other times or that the tissues are then specially sensitive to its effects. Recent work has suggested that there is greater tissue responsiveness to growth hormone in early infancy (Gerschberg, 1956) but the amount of growth hormone present at different ages is not yet known (Gaunt, 1954). The increase in B.M.R. from its relatively low value may be due to declining influence of growth hormone. The predominant retention of

protein which occurs in early life is consistent with activity of growth hormone then (Lee & Shaffer, 1934; Gordan, Bennet, Li & Evans, 1943; Young, 1945; Li, Simpson & Evans, 1948, Maasen, 1952). Later the effect of growth hormone is believed to diminish, being superseded by steroid hormones (Kinsell, 1955). Although in old age there is diminished responsiveness to thyroxine (Grad, 1953), Miller & Conrad (1956) consider that the decline in basal metabolic rate from youth to old age is not due to a progressive waning of thyroid influence.

Apart from neuromuscular and hormonal influences, changes in bodily composition may affect the level of basal and total metabolic rate. The estimation of the amounts and relative proportions of the different tissues is not, however, easy. Even supposing that the quantities of different tissue at different ages could be readily assessed, the determination of varying levels of cellular metabolic rate in the different tissues would be difficult to make and "basal" conditions of cells would still be difficult to define. It has been concluded, possibly with rather too sweeping an assertion, that changes in body composition probably play a minor rôle in the decline of B.M.R. with age (Conrad & Miller, 1956). It is

claimed that the "active tissue mass" (Keys et al., 1950) remains virtually unchanged with increasing age. This claim is based on the belief that the progressive increase in bone and fat content with age is offset by a decrease in the extracellular fluid, with the result that there is no appreciable change in the "active tissue mass".

The influence of changes in bodily composition on B.M.R. may be approached directly from a study of tissue metabolism in vitro. In this connection, there is the question of whether the basal oxygen consumption of the whole animal can be accounted for by the summed oxygen consumption of the tissues which compose it. Attention has therefore been given to the relative contribution of each tissue to the basal metabolic rate of the intact animal. Also the question has been considered whether the decrease in B.M.R. with increase in body size is due to intrinsic differences in cellular metabolism or to regulative factors in the organism as a whole.

Earlier work on the respiration of homologous tissues (i.e. comparison of the oxygen usage of one organ of one species with that of the same organ of another species) was contradictory, largely for technical reasons (von Grafe, 1925; Terroine & Roche, 1925;

Wels, 1925; Le Breton & Kayser, 1926). More recent work, however, is not completely conclusive. There are data from various sources showing that the respiration of mammalian tissues declines with age, but these estimations take no account of the varying proportions of the tissues in the body with age (Meyerhof & Himwich, 1924; McEachern, 1932; Victor & Potter, 1935; Pearce, 1936; Adams, 1937; Belasco, 1941; Wollenberger & Jehl, 1952). It has, however, been calculated that summated tissue respiration will account for 89% of the respiration of the intact, mature rat (Field, Belding & Martin, 1939); in the dog and mouse similar conclusions have been reached (Martin & Fuhrman, 1955). On the other hand, with a different medium it has been alleged that in the rat a value over 100% (Bertalanffy & Pirozynski, 1953) instead of 89% (Field et al.,1939) would have been recorded. This discrepancy of estimates and the marked differences of oxygen usage in different media (Krebs, 1950) throw doubt on the validity of assessing the total B.M.R. from summed values of isolated tissues. The least that can be said is that care is necessary in the interpretation of these in vitro studies; on the other hand, a frankly sceptical attitude to all deductions from such work may be justified.

Because of the apparent agreement between the oxygen usage of summed tissues and the oxygen usage of the whole animal, the conclusion has been drawn that the level of tissue respiration is determined by a factor operating *in vitro* as well as *in vivo* (Weymouth, Field & Kleiber, 1942). This belief is supported by the finding that the lower B.M.R. of rats given injections of growth hormone was reflected in a lower rate of oxygen consumption per unit dry weight of isolated tissue. Also the tissues of rats exposed to cold for fifty days, and presumably acclimatized, had a higher metabolic rate *in vitro* than those of control rats (Denison, Jasper, Hiestand & Zarrow, 1955).

In animals of different size, it has been found that in several tissues, the metabolic rate per unit weight *in vitro* decreased consistently with increasing size (Weymouth *et al.*,1942; Kleiber, 1947a), but with a more stringent technique, no strict parallelism was found between the oxygen usage per unit dry weight expressed in $mm^3/mg/hr$ (Q_{O_2}) of several tissues and the B.M.R. of nine different species (Krebs, 1950). In general, however, it was found that the Q_{O_2} of tissues from larger animals was less than that of tissues from smaller. For example, the mean Q_{O_2} for liver in one medium in the mouse was 19.3 and in

the horse 2.6.

It has been suggested that the Q_{O_2} is governed mainly by the local energy requirements of the tissues and that the differences in basal heat production in animals of different size are to be attributed, for the most part, to variations in the Q_{O_2} of the skeletal musculature (Krebs, 1950; Schmidt-Nielsen, 1951). This hypothesis seems to receive some support from the finding that in the rat the only tissue of those examined which showed a significant correlation between the rate of oxygen usage and body size was the diaphragm (Bertalanffy & Pirozynski, 1953). When direct estimations of the oxygen usage of skeletal muscle in vitro were made, there was little change in oxygen consumption per unit dry weight with age, and the change in oxygen consumption did not explain the decline in basal metabolic rate with increasing body size (Bertalanffy & Estwick, 1953), although the change in water content of skeletal muscle with increase in age does not seem to have been taken into account. The effect of the greater water content of muscle in young rats would, however, result in a lower oxygen consumption per g total muscle tissue, i.e. in the opposite direction to the changes in basal oxygen consumption of the whole animal with age. In any case, the contribution of total oxygen usage from skeletal

muscle may be smaller than might at first sight be thought, if the values from arterio-venous oxygen differences in man are considered. In the resting state, the skeletal musculature is responsible for about only 25% of the basal oxygen consumption of the body. This technique must, however, be considered with reservations (Mottram, 1954, 1955; Brožek & Grande, 1955).

When all the evidence from in vitro studies is taken together, it would seem that metabolic dissection of the body cannot yet state conclusively whether the decrease in metabolic rate with age is due to intrinsic differences in cellular metabolism or to regulative factors in the organism as a whole. The weight of evidence favours the latter view, although tissue metabolism in vitro seems to reflect to some extent the effects of metabolic regulation in the intact animal. At the tissue level, there are undoubtedly chemical (Brachet, 1940; Davidson & Waymouth, 1944; Davidson & Leslie, 1950) and enzymic changes with age (Fried & Tipton, 1953; Kunkel, Spalding, De Franciscis & Futrell, 1956). In the liver it has been calculated that there are changes in the oxygen usage per liver cell at different ages. The oxygen consumption per cell at 8 days of age is only half the adult value. At 2 months the oxygen consumption is still 20% lower than the adult value. In old age (rats over 2 years) a

decline in oxygen consumption per liver cell has been described (Jacob, Mandel & Mandel, 1954).

Another problem which has a bearing on the causes of the variations of B.M.R. with age is concerned with so-called "organizational energy" associated with the growth process (Brody, 1942). This specific organizational energy was postulated because a higher heat production was found in rapidly growing weanling rats than in those growing more slowly. This work has been criticized on the grounds that there was food restriction in the more slowly growing group which caused subsequent lowering of the B.M.R. (p. 23) (Kleiber & Cole, 1950). An alternative hypothesis to that of "organizational energy" is that the additional energy expended during growth is wholly accounted for by the increase in body weight and the increase in food intake. No direct proof of this has been given, but there are indications that food intake has some influence. A higher B.M.R. has been noted in rats on a higher plane of nutrition compared with those on a lower plane (Black, 1939). A raised B.M.R. is also seen in rats after an increase in food intake (Mukherjee & Mitchell, 1949; Triechler & Mitchell, 1949). Differences in food intake may also account for the slight increase in B.M.R. observed in rapidly growing rats (40 - 100 days old) compared with less rapidly growing animals (Horst, Mendel

& Benedict, 1934b). Conversely, rats retarded in growth because of caloric restriction have a B.M.R. lower on a surface area basis (Horst, Mendel & Benedict, 1934a; Will & McCay, 1943) but higher on a weight basis, compared with controls (Benedict & Sherman, 1937; Will & McCay, 1943). Since surface area is approximately $W^{2}/3$ it changes less rapidly than does body weight. The higher metabolic rate has been attributed to the fact that the viscera constitute a greater proportion of the body weight in the retarded rats (Ashworth, Brody & Hogan, 1932), but the diminished amount of adipose tissue which they contain with its lower requirement of oxygen could also be cited in explanation.

It is impossible to separate the influence of food intake on B.M.R. from some alterations in body composition which have been described as being associated with changes in utilisation of nutrients, or to separate the influence of food intake from hormonal effects. When rats with a high and low efficiency of food utilisation expressed as

$$\frac{100 \times (\text{dry matter consumed})}{(\text{gain in weight}),(\text{mean body weight during the period})}$$

were compared as regards basal metabolism per unit body weight, the former showed lower values. On the same amount of food intake the less efficient strain made smaller gains in protein, ash, fat and calories

than the more efficient strain (Palmer, Kennedy, Calverley, Lohn & Weswig, 1946). Alterations in body composition may account for the apparently contradictory finding that different rates of growth unassociated with different caloric intake did not cause any change in B.M.R. (Hamilton, 1937). Rats of a heavier strain (i.e. animals whose weight at maturity was greater than another, less heavy strain) were found to have a B.M.R. lower than those of the lighter strain (Kleiber & Cole, 1950). No information was given, however, about the food intake or body composition in the two groups.

Closely linked with efficiency in food utilisation is an influence of thyroid hormone, for the low and high efficiency strains of rats quoted above seem to have higher and lower levels of thyroid activity, respectively (Palmer et al.,1946). A similar explanation may also account for the differences between one group of rats which grew faster but for a shorter time and which had a greater degree of excitability and another group of less rapidly growing, less excitable animals (Lát, 1956). The more rapid growth of male rats compared with female rats on isocaloric feeding (Kim, Magee & Ivy, 1952) might repay metabolic study and most critical appraisal. Seasonal

changes in B.M.R. (Sherwood, 1936) and in the rate of growth of rats (Hanson & Keys, 1927; Campbell, 1945) have been described, but no systematic investigation into any possible relationship between them seems to have been made.

There are thus many complex influences which may account for the changes of B.M.R. with age. There are neuromuscular and hormonal effects and changes in body composition and cellular activity, all of which are closely linked with alterations in food intake and genetic and constitutional differences. Inseparable interaction of all these effects must contribute to the general association, namely a parallel decline, between growth rate (on a percentage basis) and basal metabolic rate (Kibler & Brody, 1942; Brody, 1945), which is found in rats, except in the early post-natal period. This intricate association of influences must also account for the increase in B.M.R. which coincides with the adolescent growth spurt found in children (Du Bois, 1927; Tanner, 1955). Systematic study of the basal metabolic rate combined with assessment of the changes in body composition which accompany alteration in food intake and rate of growth (McMeekan & Hammond, 1940) might assist, to some extent, in elucidating some aspects of the complex causes of the changes of B.M.R. with age. In a

consideration of the changes of total metabolic rate with age, the contribution of physical activity as well as food intake at different ages has to be taken into account.

Food Intake during Growth.

Over short periods, gain in weight is directly proportional to caloric value of food (Rost, 1902; Wilson, 1903; Rubner, 1908; Hopkins, 1912; Funk & MacCallum, 1915), although there is a changing pattern of gain in weight and caloric intake with increasing age. In rats, as in other animals, food intake increases with age when expressed as kcal/g body weight increase. For instance, 4.8 kcal/g are required in the time necessary to double the birth weight (Rubner, 1908), while weanling rats require a greater amount of dietary energy per g new tissue (10 - 15 kcal/g from the data of Funk & MacCallum, 1915; Smith & Carey, 1923, Griffith, 1929, Campbell, 1945, Forbes, Swift, James, Bratzler & Black, 1946, and French, Ingram, Uram, Barron & Swift, 1953). Older rats require still more energy intake per g weight increase (30 - 150 kcal/g from the data of Hitchcock, 1927 and French et al., 1953).

The reason for the increase in amount of food energy intake per g new tissue with age is that, as an animal grows larger, its maintenance cost in comparison to

weight gain increases and that relatively more food is required for each unit of weight gain.

An alternative method of expressing food intake, namely in kcal intake per 100 g body weight per day, shows that there is a diminution in this value with increasing age, when individual estimates are compared (from 50 down to 20 kcal/100 g body weight/day, from the data of Hopkins, 1912, Funk & McCallum, 1915, Drummond, 1918, and Campbell, 1945). In one longitudinal survey of caloric intake, there was a sharp decrease in caloric intake from 20 to 60 days of age and a slow decline thereafter (Wang, 1925). In a later estimate, using a better diet (Harte, Travers & Sarich, 1948) a maximum value for energy intake, expressed in kcal/sq. dm/day, occurred during the 5th week of post-natal life, followed by a decline. This pattern closely paralleled the graph of B.M.R. with age.

Because of the fact that a greater proportion of food intake is directed towards maintenance with increasing age, there is a reduction in gross efficiency, expressed as $\frac{\text{weight of added tissue (g)}}{\text{weight of food intake (g)}}$ (Armsby & Moulton, 1925). Many of the values given for gross efficiency are subject to criticism because they are based on arbitrary conversion factors and no allowance

has been made for the differences in energy equivalents of the weight gains (Brody, 1945). The energetic efficiency, $\frac{\text{energy gain (kcal)}}{\text{energy intake (kcal)}}$ of early post-natal growth, during doubling of the birth weight was estimated by Rubner (1908) to be 38% and the value quoted by Lusk (1928) was 20%. There is a steady decline in gross efficiency expressed on a weight basis from weaning onwards, but it has been noted, in contrast, that the energetic (or thermochemical) efficiency does not decline till the 30th day after weaning. The reason for the delayed decline is that the energy equivalent of weight increase becomes progressively higher with age, due, principally, to fat deposition. The thermochemical efficiency was at first estimated to be 35% (Mayer, 1949b) but later determined as 24% (Mayer, Vitale & Taira, 1951). From balance studies during the period of maximal growth, gross efficiency (calculated from the data of Forbes et al., 1946a) on the basis of metabolizable energy intake is 20%. Other values are 25% and 19% for rats of high and low efficiency respectively (Palmer et al., 1946). Considerable variability is found in the efficiency of growth of rats calculated from direct caloric equivalents of carcases (Mitchell & Carman, 1926).

The specific dynamic action (S.D.A.) of the ration fed during growth is important in a consideration

of total metabolism. The S.D.A., the heat increment of feeding or the calorigenic effect of food, represents the extra heat incident to the utilisation of food. The heat increment can be measured either from the base-line of the post-absorptive or of the maintenance state and its value for dietary constituents therefore varies with this initial starting level. S.D.A. is important in young animals, for when protein is retained for tissue growth it is withdrawn from dynamic action (Brody, 1945). This is well illustrated in a comparison of egg and milk proteins with isocaloric feeding; the former was superior for growth and caused a lower production of heat (Black & Murlin, 1939). The energy cost of feeding is distinguished from S.D.A. by the fact that it also involves the physical energy generated in the obtaining of food.

Nitrogen Metabolism during Growth.

Many studies of nitrogen (N) intake and balance have been made in rats. These have, however, been more concerned with the determination of the biological value of proteins than with a systematic study of the changes in nitrogen metabolism during growth. One clear-cut fact is evident, namely, that, on an adequate diet, the positive N balance per g ingested N decreases rapidly with age (Allison, 1951). Calculation from some representative data confirms that the percentage of N

intake retained is greater in younger (Mitchell, 1924; Forbes, Swift, James, Bratzler & Black, 1946; Arnrich, Hunt, Axelrod & Morgan, 1951), than in older rats (Black, French & Swift, 1949). This method of measuring protein utilisation has greater significance than the more usual method of expressing protein efficiency, viz. gain in weight/g N ingested (Arnrich et al, 1951, Ruegamer, Polling & Lockhart, 1950). The N content of tissue added during growth, derived by balance techniques (Black, French & Swift, 1949; Forbes et al, 1946a; Arnrich et al, 1951; Kon, 1931) is similar to that determined by carcase analysis (p.104). Since during growth there is a strong stimulus for N retention, it is not surprising that the relationship between endogenous N and basal metabolism in growing rats (Brody, 1945) is not similar to that in adults (2 mg N/kcal), (Smuts, 1935). Endogenous N is defined empirically as the lowest level of N excretion attained after an arbitrarily defined time interval on a diet low in N but otherwise complete.

Analogous with B.M.R. in the growing animal (p. 18), the reality of true endogenous N is even more suspect in the young than in the adult animal, owing to the highly artificial procedure of feeding a diet poor in nitrogen at a time when N retention is normally extremely marked.

Activity during Growth.

Physical activity, like food intake, makes a variable contribution to the total metabolism. Estimates of the extent of physical activity vary because of different methods of measuring the movements of rats; in adult rats the range is from 10 to 25% of the total metabolism. Gross spontaneous movements of a rat in a fixed living space can be recorded in some way and their magnitude estimated quantitatively or semi-quantitatively. Also, the revolutions of an "activity" wheel set in motion voluntarily by a rat can be counted and the spontaneous running in the wheel measured. These two methods and other techniques detect different types of physical activity. The relationship between activity and age has not been clearly defined, though recent work has attempted to clarify the position (Jones, Kimeldorf, Rubadeau & Castanera, 1953). The close interactions between age and experience in the wheel cage seemed to be an important factor in determining the reliability in volitional activity, and it was suggested that experience is the main source of discrepancy in previous results, along with differences in genetic background, illumination, sound insulation and environmental temperature. It was found that activity varied inversely with age for all animals of equal

experience, though the relationship was not linear. The greatest activity occurred about the time of puberty (50 - 70 days), which agreed with some of the previous data (Slonaker, 1907; Hitchcock, 1926; Richter, 1927), but not with others (Slonaker, 1912; Richter, 1922; Shirley, 1928), who found the peak activity at 200, 175 and 200 days respectively. Since the conditions of the wheel cage are not directly comparable with normal spontaneous movements in "fixed" accommodation (Eayrs, 1954), results therefore obtained by various techniques are not directly comparable. On the other hand, general types of activity, such as cyclical changes in activity, occur in both circumstances.

The non-periodic activity of the newborn rat is succeeded by the development of periodic rhythm about the 10th-16th day after birth (Richter, 1927). Cyclical activity with longer or shorter rhythms (Slonaker, 1912, 1925, 1926; Szymanski, 1918; Brown Shriner & Ralph, 1956) has been described as largely associated with physiological processes, particularly with the feeding cycle. Fluctuations in daily activity have been compared in a general way with fluctuations of growth, and are often, although not always, related to changes in food intake. The diurnal rhythm with maximal nocturnal activity, which is independent of light variations (Richter, 1927; Shirley, 1928; [illegible],

1937; Herring & Brody, 1938; Hunt & Schlosberg, 1939) seems to become established sometime between 1 and 6 months of age (Slonaker, 1912). In different strains of rats there are variations in diurnal activity.

That dietary factors influence activity is shown by the consistent increase in activity on a synthetic diet compared with a natural diet (Wald & Jackson, 1944) and also by the fact that deprivation of food or water caused increased running in activity cages (Richter, 1922; Hitchcock, 1928; Richter & Rice, 1954). It is possible that this increased activity occurs only in animals which have been conditioned to associate the acquisition of food with active expenditure of muscular activity and that prolonged failure of this activity to produce food will lead to extinction of the activity drive (Anliker, unpublished).

Water Metabolism during Growth.

Only a limited study has been made of the water exchanges of the rat, growing or adult. In fact, no complete analysis of water balance has been done apart from the work of Morrison (1955, 1956) using non-pregnant and pregnant rats. Other studies on water metabolism which are recorded have been restricted to measurement of fluid water intake and vaporized water loss.

Fluid water intake has been found to increase

gradually with age and to a less extent than the increase in body weight accompanying increasing age (Richter, 1926; Jackson & Smith, 1931). A high correlation with body surface area, however, has been claimed (Richter & Brailey, 1929). Rats from 30 to 160 days old were found to drink 800 ml/sq m body surface area per day. Although daily variations might be considerable a constancy in amount from one 10-day interval to another was reported.

Regarding water loss, constancy of the total quantity of vaporized water over the body weight range 100 - 250 g was found by Morrison (1955). This is consistent with the basic data found by Greene & Luce (1931). For rats for which values of energy expenditure below 25 kcal/day (below 80 g body weight) were recorded there was a tendency for a decline in vaporized water. This is consistent with the form of curve obtained in cattle (Armsby & Fries, 1917) for the relationship of vaporized water loss to total heat loss.

The insensible water loss has been used to derive the basal heat production in various species and there seems to be agreement that under temperate conditions the heat loss by vaporization of water (from skin and lungs in adults) is 25% of the total heat loss (Greene & Luce, 1931; Greene, 1934; Newburgh,

Johnston, Lashmet & Sheldon, 1937; Lee, 1940). In children, the same proportion of the total heat loss from vaporized water has been found (Levine & Wilson, 1927).

Growth Curves.

Since the term growth "curve" is commonly applied to the graph of body weight on age, such will be the usage here. Numerous records of serial weights of rats, as well as of other animals, have been made, either with the aim of demonstrating nutritional improvements or of formulating mathematical theories of growth. Much discussion has centred on the latter. The earlier concept (Robertson, 1923; Crozier, 1926) of growth as an autocatalytic, monomolecular process has been criticized on the grounds that these equations do not take into account the expanding volume of the growing organism (Snell, 1929). The mathematical analysis of growth curves has been considered unreliable because growth has been regarded as a simple physico-chemical process in the absence of rigid and direct proof (Gray, 1929). Nevertheless, more recently the values for the daily weights of rats have been stated to be represented by a polynomial plus a sine curve component plus a residual mean square or variance (Baker & Kleiber, 1944). Further analysis at a highly theoretical level (Eichorn, 1940) derived mathematical expressions relating

the cycle of growth and reproduction to the continuous exchange of vital power from generation to generation.

Zucker, Hall, Young & Zucker, (1941b), critically analysed the growth equations of many earlier workers and found them for the most part unsatisfactory for their growth data of rats in the post-weaning period. In fact, they found them representative of growth at suboptimal nutritional levels. They proposed a formula for testing growth (on the basis of gain in weight) under adequate nutritional conditions which has been satisfactorily applied to other rat colonies (Bertrand & Quivy, 1947; Dunn, Murphy & Rockland, 1947; Gray & Addis, 1948). The equation is $\log W = \frac{k}{t} + \log A$ where W = weight at time t, A is the weight approached asymptotically in the adult animal (log A being the intercept of the straight line) and k is the slope of the line which characterizes the rate of growth.

Although it has an empirical basis, this equation is claimed to conform with two basic concepts of growth (Huxley, 1932), self-multiplication of living substance and reduction of the rate of self-multiplication with increasing size.

On a diet optimal for growth the point of inflection is stated to occur at 3 - 4 weeks (Zucker, Hall, Young & Zucker, 1941a) but it can be artificially delayed by inferior nutrition to 6 weeks (Sherman &

Campbell, 1924; Sherman & MacLeod, 1925; Sherman & Booher, 1931) or to 10 weeks (Donaldson, Dunn & Watson, 1906). Various alterations in the shape of the growth curve may be produced by changes in the diet (MacDowell, 1928; MacDowell, Gates & MacDowell, 1930; McCay, Crowell & Maynard, 1935; McCay, Maynard, Sperling & Barnes, 1939). Thus the simultaneous occurrence of the point of inflection and puberty (Brody, 1945) may only occur on a deficient diet.

More recently, Zucker's relation has been found to be invalid when applied in rats to growth which was more rapid than any previously recorded (Mayer, 1948). The significance of this is not clear, but it is recognised that more rapid gain in weight is not necessarily better growth; on the other hand, the empirical nature of the equation renders it subject to amendment. A plea has been made for consideration of thermodynamics in growth equations (Mayer, 1949a) on the grounds that a better representation of growth is given than when body weight is used.

MATERIAL AND METHODS.

Experimental Animals.

All the animals used for metabolic studies and carcase analysis were male rats of the hooded Wistar strain, bred as a closed colony in the Institute of Physiology from animals originally obtained from the stock of the Rowett Research Institute. Both male and female rats of this strain were used in the growth studies for dietary evaluation. Details of sex, date of birth and experimental use are in Tables 6 and 7, the growth curves are in Figs 14 - 17 and the body weights during metabolic study in Figs 46 - 48.

Diet.

Choice of diet.

The diet used was called Metabolic Synthetic Number I, subsequently referred to as M.S.I. Its preparation is given in Appendix I, G, and its composition is as follows:-

Composition of Diet M.S.I.

Casein (light, white, B.D.H.)	20 parts
Rice starch	55 "
Sucrose	9 "
Special margarine (vitaminized)	9.5 "
Salt mixture (p. 40)	5 "
Hepamino (Evans) (p. 41)	1 "
Cod liver oil	0.5 "

To 10 kg of this mixture were added the following synthetic vitamins (Roche).

Thiamin	40 mg.
Riboflavin	40 mg.
Pyridoxin	20 mg.
Choline chloride	20 g.
α-tocopherol acetate	500 mg.

Salt Mixture.

	grams
Sodium chloride	168.6
Dibasic calcium phosphate	167.3
Patassium citrate	111.5
Calcium carbonate	77.0
Dipotassium phosphate	36.4
Magnesium carbonate	19.2
Ferric citrate	7.5
Manganous sulphate	0.59
Copper sulphate (anhydrous)	0.051
Potash alum	0.04
Cobalt chloride (anhydrous)	0.025
Potassium iodide	0.02
Zinc carbonate	0.02
Sodium fluoride	0.0004

Contents of Hepamino (per 100 g).

Thiamin	1 mg.
Riboflavin	13 mg.
Pyridoxin	2 mg.
Pantothenic acid	100 mg.
Folic acid	3 mg.
Biotin	0. 4 mg.
Inositol	250 mg.
Nicotinic acid	60 mg.
Hydrolysed protein	80 g.
Iron	230 parts per million
Copper	40 " " "

A semi-synthetic diet was chosen instead of a stock diet because of the greater accuracy possible in the calculation of the balances of energy, nitrogen and water when the exact dietary constituents are known. The advantage of more rigid chemical and energetic definition of the dietary components was considered to be worth the risk of not obtaining optimal growth with a semi-synthetic diet. When the growth rates of the rats on the semi-synthetic diet M.S.I. were compared with those on the stock diet M.R.C. diet 41 (Bruce & Parkes, 1949), growth performance on diet M.S.I. was not greatly inferior to that on diet 41 (Figs. 14 - 17 and (p. 13). Male rats at 115 days of age, which were the oldest rats studied in the metabolic apparatus, weighed 230g. when fed on diet M.S.I. Littermates of the same age and sex, when fed on diet 41, weighed 260 g. There is quite a marked difference in the constituents of the two diets, diet 41 having, for instance, the natural substances wholemeal flour, ground oats and fishmeal, instead of purified protein, fat and carbohydrate; the level of protein in diet 41 was 15% compared with 20% for diet M.S.I.

For ease of calculation one main source of protein was chosen, namely casein, at a level of 20% by weight. A small amount of hydrolysed protein was

also present in "Hepamino" (Evans), which is proteolysed and dried liver. "Hepamino" was included in the diet because it contained a concentrated source of impure vitamins of the B complex and traces of vitamins which would otherwise be absent from the diet (e.g. pantothenic acid, folic acid, biotin and inositol).

"Special Margarine" was the fat used in the diet. It was a non-branded product, manufactured under the governmental control of the Ministry of Food, during and for some time after the second world war. Its composition varied slightly depending on the vegetable fats available; the average composition was, however, kindly supplied by Dr. P.N. Williams of Unilever Ltd., and is as follows:-

Average Composition of "Special Margarine".

Saturated fatty acids	%
Caprylic acid (C_8)	2
Capric acid (C_{10})	3
Lauric acid (C_{12})	20.5
Myristic acid (C_{14})	7
Palmitic acid (C_{16})	22
Stearic acid (C_{18})	4
C_{20} C_{22} and C_{24} acids	1.5

Unsaturated fatty acids	%
Oleic acid (monoethenoid C_{18})	20
Iso-oleic acid (C_{18})	9
Linoleic acid (diethenoid C_{18})	11

Glyceride composition	
Tri-saturated glycerides	36
Di-saturated, mono-unsaturated	23
Mono- saturated, di-unsaturated	31
Tri-unsaturated	10

It was fortified by the manufacturers by the addition of 450 - 500 I.U. Vitamin A and 90 I.U. vitamin D per oz. The water-soluble vitamins were derived from three sources, from pure vitamins, from "Hepamino" and, in traces, from casein.

With a semi-synthetic diet, special attention has to be paid to the level of vitamins fed. In constructing the diet, requirements for vitamins were taken, for the most part, from Russell's (1948) review, which is concerned mainly with requirements for pregnancy. From Table 1 it can be seen that, apart from folic acid and pantothenic acid which were slightly below the recommended amounts, the vitamin content of the diet satisfied these requirements.

According to Unna, Richards & Sampson (1941), the diet contained sufficient calcium pantothenate to prevent achromotrichia, if an average daily food intake of 10 g is assumed. However, higher levels in diet M.S.I. would probably have been desirable, since at 100 days old, several rats fed on this diet had greyer coats than their littermates fed on diet 41.

Copping, Crowe & Pond (1951), using a synthetic diet, fed to rats levels of pure vitamins similar to those in diet M.S.I.; when crude liver extract was substituted for the pure vitamins in the same diet little better growth was obtained. The vitamin content of diet M.S.I. was well above the requirements for growth in rats recommended by Coward (1953) who based her suggested values on a review by Brown & Sturtevant (1949) in which searching analysis of the literature on this subject was made. A more recent dietary recommendation for growth in rats (Cuthbertson, 1957) proposes a vitamin content, which, in general, is below that which diet M.S.I. contains, with the exception of the contents of vitamin D and nicotinic acid which are slightly above those in diet M.S.I. Much larger quantities of vitamins were fed both by Mayer (1948) who obtained greater weight gains on a synthetic diet than with stock diets and by the Glaxo Laboratories (Cuthbertson, 1957) who obtained no increase

in growth rate when even larger quantities of vitamins were administered.

Comparison between Diets M.S.I. and 41.

No extensive test of diet M.S.I. for growth and reproduction was carried out, but several comparisons of the weights of littermates on the two diets M.S.I. and 41 were made, the graphical records of which are in Figs. 14 - 17 and the details of the animals used in Table 7. It can be seen that, in general, males and females on diet 41 gained weight somewhat more rapidly than those on diet M.S.I. though initially the latter diet promoted greater gain in weight, presumably because of its higher content of protein. In one instance, (Fig. 17) when the males on diet 41 were heavier than the females, while the females on diet M.S.I. were heavier than the males, there was striking similarity in the growth curves for males and females taken together. Data from animals on both diets were plotted on a log-reciprocal grid i.e. on a graph where the ordinate is the logarithm of body weight and the abscissa is the reciprocal of time expressed in weeks (Fig. 18). It is claimed by Zucker et al. (1941b) that when data are thus plotted and a straight-line relation is given, growth of rats is adequate. It is shown that, for the most part, the

relation derived by Zucker et al. is satisfied by the present data, though in one case a break in the line appears to be present (data for male and female rats born 19.9.53 and 29.9.53, fed on diet M.S.I.).

In addition, histological examination of tissues (liver, kidney, adrenal, thymus, small and large intestine, testis or ovary) was made from two groups of animals fed diet M.S.I. and diet 41 for 52 days after weaning. No abnormalities in either group nor any differences between the groups were detected. A few studies of reproductive performance were made with animals fed diet M.S.I. Mating of three males and three females was unimpaired and pregnancy was continued to term in all three cases. In two cases in which lactation was undertaken on diet M.S.I. a fair degree of success was achieved.

Metabolic Apparatus.

The apparatus used for the measurement of respiratory metabolism was a closed-circuit respirometer with pump-circulated air, based on that described by Dewar & Newton (1948) and modified considerably by Morrison (1952). Since its construction has already been described in detail (Morrison, 1952, 1955), only a general outline of its use will be given here, to accompany Figs. 1 - 3.

The components of the apparatus were enclosed in an insulated wooden cabinet which was thermostatically controlled, usually at 23($\pm$ 1)^{o}C. The temperature in the animal chamber was about 3^{o}C higher than that in the cabinet because of the heat generated by the rat there. In the primary circuit, air was circulated through the animal chamber and thence to the tubes carrying absorbents for carbon dioxide and water. The air then returned to the animal chamber via the air pump. Airtightness of the system was of prime importance; the detection and prevention of leaks is discussed later (p. 54).

Inside the animal chamber, of approximately 7 litres capacity, was fitted a frame to carry the food-box and water-bottle. This frame, which comprised the living-space of the rat, had two grids, one of wide mesh on which the animal stood, and another, below this, of fine mesh which retained the faeces produced. Because of these arrangements of grids coprophagy was prevented, but urine was able to pass through the fine mesh of the lower grid. It was collected, via a funnel into which the lower part of the frame was inserted, in a conical flask containing about 10 ml of 10% sulphuric acid.

The absorbing train consisted of a series of U-tubes. One tube of anhydrous calcium chloride and one tube of magnesium perchlorate ("Anhydrone") were

for the absorption of vaporized water and two tubes of "soda asbestos" were for absorption of carbon dioxide. Soda asbestos was used instead of soda lime because it has a higher carbon dioxide combining power, namely 44 g per 100 g absorbent, compared with 6 g per 100 g for soda lime. A final guard tube of anhydrone was present to absorb the water of reaction from the "soda asbestos" tubes. Into the final limb of this U-tube a few grams of activated carbon were introduced as a modification, to reduce the tendency to vitiation of the private atmosphere in which the rat lived. There was a subjective impression, however, that the need for this was much less when a semi-synthetic diet rather than a stock diet was used. The procedure for changing absorbing tubes during the running of the metabolic apparatus is given in Appendix I,C.

Circulation of air in the closed system was done by means of a Dale-Schuster membrane pump with a special valve system driven by 1/8 H.P. motor via a driving belt and pulleys. The valves previously used were Bunsen valves which have the disadvantage that the constriction of the glass ducts to which the valve tubing was attached obstructed the airflow and limited the ventilation of the system. Rubber with a wider bore and/or heavier tubing made the Bunsen valve too insensitive or decreased its competence. With the syste

of Bunsen valves a higher concentration of carbon dioxide (0.5 - 0.8%) and a higher relative humidity (R.H.) (70 - 80%) were obtained than was desirable.

Accordingly, to improve the environmental conditions of the rat, a lighter and more efficient form of valve was sought. At first, trial was made of the "flap" valves of rubber dam used in recording of tidal air and respiratory rate in rats into which a tracheal cannula had been inserted (D'Amour & Blood, 1948). These valves were simply circular membranes of thin rubber, attached for one-quarter of their circumference to the ends of glass tubes. The air flow in the system was too great for these to be used, for it caused the free edge of the membranes (which were unattached for three-quarters of their circumference) to be sucked back into the glass tube. If, however, the circular membrane of rubber dam was "anchored" to the edge of the glass tube in three places by thin strips of rubber dam in continuity with the main circular membrane using "Bostik", a light and competent valve was obtained (Fig.4). It was expected that these valves would probably require frequent replacement, but the original valves remained in use for approximately four years and were in good condition throughout.

Dried oxygen passed into the closed system from a spirometer through a Bunsen valve as the internal pressure

fell due to the consumption of oxygen and absorption of carbon dioxide. The spirometer had a cursor attached to its counterpoise which ran on a centimetre scale at the side of the spirometer. Readings of the spirometer were made on this scale at the beginning and end of each 24 hr. period and on refilling the spirometer; these measurements corresponded to the uncorrected volume of oxygen. The corrected volume of oxygen and its weight were derived as shown on p. 58. Continuous recording of oxygen usage was done by arranging that a light pointer fixed on top of the spirometer bell wrote on smoked paper on a 12-inch kymograph. Each paper was graduated in lines 1 cm. apart. Since a sloping line was traced on the smoked paper by the pointer the trend of oxygen consumption was immediately evident during the course of the day (see Fig. 9). Because of the limited capacity of the spirometer, (5 litres), refilling with oxygen had to be done once or twice a day. The standard routine is given in Appendix I,B.

To estimate the "ventilation rate" of the pump and compare the new "flap" valves with those Bunsen valves formerly in use, the closed circuit was broken on the intake side of the pump and a Bunsen valve was fitted to the outlet duct of the chamber. The air inlet to the pump was occluded. The pump therefore

delivered its load of air through a non-return valve to the external air, its only source of gas being oxygen supplied from the spirometer. The rate of removal of oxygen from the spirometer was thus a measure of the "ventilation rate" of the pump. With the Bunsen valves a slight and variable effect of pump speed on pump ventilation was previously found (Morrison, 1952). This was due to incompetence of the valves and was confirmed in further tests with this type of valve. When the "flap" valves were in use, "ventilation rate" varied consistently with alteration in pump speed, and higher "ventilation rates" were obtained than with the Bunsen valves (Fig. 8).

A pump speed of 240 r.p.m. was used throughout the present study and the pump stroke was varied from 8 - 12 mm, depending on the size of the rat in the animal chamber. This meant that the membrane of the pump was never being over-strained (maximum stroke 15 mm) and yet a suitable range of "ventilation rates" was obtained (approximately 1015 - 1670 litres/day). The mean production of carbon dioxide and water for each experimental series at each level of pump stroke is given on page 53 and from these and the "ventilation rate" of the pump the mean R.H. (45.3%) and the mean percentage of carbon dioxide (0.43%) are calculated. These values indicate that more satisfactory

Environmental Conditions of Metabolic Studies.

Series	Pump Stroke mm	Ventilation litres/day	CO_2 litres/day	CO_2 %	Water Vapour g/day	Water Vapour g/litre air	R.H. at 26°C
I	8	1015	5.389	0.53	14.505	0.0143	58.6
	10	1382	6.888	0.50	17.756	0.0128	52.7
II	10	1382	4.943	0.36	12.283	0.0089	36.5
	12	1670	6.519	0.39	17.092	0.0102	41.9
III	10	1382	5.335	0.39	14.242	0.0103	42.3
	12	1670	7.224	0.43	16.209	0.0097	39.8
Mean of Series I, II and III				0.43			45.3
Weanlings	10	1382	6.276	0.45	15.162	0.0110	45.1

environmental conditions for the rat are obtained with the "flap" valves than with the Bunsen valves formerly in use; the R.H. was then 70 - 80% and the percentage of carbon dioxide 0.5 - 0.8%,. On several occasions a direct reading hygrometer was introduced into the animal chamber for approximately six hours along with the rat and water-bottle. Readings of R.H. stabilised under these conditions at about 50 - 55%.

Test methods.

Considerable difficulty has been experienced in testing the apparatus for leaks by the classical alcohol combustion method, since the ventilation rate for maintaining carbon dioxide concentration and humidity at a satisfactory level for a rat is quite inadequate to maintain the smallest alcohol flame for any length of time. However, satisfactory evidence of airtightness for this apparatus had previously been obtained by this method and by Haldane gas analyses (Morrison, 1955). Routine testing of the apparatus for leaks was done in the present work by placing an aneroid barometer instead of a rat in the animal chamber and raising or lowering the internal pressure by about 5 cm Hg. If there was an alteration of more than 2mm Hg, taking account of temperature changes, a leak was presumed. The most frequent cause of leaks came from the animal chambers, which were therefore tested under

water with raised internal pressure at the beginning of each 5-day period (p. 5). The only other cause for leaks which was discovered was the development of a flaw in the rubber membrane of the pump; fortunately, this occurred on only one occasion. Indirect evidence of the presence of leaks was derived from calculation of the total weight balance of all ingoing and all outgoing components (p. 56) in the daily Record Sheet (Appendix I,D). If there was marked discrepancy in this weight balance (p. 66), that is if the computed weight balance were outwith +0.70 to -1.0g a leak was suspected. On the days when such discrepancies occurred (15 out of a total of 135 days in the main experimental series) the data on respiratory exchange were discarded.

Experimental Procedures

Daily routine.

The metabolic apparatus is so designed that measurements can be made of the total intake and the total output of all components, i.e. gaseous exchanges, solid and liquid ingesta and excreta. In the present work the intake and the output of nitrogen, energy and water were measured and from these were derived the balances of nitrogen, energy and water.

The primary data from which these balances were eventually obtained are shown in the Record Sheet (Appendix I,D) and the derivatives of these primary data are given in the section on computation of results (p. 58). Oxygen usage was determined volumetrically but all the other estimations were gravimetric. Weighings were done on a balance with a precision limit of 5 mg.

The order of weighing the various items was arranged so that minimal loss of water would occur from them, either before they were placed in the metabolic apparatus or removed from it. For example, on removal from the apparatus priority of order of weighing was given to the rat, the urine flask, the funnel and frame with scattered contaminated food, the wet faeces and the water bottle. Then the absorbing tubes for water and carbon dioxide, the food box and the dried scattered food were weighed.

The rat was weighed daily in a ventilated tin box. When not in use for this purpose the same box contained faeces which were weighed in it in the fresh and then in the dried states.

The daily routine for change-over is given in Appendix I,A. Normally there was a break of only 10 - 15 minutes between two daily runs. The change-over

was always made in the morning at approximately the same time each day. This was usually between 9.30 a.m. and 10.30 a.m.; from the daily records the earliest time of change-over was 8.15 a.m. and the latest 11.30 a.m.

Heat of Combustion.

The heat of combustion of food and faeces was measured by a Berthelot-Mahler bomb calorimeter (Appendix I,E), using pellets of material weighing 1.5 - 2.0 g.

Nitrogen estimations.

The nitrogen content of urine, faeces and food was estimated by a micro-Kjeldahl method (Ma & Zuazaga, 1942). The urine was collected in a 100 ml Erlenmeyer flask containing about 10 ml of 10% sulphuric acid. The urine-contaminated food adhering to the funnel and frame was washed with distilled water into the flask and filtered off; the filtrate and filter washings were made up to 100 ml with distilled water. Nitrogen estimations were made on 1 ml aliquots of this solution; duplicates agreed within 0.5%. Tests of recovery of nitrogen were made, whereby 5 ml of a urine of known nitrogen content was pipetted over the grid of the frame where food had been scattered. When the funnel and frame were washed and the washings analysed as outlined above, 96% recovery

of nitrogen from the urine was obtained.

Computation of Data.

In deriving the daily values for energy, nitrogen and water, the arbitrary convention was adopted that intake of food and output of faeces and urine were on a 24 hour basis, though, in fact, they were measured over a range of $22\frac{1}{4}$ - 25 1/6 hours. Most of the measurements were, however, within $23\frac{1}{2}$ - $24\frac{1}{2}$ hours (see Table 35). The values for energy expenditure, vaporized water and metabolic water were all computed to a 24-hour basis, since they were produced continuously during the day, though not, of course, at a constant rate.

Oxygen consumption.

The calibration curve for the spirometer was linear and the equation for the straight line of best fit was:-

$$\text{Vol. of oxygen } (O_2) \text{ in litres} = \frac{\text{initial spirometer reading} - \text{final spirometer reading (mm)}}{5.111}$$

To reduce oxygen volume to S.T.P. correction factors derived from the nomogram given by Weir (1949) (Fig.10) were used. Further corrections for the uncalibrated volume of spirometer and ducts and for the change in temperature in the animal chamber were embodied in Morrison's (1955) equation for the volume of oxygen used;-

$$\text{Vol.}O_2 \underset{\text{STP}}{} = \left(\frac{1}{5.11}\right)(px_1 - qx_2) + 0.454\,(p-q) + 0.0214\,(T_2 - T_1) + 0.015 \text{ litres}).$$

where x_1 = initial spirometer reading

x_2 = final spirometer reading

p = correction factor (to S.T.P.) of x_1

q = correction factor (to S.T.P.) of x_2

T_1 = initial temperature of animal chamber

T_2 = final temperature of animal chamber

The volume of oxygen in ml at S.T.P. was converted into weight in g by multiplying by the factor 1.429.

Carbon Dioxide Production.

The weight of carbon dioxide (CO_2) was given by the final weights of soda asbestos and anhydrone guard tubes less the initial weights of these tubes. A correction of 45 ml or 0.093 g CO_2 was added to allow for the raised carbon dioxide concentration in the apparatus. This corresponds to a concentration of 0.7% CO_2 in the end chamber air which is greater than the estimated average concentration of CO_2 in the present work (0.43%). It is recognised that the use of this correction involves an error. This is not large,

however, because of the small size of the correction relative to the total weights of CO_2 produced. The percentage error when 0.093 g is added as a correction, instead of 0.058 g (calculated on the basis of a CO_2 concentration of 0.43%) to, say, 12 g CO_2 is only 0.3% and may therefore be regarded lightly.

Energy expenditure.

This was calculated from the values of oxygen, carbon dioxide and urinary nitrogen, using a form of Weir's (1949) equation. The following basic metabolic constants were used:-

	Carbohydrate	Protein	Fat
Respiratory quotient (R.Q.)	1.0	0.821	0.707
kcal/litre Oxygen	5.033	4.586	4.757

These constants were derived from various sources. For carbohydrate, the energy equivalents of a litre of oxygen used to metabolize sucrose and starch are 5.0091 kcal and 5.037 kcal respectively. Weighting these values according to the carbohydrate distribution of the diet (which was for starch 85.94% and for sucrose 14.06% of the carbohydrate present) gives an energy equivalent of 5.033 kcal/litre of oxygen. For fat, the R.Q. and the energy equivalent of oxygen were computed from average figures for the composition of "Special Margarine", kindly supplied by Dr. P.N. Williams of Unilever Ltd. (p.43).

It was assumed that complete combustion of the fat, for which an empirical formula was derived, had taken place. For protein, the values for the R.Q., the energy equivalent of oxygen and the energy equivalent of urinary nitrogen were estimates from the data of Kriss & Miller (1934) for the albino rat fed casein exclusively. They are in very close agreement with the constants later derived by Kriss & Voris (1937) from rats fed a mixed diet supplemented with casein. Since sources of protein other than casein in the present diet were very small (p. 42) these values were considered valid. The data of Kriss & Miller involve a very slight error, which is noted by themselves, namely that no direct experimental determinations were made of the hydrogen and oxygen content of the excreta. Also, the energy of the urine was corrected to nitrogen equilibrium which differs from the state of nitrogen retention in the present work and involves another slight error. These data, however, are the best available, and, on the whole, seem quite satisfactory.

All the energy values on p. 60 are referred to the dietary components directly, which is an advantage of using a semi-synthetic diet. Sometimes energy equivalents are based on the metabolism of body substance in a post-absorptive condition, which values would not be applicable to a study of total

metabolism such as the present work. Using the above constants, the equation for energy expenditure is:-

Total kcal = (4.077 x litres O_2 used) + (0.956 x litres CO_2 produced) - (1.841 x g urinary N).

Energy Balance

The equation for energy balance is:-

$$E_g = E_i - E_f - E_u - E_m$$

Where E_g = heat of combustion of body substance gained

E_i = heat of combustion of food consumed

E_f = heat of combustion of faeces formed

E_u = heat of combustion of urine solids formed

E_m = energy expenditure (calculated from respiratory exchange)

The assumption was made that faeces and urine excreted on one day were equivalent to the faeces and urine formed during that day, This is not strictly accurate, though it was considered a justifiable assumption because the error is reduced when results are taken over 5-day periods. Some indication that the error involved with a 5-day block is likely to be small is shown in Fig. 30. Here a linear relation between the faecal energy and the ingested energy over 5-day

periods is seen. Even the relation between the daily weights of food and faeces shows a fairly close correspondence (Fig. 36).

The heat of combustion of food and of faeces was measured directly with a bomb calorimeter. Since the urine was passed into sulphuric acid to prevent loss of nitrogen and formation of gaseous products of decomposition, no direct measurement of urinary heat of combustion was made routinely. However, pooled samples of urine, collected from rats which were used in the determination of the amount of moisture on the funnel and frame (p. 73) were frozen-dried and the heat of combustion of the urine solids was measured. A small weighed pellet of benzoic acid was used to promote and maintain combustion; the heat of combustion produced by the benzoic acid was then subtracted from the total heat generated, giving the heat of combustion of the urine solids. Only six estimations were made, since it was difficult to obtain a sufficient quantity of urine solids, as the dried material adhered tenaciously to the flasks after being frozen-dried. The average energy value obtained was 1.65 kcal/g urine solids and 8.81 kcal/g urinary nitrogen (range 7.4 - 10.7). In view of the small number of determinations and the wide scatter of results, it was decided to use the value of 8.6 kcal/g urinary N, derived by Morrison (1952) from the data of

Forbes, Bratzler, Thacker & Marcy (1939), Forbes & Swift (1944), Forbes, Swift, Elliot & James (1946a) and (1946b), Black, Maddy & Swift (1950), since this value was based on a much greater number of estimations (29).

Non-protein Respiratory Quotient (Non-protein R.Q.)

Non-protein R.Q. is given by the expression:-

$$\frac{(\text{Total } CO_2 - \text{Protein } CO_2) \text{ litres}}{(\text{Total } O_2 - \text{Protein } O_2) \text{ litres}}$$

Using the constants of Kriss & Miller (1934) (p. 60), for catabolism of casein, the expression becomes:-

$$\frac{\text{Total } CO_2 \text{ litres} - 5.47 \text{ g urinary N}}{\text{Total } O_2 \text{ litres} - 6.67 \text{ g urinary N}}$$

Food consumption

The difference between the final and initial weights of the food gives the weight of scattered food in addition to true food consumption. Uncontaminated food was weighed directly but scattered food contaminated with urine had to be estimated and a correction made. A correction can be derived from a mean value of contaminated food on the funnel and frame obtained from

runs similar to but outwith the experimental series. This was the approach used by Morrison (1952). This was also essentially the approach used in part of the present work (Serial numbers 1 - 17 and 41 - 135), where the total weight of contaminated food on the urine funnel and floor grids of the frame was plotted against the total dry weight of uncontaminated food after washing and drying (Fig. 12). This correction was based on 21 runs additional to the experimental series (Tables 4 and 9).

In the rest of the work (Serial numbers 18 - 40 and 136 - 140), a more direct and accurate method of establishing this correction was used. This was particularly necessary when there was a large amount of scattered food. All the contaminated food on the previously weighed funnel and frame was washed into the urine flask, filtered through tared filter paper and the residue and filter paper dried overnight at 50°C. This gave the weight of the washed and dried contaminated food, which weight was then corrected to its normal moisture content. A unique correction was thus obtained for each day of running and no block correction with its second order error was involved.

Weight balance.

As indicated (p. 55), the apparatus was designed

to measure the balances of various components. Because of the law of the conservation of matter the sum of the weights of the ingoing components should equal the sum of the outgoing components i.e. the weight balance should be zero in a completely closed system.

An equation for this weight balance is:-

$$W_o + W_f + W_w + W_1 = W_{co} + W_e + W_u + W_2$$

where W_o = weight of oxygen used

W_f = weight of food ingested

W_w = weight of fluid water ingested

W_1 = initial weight of animal

W_{co} = weight of CO_2 produced

W_e = weight of faeces produced

W_u = weight of urine produced

W_2 = final weight of animal

On the left hand side of the equation are the ingoing components and on the right hand side the outgoing components. If the two sides of the equation are not equal, the weight balance is not zero, but is either positive or negative. (If the sum of the outgoing components is less than the sum of the ingoing it is considered negative, if the reverse, positive). If there are discrepancies in the weight balance in either a positive or negative direction, they must occur because of inaccuracies in the apparatus or from errors in

weighing or measuring. In practice, the weight balance is usually negative.

In a leak-free system, there is the possibility of instrumental water loss under certain conditions of operation i.e. a deficit in recovery of water from the apparatus. This was considered by Morrison (1952) to be a major cause of negative weight balance discrepancy found by him and to be due to rather inadequate conditions of ventilation. In the present work the mean negative weight balance was much less, namely -0.4 g (with extremes of +0.67 to -0.98 g) compared with Morrison's -1.0 g or more, and with the better conditions of ventilation instrumental water loss was probably negligible.

There was some loss of vaporized water and carbon dioxide when the rat was out of the animal chamber during the change-over. For example, with a mean daily loss of vaporized water of 15 g, when the rat is out of the chamber for 10 - 15 mins, 0.15 g is liable to be lost from this source. The mean difference between the CO_2 produced and the oxygen consumed over the same period would be approximately 0.03 g, so that the mean weight loss from vaporized water and carbon dioxide together would be 0.18 g, which would account for 45% of the weight deficit. The lack of precision in weighing a rat which was not always immobile was another source of error, but this was considered small, for an animal

could be weighed accurately to within 20 mg, with practice (Morrison, 1952).

To account for the negative weight balance discrepancy there are, then, the possibility of instrumental water loss and the loss of vaporized water and carbon dioxide from the rat when out of the animal chamber. There are also random errors in weighing (2 sets of 11 components, each set totalling approximately 3 kg) and there are possible errors in measuring the volume of oxygen, including the correction factors. The main source of the remainder of the weight deficit probably lay in evaporation from the wet faeces and from the funnel and frame during the change-over period (10 - 15 min.). It is interesting to note that in a recent series of experiments (Cumming & Morrison, 1955) with rats fed on diet 41 and then fasted for 48 hours, the discrepancy in weight balance was least on the days of fasting and greatest on the days of feeding when there was a large amount of scattered food. The conclusion, therefore, was that water loss (and a corresponding weight balance deficit), came in these circumstances largely from wet faeces and from urine contaminating the scattered food.

Water Balance.

The required measurements for water balance involve the intake of water from food, fluid and metabolic

water and the loss of water from urine, faeces, lungs and skin. The working equation for direct estimation of the water balance of an animal which was used by Morrison (1952) was:-

$$W_i + W_f + W_m = W_u + W_a + W_e + W_t + W_w + P$$

where

W_i = fluid water intake
W_f = food water intake
W_m = metabolic water
W_u = urinary water
W_a = water absorbed on scattered food
W_e = water of solid excreta
W_t = water in absorbing tubes
W_w = water increment of the animal
P = instrumental water loss

This equation represents total water balance, but in practice the accurate physiological partition of some of its components is difficult. This is discussed in the section on vaporized water (p. 75).

Because of the doubtful assessment of instrumental water loss, water balance was estimated indirectly by Morrison (1952) using an equation modified from that of Peters, Kydd & Lavietes (1933), namely:-

$$\underline{W} = \underline{Wt} + \underline{Se} - \underline{Si} + \underline{C} + \underline{F} + 0.49\,\underline{P}$$

where

$\underline{W}$ = water loss from animal

$\underline{Wt}$ = body weight increment

$\underline{Se}$ = weight of dry, solid excreta

$\underline{Si}$ = weight of dry, solid ingesta

$\underline{C}$ = weight of carbohydrate metabolized

$\underline{F}$ = weight of fat metabolized

$\underline{P}$ = weight of protein metabolized

For protein, the factor used in the present work was 0.56, derived from the constants for casein already given (p. 60). $\underline{C}$ and $\underline{F}$ were estimated from a nomogram (Fig. 11) similar to that used by Forbech (1938) and Morrison (1952) but derived from constants relevant to the diet used and covering a range of values more suitable for the present work. The nomogram was constructed from the following equations:-

$$\text{Fat catabolized} = \frac{O_2 \text{ litres} - CO_2 \text{ litres}}{0.576}$$

$$\text{Carbohydrate catabolized} = \frac{CO_2 \text{ litres} - 0.710_2 \text{ litres}}{0.241}$$

These equations are simply derived using the constants:-

O_2 required for complete combustion of 1 g carbohydrate (mixture p. 60) = 0.829 litres

O_2 required for complete combustion of 1 g fat ("Special Margarine") = 1.985 litres

Both direct and indirect water balances have been computed (Tables 38 and 39). In most cases there is close correspondence between them.

Fluid water

Fluid water has been derived as the difference between the initial and the final weights of the water bottle. A series of nine "blank" runs with the water bottle alone in the animal chamber showed a mean daily loss of 0.61 g of water. As this amount was not large and could be presumed to be constant, it was not applied as a correction to the daily measure of fluid intake, but could, if necessary, be applied as a correction to the derived means. It does, of course, magnify the apparent water turnover when considered in the water balance, but this amounts to only 0.6 g in a mean daily total fluid intake of 24 g.

Food moisture

The moisture content of each batch of diet M.S.I. was estimated by drying samples to constant weight at 50°C (24 - 48 hours) (Table 2). The weight of the food

moisture was derived from the measured daily food consumption using these values for moisture content. The mean moisture content was 7%.

Metabolic water.

Metabolic water or water of oxidation was calculated using Morrison's (1953) method. An equation was derived from the constants of the dietary constituents used:-

	Carbohydrate	Protein	Fat
R.Q.	1.0	0.821	0.707
kcal/litre O_2	5.033	4.586	4.753
g H_2O/litre O_2	0.699	0.386	0.533

The sources of these constants are given on p. 60 .
The equation is thus found to be:-

$$\text{Metabolic water formed (g)} = (0.205 \times \text{l. } O_2 \text{ used}) + 0.464 \times \text{l. } CO_2 \text{ produced}) - (1.334 \times \text{g urinary N}).$$

This differs from the equation given by Morrison (1953) since different constants are used here.

Urinary water.

The difference between the weights of the urine flask at the end and the beginning of a run gave the weight of urine passed directly into the flask. Urine

retained on the funnel and frame was derived as the difference between the weight of the funnel and frame plus contaminated food and this weight less that of the isolated, dried food, corrected for moisture content. This value was added to the weight of urine in the flask. Urine solids, which are required for the estimation of the water balance cannot be measured routinely because of the presence of sulphuric acid in the urine flask. For the estimation of urine solids, Morrison (1952) used a value of 12%, derived from three samples of urine collected in a dry flask and measured by evaporating the urine *in vacuo*, over calcium chloride. In the present work, 21 runs were made, comparable with but outwith the experimental series, during which urine was collected in dry flasks and samples were taken for nitrogen estimation. The remainder of the urine collected was then frozen-dried. The weight of urine solids was plotted against the N content of the samples (Fig. 13, Tables 5 and 10) and a very regular relationship was obtained. The equation of the regression line fitted to these data is:-

$$S = 0.174 + 0.0041\,U$$

where S is urine solids in g and U is urinary N in mg. Since data for urinary N were available for all days of the metabolic measurements, values for urine solids were always derived from this graph.

Faecal water.

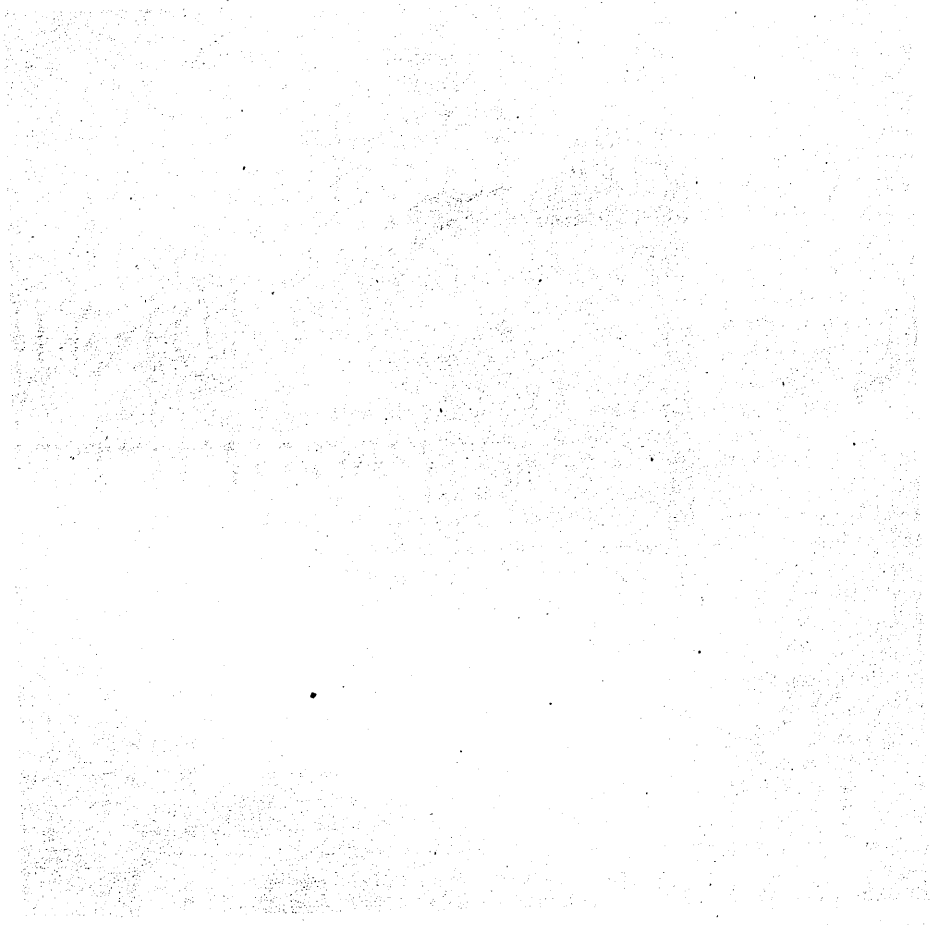
Faecal water was measured as the difference in weight between the fresh faeces and their weight after drying for 24 hours in an oven at 50°C. No allowance was made for the variable degree of drying of the faeces by air flow through the chamber nor for the possible addition of moisture to them by urine or by water spilt from the water-bottle. These occurrences would not, in any case, affect the validity of the general water balance.

The consistency of the freshly passed faeces was not constant, but it is not known. A block correction (2.5 g water/g dry faeces) was applied by Morrison (1956) to the weight of dry faeces from pregnant rats. The difference between this weight and that weight of water measured in the faeces was subtracted from the water in the absorbing tubes, as being "adventitious" water (see p. 75) from the faeces. The value for the correction quoted above was derived from faeces freshly passed by rats on diet 41. In pregnancy, because of the large faecal mass it was specially important for this approximate correction to be applied. In the present work the faecal mass was very much less and no correction was made. The mean value for dry faecal mass was about 0.4 g compared with over ten times this amount in rats receiving diet 41.

Vaporized water.

Total vaporized water was measured as the difference between the final and initial weights of the water absorbing tubes. This value represented water of respiration (from lungs) and water of transpiration (from skin) but it also included any water from urine, faeces or water-bottle which might have been vaporized by the air flow through the chamber. These sources of water, other than from lungs and skin, may be termed "adventitious". It was virtually impossible to get an accurate measure of this adventitious water, though an attempt was made to estimate part of it by running the metabolic apparatus without a rat, namely a "blank" run, and measuring the water removed from the water-bottle and urine flask under these conditions. In nine such "blank" runs the average water removed from the water-bottle was 0.61 g and from the urine flask 0.13 g, a total of 0.74 from these sources. Since the R.H. would be very much less under these conditions than normally, the water taken up in the absorbing tubes would be much greater than normal. This would be offset to a certain small extent by the higher temperature when a rat is present, but nevertheless these "blank" runs would give an excessive estimate of normal environmental drying. It is doubtful, therefore, if a correction should legitimately be applied to the normal runs, and, in fact,

no such correction has been made. Neither has any account been taken of water from adventitious sources in partitioning the components of the water balance.



RESULTS OF METABOLIC STUDIES

The data of results are presented *in extenso* in Tables 30 - 39. In each Table, serial numbers 1 - 45 refer to Series I, 45 - 90 to Series II and 91 - 135 to Series III. Numbers 136 - 140 refer to data on weanling rats.

Energy Metabolism

The data for the respiratory exchanges from which the energy expenditure is derived are in Tables 31 and 32 and the data for energy metabolism in Table 34.

Energy Expenditure

Within the total consecutive series of days the mean day to day variation in energy expenditure amounted to 4.7% of the mean (33.2 kcal/day) (Fig. 19). At 30 days of age, energy expenditure is about 22 kcal/day, at 115 days 44 kcal/day. The daily variability was probably due in part to alterations in the food and water intake and to variation in physical activity, but there is no way of determining the extent of these effects with the exception of the effect of food intake (p. 80). Scatter of results was reduced when 5-day periods were taken together. There is a certain limit to the daily variations because of the approximate

constancy of environment as regards temperature, humidity, food and water supplies and because of some restriction of physical activity due to the confined living space. There is not the attempt at rigid artificial standardisation of conditions which is made in estimations of B.M.R.; on the other hand, there is not the freedom of living which is possible under natural conditions.

Total daily energy expenditure increased with body weight. The relation between energy expenditure and body weight was substantially linear over the weight range studied, but the value (16.7 kcal/24 hr) for the one 5-day period studied in weanling rats lay below this line (Fig. 20). The fitted linear regression equation (Table 11) was:-

$$\underline{E} = 20.34\ (\pm\ 0.427) + \underline{W}\ (0.0833 \pm 0.003)$$

where $\underline{E}$ is energy expenditure in kcal and $\underline{W}$ is body weight in g.

The analysis of variance of energy expenditure is given in Table 20. There was no significant difference between days within periods but there was a significant difference between periods and between series. The difference between periods involves a difference in age as well as in weight. The difference between series is related to the different rats, not littermates, which

were used in these separate metabolic studies.

The whole metabolic experiment was originally designed to be susceptible of fairly complete statistical analysis. However, because of the importance of time sequence in growth studies, data lost accidentally through technical difficulties and breakdowns cannot be replaced. Out of the total projected number of days (135) the data for energy expenditure of 13 days were lost in this way. Substitute values for these lost data were derived by a "missing plot" technique (Kendall, 1946) which eliminates the great additional labour of computation involved in analysis of unequal classes. In the missing plot technique, the reduction in the total degrees of freedom compared with the actual number of observed data allows the error variance to be a valid estimate (Kendall, 1946). The weight to be allotted to the main or "effect" variance is, however, still magnified. An adjustment was made to take account of this increased weight by altering the calculated effect variance in the ratio of the original to completed (by missing plots) total variance for the same (reduced) number of degrees of freedom (Morrison, 1952).

It has been shown that the fall in energy expenditure during a 48-hour fast in rats is wholly accountable to the fall in body weight and food intake

(Cumming & Morrison, 1955). It was of interest to know, whether, when energy expenditure increases with age, this increase can still be held wholly accountable to changes in food intake and body weight. The possibilities are either that (1) the increase in energy expenditure during growth is wholly attributable to increase in body weight and increasing food intake or that (2) the increased energy expenditure contains a component independent of body weight and food intake which may be attributable to a true increase of tissue metabolism. On the other hand, (3) the change may contain an independent component which is not detectable by the present methods. That is to say, that the method of analysis may not be sufficiently sensitive to reveal a small change in tissue metabolism or that an independent component is masked by the effect of body weight and food intake and therefore is not measurable by these techniques.

To approach this complex problem, analysis of co-variance of the data for energy expenditure on those for body weight and food intake was done and the general co-variance or multiple regression equation found was (Table 21):-

$$\underline{E} = (14.89 \pm 4.30) + (0.086 \pm 0.015)\underline{W} + (0.115 \pm 0.080)\underline{F}$$

where $\underline{E}$ is daily energy expenditure per 24 hr. in kcal, $\underline{W}$ is body weight in g and $\underline{F}$ is daily absorbed food energy in kcal. This equation was derived from the means (27) of

the nine 5-day periods in the three series for energy expenditure, body weight and food intake.

For the 13 days when values for E were missing, substitute values for E were derived by the missing plot technique described by Kendall (1946). It was considered justifiable to take as values for F and W the means of the available values in each 5-day period, i.e. if 4 out of a possible total of 5 values for F or W were present, a mean value for these 4 measurements was taken. There were less missing values for food energy intake (8) and for body weight (5) than for energy expenditure, since these measurements did not depend on the existence of a leak-free system.

The analysis of co-variance shows that, after elimination of the component due to the multiple regression, no significant variation remains between the daily means of energy expenditure. After adjusting to a standard body weight of 200g and a standard food intake of 50 kcal/day of absorbed food, the graph of energy expenditure against age shows no variation with age (Fig. 21). This adjustment to the values for energy expenditure was made for each of the 9 age periods in the following way. The difference between the actual (or crude) value for food intake and the standard value was taken and multiplied by the coefficient for food intake. This product was

either added to or subtracted from the standard value for energy expenditure, depending on whether the crude value was less than or greater than the standard value for food intake, respectively. The same procedure was carried through for the values of body weight, so that the crude values were adjusted to the standard values of both food intake and body weight.

It is therefore apparent that the increase in total energy expenditure during growth can be wholly attributed to changes in body weight and food intake, as was found for the adult fasting rat. The same reservation, however, still holds, that there may be either a small component, not detectable by these techniques, or that a component, possibly large, is entirely masked by the effect of body weight and food intake and therefore is not measurable by these techniques.

Diurnal Variation in Energy Expenditure.

A direct estimation of diurnal variation in energy expenditure was not made. Oxygen consumption has been used as an approximate substitute for energy expenditure, though it is not exactly proportional to energy expenditure because of variations in R.Q. Substantial constancy of R.Q. has, however, been found throughout the day in rats fed a stock diet ad lib. (Burr & Beber, 1937). In the present work the diurnal

variation in oxygen consumption in Series III was estimated as described (Appendix I, F) at 4-hourly intervals (10 a.m. - 2 p.m., 2 p.m. - 6 p.m., 6 p.m. - 10 p.m., 10 p.m. - 2 a.m., 2.a.m. - 6 a.m., 6 a.m. -10 a.m.). The results are presented in Figs. 23 - 25.

A cyclical change in oxygen consumption throughout the day is evident from the means of the 5-day periods (Fig. 25) and from the total estimations (Fig. 23). The maximum rate of oxygen consumption occurs between 6 p.m. and 2 a.m. but there is some irregularity in the pattern of oxygen usage on individual days (Fig. 24). The variation has a total mean swing of 10.8% of the mean oxygen consumption. From Fig. 25 it is apparent that the cyclical change for the 30 - 35 day run is much less evident than for later age periods. The regular form of the diurnal cycle does not appear to become established until the age periods of 50 - 55 or 60 - 65 days. It is possible, therefore, that the adult pattern of oxygen consumption throughout the day does not become finally established until about the age of 50 - 60 days, which is roughly the age of puberty.

Food energy intake

The variation in daily food energy intake (Fig. 26 and Table 33) was greater than the variation

in energy expenditure. On consecutive days the mean day to day variation in gross food energy intake was 17.9% of the mean (45.8 kcal/day) and in absorbed food energy intake was 16.6% of the mean (44.6 kcal/day). At 30 days of age, gross food intake was about 24 kcal/day and at 115 days 54 kcal/day. There was a substantially linear relation between absorbed food energy and energy expenditure (Fig. 27) for which the fitted linear regression equation (Table 12) is:-

$$\underline{E} = (11.22 \pm 2.32) + \underline{N}\ (0.490 \pm 0.051)$$

where $\underline{E}$ is energy expenditure in kcal and $\underline{N}$ is absorbed food energy in kcal. The average percentage of food energy absorbed, $\frac{\text{food energy - faecal energy}}{\text{food energy}} \times 100$, was 96.8% (Table 24). This value is similar to a value calculated from the data of Forbes et al.(1946c), namely 95.5%.

The non-protein R.Q. derived from the R.Q. (p. 64 , Table 35) was variable, with a mean value of 0.93, extreme values being 0.697 and 1.109. The R.Q. expected from the dietary composition, assuming an energy balance of zero, was 0.899 (Table 3). In the adult mouse, it was found (Dewar and Newton, 1948) that the R.Q. varies directly with the food intake. This occurred when body weight and energy expenditure remained substantially constant. In Morrison's (1955)

data these covered a wide range in adult rats and so some degree of adjustment for this was made by relating non-protein R.Q. to the ratio of energy intake to energy expenditure. However, when a predominantly positive, though variable, energy gain occurs, as in the present data, this adjustment is not sufficient and the relation cannot be clear cut. The fitted regression lines are shown for the relation of non-protein R.Q. to (a) the ratio of ingested energy to energy expenditure, G/E (Fig. 28, Table 13) and to (b) the ratio of absorbed energy to energy expenditure, N/E (Fig. 29, Table 14). At the average R.Q., 0.93, the ratio N/E is 1.36 and the ratio G/E is 1.40, indicating that there was a loss in the faeces of 2.8% of the gross energy intake. A similar value (3.2%) was derived from the relation between food energy and faecal energy (Fig. 30, Table 16). This contrasts with the value of 22% derived from rats on a stock diet containing a relatively high amount of fibre (Morrison, 1955). Although separate regression lines for the three series were not drawn (in Fig. 30) the impression is gained that there was a slight difference, among the three series, in the relation between ingested energy and faecal energy. In Series III, it appears that a greater amount of energy was ingested for the same amount of energy lost in the faeces.

Energy Balance

The mean energy balance for each 5-day period was uniformly positive. Within consecutive series of days the mean day to day variation was considerable, being 66% of the mean value (10 kcal/day). At 30 days of age, the energy balance is 6 kcal/day and at 115 days 14 kcal/day. The observed daily energy balances differ to an unknown extent from the true values for energy balance, because of the unknown and changeable amount of gut contents from day to day. However, the agreement shown to exist between daily food intake and faecal mass (Fig. 36) indicates that this is not a large effect. During the retention of nitrogen in the body some energy is retained, the amount of which is related to the amount of nitrogen stored. This energy gain is unutilisable energy and cannot be "released" until the nitrogen with which it is associated comes to be excreted. The mean energy balance for each 5-day period is a more valid estimate of the daily energy balance, because the errors due to the changes in gut contents become relatively less. This, however, does not eliminate the error entailed in nitrogen retention.

It can be seen (from Fig. 31) that the mean daily energy balance over summed age periods increased with increasing body weight, though in series I this

increase is not sustained in the periods 100 - 105 and 110 - 115 days. There is no obvious reason for this, except that during these periods technical difficulties caused a lack of consecutive estimations in the metabolic apparatus.

When the results from metabolic study and carcase analysis came to be compared, it was noted that there were differences in the balances of energy, nitrogen and water by the two methods. It became evident that, while the rats were in the metabolic apparatus they were gaining energy and nitrogen but that the gain in body water was much less than that expected for the gain in body weight (p. 123). In other words, it seemed that relative dehydration was occurring. It then became important to know if this relative dehydration had any influence on the conclusions reached about the relation between energy expenditure and body weight and food intake (p. 82). To discover if there was any change in this relation on individual days in the metabolic apparatus, a complete analysis of co-variance was done, using data for individual days instead of mean values (p. 88).

A somewhat less elaborate and less laborious method than that used for the missing daily values of energy expenditure was used for the derivation of the missing values of body weight and food intake (Goulden, 1940).

The complete analysis of co-variance (Table 22) using data for individual days, shows that the co-variance relationship established using the means still holds. The residual variances (after removal of the regression variance) between periods, and between days within periods are not significant ($0.1 > P > 0.05$ and $P > 0.1$ respectively).

Adjustment of the values for energy expenditure for each of the 5 days was made to a standard body weight of 200g and a standard value for absorbed food energy of 50 kcal/day, following the same method as given on p. 81. There is no significant difference between the crude mean values of all the data for energy expenditure taken over corresponding days within the 5-day periods. That is, the total means for day 1, day 2, day 3, day 4, and day 5 do not differ substantially or any more than do the adjusted means. The difference between the two lines for crude and adjusted means, shown in Fig. 22, is due to the displacement produced by the arbitrary standards used for adjustment. The coefficients of body weight and food intake for the multiple regression equation derived from the "days and residual" and from "periods and residual" variance are similar (viz. 0.086 and 0.087 and 0.107 and 0.112, respectively), (Table 22). This indicates that the regression effects are homogeneous

in the two parts. That is to say, whatever effect dehydration may have, the relationship between energy expenditure and body weight and food intake is not appreciably affected.

Another indication of the influence of dehydration may be derived in the following way. From the mean values of the three series for energy expenditure (Fig. 32) the increments in energy expenditure over age periods of 5 days can be calculated, for example, increments between 30 and 35 days, 35 and 40 days and so on. In these two age periods, the increment between 30 and 35 days occurred in the metabolic apparatus and the increment between 35 and 40 days took place in the animal house. Thus the values of the increments in these alternating habitats can be compared and have been plotted as a histogram in Fig. 33. It can be seen that there is no constant trend between them, the mean values, in fact, being similar, if one rather anomalous value for the animal house (between 65 and 70 days) is excluded. That there is no appreciable difference between the increments in energy expenditure over 5-day age periods in the metabolic apparatus and in the animal house is a further suggestive indication that the effect of relative dehydration in the metabolic apparatus is negligible. If it were affecting energy expenditure to any marked

extent, a clear-cut difference would exist between the increments of energy expenditure in the two situations.

From energy balance can be derived the gross energetic efficiency which is $\frac{\text{energy retained (kcal/day)}}{\text{energy intake (kcal/day)}} \times 100$. It can be expressed either on the basis of the gross food intake or of absorbed food intake. In the present work, it has been expressed on the basis of the absorbed food energy intake (Table 24). In all the series there is some fluctuation in the values for gross efficiency (in Series III the values range from 19 - 41%, the mean being 30%). No general tendency for an increase or decrease is apparent over the age range studied.

Nitrogen Metabolism

The full data for nitrogen metabolism are given in Table 36.

Nitrogen Intake

The daily nitrogen intake followed the course of food intake, and since the composition of different batches of diet was very similar (Table 2), variations in nitrogen (N) intake closely paralleled the variations in energy intake already discussed (p. 83). The

average percentage of nitrogen intake absorbed, $\frac{\text{nitrogen intake - faecal nitrogen}}{\text{nitrogen intake}} \times 100$, was 95.4% (Table 24). This compares well with other values with synthetic diets, namely 93.6%, 90.1% and 93.5% from the data of Forbes et al. (1946c), Brown & Morgan (1948) and Arnrich et al. (1951) respectively. The percentage of nitrogen retained decreased in general with age, being 80% at 30 - 35 days and 38% at 110 - 115 days in Series III. This trend is less regular in Series I and II, probably because the mean data were not all from consecutive days as in Series III.

Nitrogen Loss

Urinary Nitrogen. Within the total series of consecutive days the mean day to day variation in urinary nitrogen was 16.5% of the mean (158mg/day) (Fig.34). At 30 days of age about 70mg/day urinary N was excreted, at 115 days 230mg/day. The fraction of total N excretion which was lost in the urine was 91%.

The graph of urinary nitrogen against food intake (ingested energy) is given in Fig. 35 and the regression equation in Table 15. (The regression line in Fig. 35 is the joint regression derived from the three series, i.e. with the displacement differences between the series removed). The relation between

urinary nitrogen and food intake represents the combined effects of age change and variation in food intake. It is not possible, therefore, to present any simple physiological interpretation of the slope or of the intercept of this line.

Faecal nitrogen. The variation in N content of the faeces amounted to 35% of the mean (16 mg/day) within the series of consecutive days. This was in part due to the occasional and variable absorption of urinary N on the faecal pellets. That this contamination was not great, however, was shown by the high value for apparent absorption of ingested N (p. 91). The fraction of total N excreted as faecal N was 9%. At 30 days of age faecal N was about 10 mg/day, at 115 days about 20mg/day.

In Fig. 36, the daily dry faecal weight has been plotted against daily food intake (Table 17). The relation between them is linear, although with a large scatter. This has been commented on earlier in a different connection (p. 86). The total N lost in faeces and its relation to food intake is therefore paralleled by the total dry faecal mass.

Nitrogen Balance

The daily nitrogen balance was variable and in most cases positive. The day to day variation

within consecutive days was 33% of the mean (154mg/day). The mean N balance for each 5-day period was uniformly positive (Fig. 37). It fluctuated irregularly but its absolute amount did not alter appreciably with increasing body weight. At 30 days of age it was 140mg/day, at 115 days 190mg/day. Therefore, computed on the basis of body weight, there was more N retained/100 g body weight in younger rats than in older ones.

Values for retention of N in growing rats, 30%, 36% and 49% of the N ingested respectively from the data of Forbes et al.(1946c), Brown & Morgan (1948) and Arnrich et al.(1951) cannot be directly compared with the present data (37.5 - 80.7% at different ages in Series III (Table 24) because of the existence of relative dehydration (p. 123). The discrepancy is even more evident when the retention of N per g gain in weight is considered. For instance, when the data of Table 24 (56 - 175 mg N/g gain in weight in Series III are considered beside the values of Forbes et al.(1946c) for retention of N/g gain in weight viz. 34.3 mg, the concentration of solid constituents in the tissues of the rats in the metabolic apparatus is strikingly apparent.

An estimate of the N retained per g body weight on a fat-free basis may be reached by combining the data of carcase analysis (p. 121) with the results from the metabolic study. A rat aged 115 days, weighing

233g has a fat-free body weight of 212g. The N content is 7g. Therefore the fat-free body weight per mg N is 30 mg. From N balance studies, the N retained is about 190 mg. Therefore the fat-free body weight gained/day is 5.7 g. This is about twice the actual body weight gain measured and the discrepancy lies in the condition of relative dehydration previously mentioned (p. 87) and discussed later (p. 143).

Gross nitrogenous efficiency, $\frac{\text{N retained (mg/day)}}{\text{N intake (mg/day)}} \times 100$, can, like gross energetic efficiency (p. 90), be expressed on the basis of either the gross N intake or the absorbed N intake. The latter reference standard has been used in the present work. In Series III(and to a lesser extent in the other series) a decrease in gross N efficiency with age is shown (Table 24). The value is 83% at 30 - 35 days of age and 40% at 110 - 115 days.

Water Metabolism.

The full data for water metabolism are given in Tables 37 - 39.

Water Intake

Fluid Water. The daily fluid water intake was very variable (Fig. 38). Within consecutive days the day to

day variation was 32% of the mean (19.4g/day). Mean values for water intake of rats of 30 days of age and 115 days were 13g and 24g respectively. Occasionally accidental water restriction occurred (8 times), due to blockage of the duct of the water-bottle by air-locks, but this was usually offset on the following day by a greatly increased intake of water. However, the variation in water intake among rats of comparable age and body weight and among experimental series was great. There was sometimes considerable variation between successive 5-day periods for the same rat. An exceptionally voluminous water intake and polyuria was shown by rat 33 (serial numbers 14 - 18), so large, indeed that leakage from the water-bottle was suspected. This did not appear to be the case, so the animal was considered abnormal in this respect, and possibly in other metabolic functions and was temporarily withdrawn from metabolic study at the age of 65 days. For the age periods 90 - 95 and 100 - 105 days it was again studied in the metabolic apparatus. The result of a post-mortem examination showed no histological abnormality of the hypothalamic region, but a mycotic lesion in the abdomen was found which may have been responsible for the animal's lack of well-being and for the abnormal water exchanges. In Fig. 39 are plotted the daily water intake and the daily food intake.

While there was some general correspondence there was no close association between them.

Food Moisture. The food as eaten contained 7% moisture. Food moisture, therefore, varied with food intake (Table 33). As has been noted (p. 83) daily food intake was very variable. Food moisture accounted for 2.9% of the mean total water intake, approximately 0.7g for all animals (0.4g at 30 days, 0.8g at 115 days).

Metabolic Water. Metabolic water showed variations similar to those of energy expenditure (p. 77), being derived from a similar type of equation. From these two equations an approximate estimate can be derived of the total metabolic water (W) in g in terms of the total energy production in kcal (K), namely W = 0.124 K. (In obtaining this equation the mean value of R.Q., 0.93 was taken, the energy value of casein was taken as 30.6 kcal/g urinary N (Kriss & Miller, 1934) and the protein energy was assumed to be $\frac{1}{6}$ of the total energy). Metabolic water amounted to about 3g at 30 days and 5g at 120 days. It made up, on the average, 16.5% of the total water intake, but there was a wide scatter of values in terms of percentages because of the great variation in fluid water intake.

Water Loss

Vaporized Water The day to day variations of vaporized water within consecutive days (Fig. 40) amounted to 8.5% of the mean (15.3g/day). The mean daily vaporized water was 11g at 30 days and 18g at 115 days. The vaporized water accounted for 62% of the total water loss. The coefficient for the regression of vaporized water per 24 hr on body weight for animals above 120g did not differ significantly from zero (Fig. 41 and Table 18). For animals below 120g in body weight, vaporized water varied directly with body weight (0.9g vaporized water/10g change in body weight, Table 19). No attempt was made to fit an equation to the combined data, as it was found by attempts at inspection fitting of various functions that no simple expression could be derived to fit the data better than do the two straight lines.

The vaporized water appears at first sight to vary directly with the level of energy expenditure (Fig. 42). However, the points on Fig. 42 which do appear to indicate a sloped relation between vaporized water and energy expenditure are all those representing data from rats of less than 120g body weight.

The partition of vaporized water between lungs and skin, though not measured directly, can be estimated

approximately (Morrison, 1955). Assuming that the mean oxygen content of the expired air was 4.5% below that of the chamber air, the total 24 hr pulmonary ventilation of the rat can be calculated from the 24 hr oxygen usage. Assuming also that the relative humidity was constant and at the mean value of 45.3% (p. 53) and that the chamber temperature was constant at 26°C the water load of the chamber air was calculated to be 0.011g/litre. If it is further assumed that the humidity of the expired air is equivalent to saturated air at 34°C (Osborne, 1913), the water load of the expired air is calculated to be 0.04g/litre. This gives a water elimination from the lungs of 0.029g/litre of pulmonary ventilation. In Table 23 the water lost from the lungs is expressed in g/day (3 - 6g) and as a percentage of the total vaporized water (23 - 34%). Under these environmental conditions (26°C and R.H.45.3%), the value for the latent heat of evaporation of water is 0.58 kcal/g (Newburgh & Johnston, 1942). The total mean energy lost daily by evaporation (6.7 - 10.8 kcal) and the amounts from lungs (1.8 - 3.3 kcal) and skin (5.0 - 7.9 kcal) can thus be derived (Table 23 and Fig. 43). When the percentage of total heat lost by evaporation at different ages is examined, a tendency is seen for the values in the age groups younger than

50 - 65 days (approximately below 120g body weight) to be higher than the values in the older age groups, although there is also considerable irregularity of the values, especially in Series II. The trend of a fall in the percentage of total heat lost by evaporation is most noticeable in Series III, which was technically the most satisfactory series, because there were no missing data on consecutive days. Because the total heat lost by evaporation is constant in all rats above 120g in weight, while the heat lost by evaporation from the lungs rises, the percentage of heat lost from the skin is less in the older than in the younger age groups.

Urinary water. The daily urinary water loss was very variable, (Fig. 44) amounting to a day to day variation of 42% of the mean value (7.6g/day) on consecutive days. At 30 days of age, urinary water was about 3g, at 115 days, 17g. It showed a general tendency to follow the variations in fluid water intake, and composed, on average, 31% of the total water loss.

Faecal Water. The daily water loss in faeces was also variable, but, as indicated (p. 74), the faecal water measured in the present work is not a true measure of the water content of freshly passed faeces. The amount

of water apparently lost in faeces was extremely small (0.03 - 0.13g/day) which was 0.5% of the total mean water loss.

Water Balance

The daily water balance was quite variable, but the values for the mean water balance were near zero, sometimes below zero (Fig. 45). With the increase in body weight, this represented relative dehydration (p. 87).

Using data from carcase analyses one can obtain an approximate estimate of the extent of this dehydration. A rat aged 115 days weighing 233g has a water content of 153g. Using results from Series III the body weight gain over a 5-day period for a rat of this age was +15g and the body water gain over the same period was negative, -3.5g. Thus the percentage body weight increase is +6.4% while the body water has decreased by -2.3%.

Body Weight Increment

In Figs. 46 - 48 are shown the daily body weight of the animals on metabolic study. In all cases, records were kept of the body weights in the animal house, but these have not been shown in Figs. 46 - 48 in order to avoid confusion.

The gain in weight in the animal house did not differ in amount from that in the metabolic apparatus although the composition of the weight gains in the two circumstances was different (discussed on p. 143).

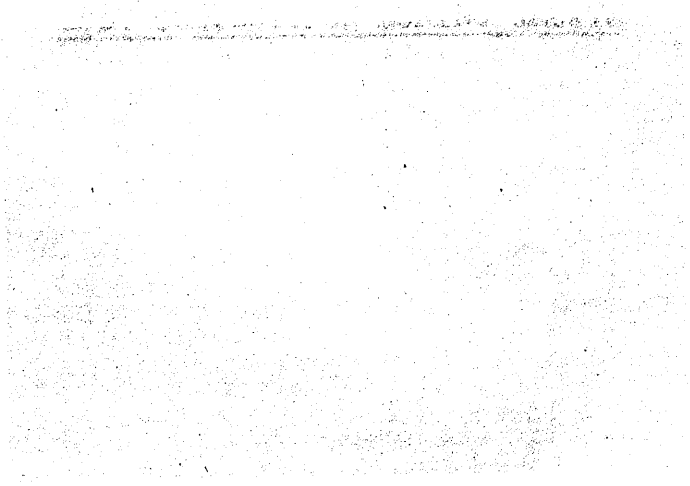
In Figs. 46 - 48 there is no evidence of any point of inflection in the growth curves; presumably, therefore, it occurred at an earlier age than 30 days.

Mercury Poisoning

An unexpected complication was the development of mercury poisoning on one occasion (9.10.53). When the animal chamber was being placed in position after the daily change-over, the chamber thermometer broke and the mercury became scattered. The contents of the animal chamber, including the rat, were quickly removed, the scattered mercury taken out and the contents replaced. On the following morning it was observed that the rat looked ill and had eaten hardly any food. This animal was removed from metabolic study and on subsequent days voluntary starvation ensued with rapid deterioration in its condition. During the night of 11.10.53. death occurred. No obvious abnormality of liver, spleen, kidneys and lungs was noted histologically, but it seemed certain that death was due to the effects

of vaporized mercury, a minute amount of which must have been left in the animal chamber and which had formed an amalgam with copper. This hazard has been previously described and has occurred in respiration chambers when mercury valves were in use.(Carpenter & Benedict, 1909).

The findings in the metabolic studies of Part I are discussed along with the results of Part II on the changes in body composition during growth.



PART II

BODY COMPOSITION DURING GROWTH

REVIEW OF THE LITERATURE.

The first scientific approach to the problem of chemical composition of the body during growth was made by von Bezold (1857), who showed, after analysis of various species of animal, that development to maturity was associated with a decrease in body water and an increase in ash. The influence of fat deposition on the water content of the tissues also interested other early workers (Pfeiffer, 1887) and it was noted that on a dry weight basis there were great differences between the body fat at birth and at different ages (Thomas, 1911). Growth and development of mammals has been extensively reviewed and the general pattern of proximate principles in the body during growth has been described (Dunn, Murphy & Rockland, 1947; Spray & Widdowson, 1950; McCance & Widdowson, 1951b). It is generally agreed that with increasing age the percentage of water in the body decreases and the percentages of protein and of fat increase.

The data pertaining to rats, from various sources, are summarised in Figs. 50 and 51. Foetal rats have a high water content, (González, 1932; Roche & Garcia, 1933; Widdowson, 1950) and it has been postulated that the periodicity in the decreasing percentage of water in the

second half of gestation indicates times of cell differentiation. Rapid loss of water content occurs in the first ten days after birth (Hamilton & Dewar, 1938) and a substantial increase in the percentage of dry matter (Lowrey, 1913) and fat (Iob & Swanson, 1938) in the first 3 weeks of life has been noted. It has been advocated that results of carcase analysis should be expressed on a fat-free basis because of the great variability of fat in the body, and on this basis the attainment of a steady percentage level of water, protein and ash has classically been termed "chemical maturity" (Moulton, 1923). There is some disagreement about the actual time of this maturity in rats - variously 20 - 30 days (Chanutin, 1931) to 100 days (Spray & Widdowson, 1950), with intermediate ages (Hatai, 1917; Mitchell & Carman, 1926; Hurst, 1933; Ashworth & Cowgill, 1938). There is, however, no substantial difference in the basic facts. There is marked similarity in the results of carcase analyses of adult rats, done for various reasons, in spite of differences in genetic strains, diets and technical methods (Truszowski, 1926; Reed, Yamaguchi, Anderson & Mendel, 1930; Horst, Mendel & Benedict, 1934a; Light, Smith, Smith & Anderson, 1934; Feyder, 1935; Bachmann, Haldi, Wynn & Ensor, 1938; Haldi, Bachmann, Ensor & Wynn, 1938; Hamilton, 1939a; Deuel, Hallman, Movitt,

Mattson & Wu, 1944; Li, Simpson & Evans, 1948; Greenbaum, 1953; van Putten, van Bekkum & Querido, 1955).

The time of reaching "chemical maturity" at approximately the same age as that when the point of inflection in the growth curve occurs may correspond to the existence of a definite shift at that time from protein synthesis to fat synthesis. Often, though not always, these simultaneous changes coincide with puberty.

The finding that all mature animals of the same species had an identical composition when the reserves of fat were removed by inanition (Rubner, 1881) led to the division of the body into "l'organisme réel", having unalterable composition and "l'organisme de reserve", having variable composition (Terroine, Feuerbach & Brenkmann, 1924). These correspond essentially with the "vital" and "reducible" portions proposed by Nash (1942), who studied the heterauxesis of these fractions. He concluded that during growth an animal becomes increasingly dehydrated and mineralised, and that this dehydration and mineralisation developed more rapidly in the vital portion. He established from his data that one of the most pronounced changes in the growth of rats is the increase in concentration of protein in the vital portion.

From another approach, namely the comparison between normal rats and rats stunted in growth from protein deficiency, it was also concluded that in the early stages of normal growth the emphasis is laid upon deposition of protein at the expense of fat, while at a later age the accumulation of fat is dominant; the fat-free tissues in both groups of animals had almost identical composition (Pickens, Anderson & Smith, 1940).

A recent statistical treatment of carcase analyses also used results expressed on a fat-free basis (Annegers, 1954). Data were analysed by the method of multiple regression in which independent variables were fat-free, dry body weight and body fat and the dependent variable was total body water. The changes in body water per g of body fat were not statistically significant. Thus, no independent effect of body fat on total body water was demonstrable. Further analysis failed to demonstrate that the intercept values of water were different from zero. Thus total body water was not shown to be other than a direct proportion of fat-free, dry body weight.

Undoubtedly the use of fat-free tissue as a reference standard has simplified the study of body composition of animals of different ages and revealed uniformity of constitution of mature animals of different species, but it is nevertheless an artifical device

with limited physiological significance. Its use has been criticized on the grounds that fundamental changes coincident with growth may be obscured if expressed on that basis, particularly with regard to the alteration in lipid composition which occurs (Sinclair, 1930; Hurst, 1933; Williams, Galbraith, Kaucher, Mayer, Richards & Macy, 1945). The difference in fat content of bodies of rats fed on diets with considerable variation in fat and caloric content was not great (Eckstein, 1929; Scheer, Straub, Fields, Meserve, Hendrick & Deuel, 1947).

In addition to analysis of carcases for water, fat and protein, the heat of combustion of rat tissues has been estimated. These data of the caloric content of rats emphasize that the composition of the gains in weight of growing rats varies considerably, even though the ration consumed, the length of the growth period and the rate of growth may be the same.(Mitchell & Carman, 1926).

Carcase analyses in species other than the rat have been carried out since the early work of Lawes & Gilbert (1858). A large volume of data mainly from mature farm animals but also from animals at various stages of growth, is available (Armsby & Moulton, 1925; Ellis & Hankins, 1925; Scott, 1930; Hammond, 1932), giving the typical findings of diminishing percentage of water and the rising percentage of fat in the body

during growth. Marked changes in the sites of fat deposition have been noted during growth and fattening (Callow, 1947, 1948). The fact that a diminishing percentage of water in fat-free tissue coincided with a diminishing rate of growth led to speculation about the possible connection between these phenomena (Murray, 1922).

The technique of determining chemical composition by careful dissection has been developed (Hammond, 1932) and applied with practical value to farm animals at various stages of growth (McMeekan 1940, 1941; Wallace, 1948; Pálsson & Verges, 1950). In this way the fundamental pattern of differential growth rates of the various tissues has been firmly established. Recently attention has been given to the alteration of carcase composition of farm animals by implantation of hexoestrol. The tissues of animals thus treated have been found to contain a higher percentage of protein and water and a lower percentage of fat than control animals (O'Mary, Pope, Wilson, Bray & Casida, 1952; Wilkinson, O'Mary, Wilson, Bray, Pope & Casida, 1955; Aitken & Crichton, 1956; Gee & Preston, 1957).

Chemical composition of the human body has been studied only to a limited extent by carcase analysis, though numerous determinations of foetal composition which have been reviewed by McCance & Widdowson, (1951b),

had been put to practical use in the calculations of dietary requirements during pregnancy and lactation (Garry & Stiven, 1936). Until recently (Mitchell, Hamilton, Steggerda & Bean, 1945; Widdowson, McCance & Spray, 1951), there was only one accurate, direct estimation on an adult human (Moleschott, 1859). One other early analysis gave less complete information (Bischoff, 1863).

Most of the information on the composition of man has been derived by in vivo techniques. For fat, the methods of specific gravity (Behnke, 1941; Messinger & Steele, 1949) and nitrogen solubility (Behnke, 1941) have been used, for water, antipyrine (Steele, Berger, Dunning & Brodie, 1950) and isotopic techniques (von Hevesy & Hofer, 1934; Moore, 1946; Pace, Kline, Schachman & Harfenist, 1947). Isotopic techniques, when tested in animals, have shown close agreement with results from carcase analysis (Rathbun & Pace, 1945; Lesser, Blumberg & Steele, 1952; Haigh & Schneiden, 1956). Some criticism of these techniques has been made on the grounds that the water content of the gut was not taken into consideration (Cižek, 1954). An attempt to combine several of the in vivo techniques to analyse the living body in terms of cell mass, fat, total body water and extracellular fluid have been made by McCance & Widdowson, (1951a). The in vivo techniques have been applied mainly to the adult,

but their use for outlining the pattern of chemical growth has not been entirely neglected (Robinow & Hamilton, 1940; Flexner, Wilde, Proctor, Cowie, Vosburgh & Hellman, 1947; Morse, Cassels & Schultz, 1947). Total body water expressed as a percentage of body weight is high in premature and newborn infants and is followed by a gradual decrease with age (Friis-Hansen, Holiday, Stapleton & Wallace, 1951; Edelman, Haley, Schloerb, Sheldon, Friis-Hansen, Stoll & Moore, 1952; Friis-Hansen, 1957). The extracellular fluid compartment of total body water decreases when expressed on the basis of body weight and increases on the basis of surface area (Robinow & Hamilton, 1940; Doxiadis & Gairdner, 1948). This is related to the changes in body weight and surface area with age (p. 10). In young infants the extracellular fluid volume per total body mass is 57 - 78% greater than in the adult (Fellers, Barnett, Hare & McNamara, 1949).

An analysis of chemical growth in man from mid-foetal life has described the water (also Na and K content) of the body as conforming to the equation for differential growth (Forbes, 1952). In addition to the well-established decrease in proportion of water in the body in early life a genuine decrease in water content during maturity (20 - 25 years) (Brožek, 1952)

has been described, due principally to addition of fat (Keys & Brožek, 1953). Incremental methods as applied by Hamilton & Moriarty (1928) and Macy (1942) have been used in assessing the retention in growing children of nitrogen, calcium and other minerals. Thus the changing chemical pattern of body composition during life which has been established in animals, has been confirmed in man.

There has been an attempt to set forth certain general "laws" about this chemical pattern. For example, the heterauxetic theory, originally applied to morphology (Huxley, 1932) has been extended to chemical development (Teissier, 1934). Water is bradyauxetic in relation to total body weight, protein N is isoauxetic, fat is tachyauxetic and ash bradyauxetic in relation to dry weight (Needham, 1934, 1942). From this type of analysis of data on body composition has arisen the formulation of a "chemical ground plan of animal growth". This implies that animals of different form and different size have the same general chemical pattern of growth and that the process of growth proceeds according to a definite plan which can be readily recognised at any stage of growth.

There is danger, however, in the false sense of security which may be engendered by bending biological events into rigid mathematical expressions. Over-simplification of the intricate processes inherent in

chemical growth may be deceptive. For instance, the marked variation in the tissue constituents even in the adult body represents a variable set of final conditions to which such curves have to be related. When such variation is also considered in the growing animal the validity of such mathematical formulation becomes even more limited. On the other hand, attempts to set forth as generalised expressions facts about chemical growth may eventually assist the progress of knowledge about chemical growth beyond the descriptive phase. This is always provided that, at the same time, research continues into their significance (Glaser, 1938).

METHODS FOR CARCASE ANALYSIS

In Table 8 is a summary of some various methods which have been used for analysis of carcases of rats. For direct estimations of nitrogen various modifications of the Kjeldahl method have been used in all cases, with the exception of the gravimetric technique of Addis, Poo, Lew & Yuen, (1936). For fat, saponification methods or Soxhlet extraction have been used, with various solvents. Oven-drying at temperatures from 55°C to 110°C has been used for the determination of water content but the later improved techniques of vacuum desiccation and freeze-drying (lyophilization) (Flosdorf & Mudd, 1935; Greaves, 1946; Harris, 1954) have superseded oven-drying in many cases. Oven-drying of fats at 70° - 100°C may result in the volatilization of essential oils (Benedict & Manning, 1905), decomposition or oxidation of fats and loss of nitrogen (Howe, Rutherford & Hawk, 1910; Teague, Galbraith, Hummel, Williams & Macy, 1942). Oven-drying at 70°C and below has been found not to alter the value for total fatty acids (Teague et al., 1942) and for total fat at 50°C, at atmospheric pressure, and the results of oven-drying have not differed significantly from drying at the same temperature at 0.1 mm Hg (Flosdorf & Webster, 1937). However, even though oven-drying

at low temperatures results in minimal loss of volatile materials, freeze-drying still allows maximum preservation of nitrogenous materials. In addition, organic solvents are better able to penetrate the friable and porous frozen-dried material compared with the harder, more resistant material dried in the oven (Sheckell, 1909).

Preparation of Carcase

The rats were killed by exposure to coal gas and weighed. The skin was dissected off and weighed rapidly on a Petri dish. Separate analysis of skin was done because of the difficulty of homogenizing the skin. If the skin had been included along with the macerated carcase, sampling errors would have been great, owing to uneven distribution of hairs. The contents of the gut were removed and weighed rapidly on a watch-glass. The empty carcase weight was thus given by the total body weight minus the weight of the gut contents. The carcase was then cut into small pieces, using scissors and bone forceps, and placed in the container of a top-drive macerator with distilled water added to cover the blades. Maceration was continued till a state of homogeneity was reached (10 - 20 minutes), then the homogenate was washed into a weighed beaker (of 1 litre capacity).

In the computation of results, the added water has of course to be taken into consideration. This is found as the total weight of the beaker with the homogenate less the weight of the fresh carcase (found above) and the dry weight of the beaker.

Estimation of Nitrogen

Carcase

The estimation of nitrogen in the carcase was done on 3 samples of macerated tissue placed in 50ml beakers. Concentrated sulphuric acid (approximately 20ml) was added to each beaker and stirred with a glass rod, while the initial digestion took place. When cool, the contents of each beaker were washed into 100ml volumetric flasks with distilled water and made up to volume. Samples of 1ml were taken for micro-Kjeldahl estimation. Duplicates agreed within 1%.

Skin

0.5 - 2.0g of skin were placed in a beaker with concentrated sulphuric acid (20 - 50ml) and heated on a hot plate till solution occurred. The procedure was then similar to the analysis of carcase.

Estimation of Fat

Carcase and skin

Samples of 3 - 5 g. were wrapped in filter paper and placed in extraction thimbles and extracted with chloroform in a Soxhlet apparatus, set on a hot plate at 73°C. Three estimations were carried out in series (Fig. 7). Extractions were continued for 16 - 20 hours, the solvent was evaporated off and the flasks dried to constant weight. Duplicate estimations agreed within 2% for carcase and within 10% for skin. The solvent chosen was chloroform in order to avoid the risk of fire when fume cupboard accommodation was inadequate. It is known that chloroform extracts pigments as well as fat but this was not considered disadvantageous, since the absolute results were of less importance than the comparison of the fat content of rats at different ages.

Estimation of Water and Total Solids

Carcase

Initially water and total solids were estimated by drying the macerated tissue to constant weight in Petri dishes in an oven at 50°C. During the course of the oven-drying a distinctly repugnant odour pervaded the

laboratory in which this was being carried out and subsequently freeze-drying technique with its many advantages (p. 115) was used.

The apparatus (Figs. 5 and 6) consisted of a round-bottomed flask (500 or 1000ml) attached to a trap for condensed water vapour, enclosed in a Dewar flask containing a mixture of alcohol and solid carbon dioxide at a temperature of -70 to -78°C. The condenser-trap was in turn connected to a moisture trap containing magnesium perchlorate ("Anhydrone"), from which led rubber tubing to a high vacuum pump ("Speedivac" Model IS50, Edwards & Co. Ltd.), driven by a motor of $\frac{1}{4}$ H.P.

Initial freezing of the samples of macerated carcase was done by immersing the flask in a large evaporating dish containing alcohol-solid carbon dioxide mixture and spinning it round with a continuous circular motion till a thin layer of frozen material covered the inner surface of the flask. Rapid connection of the flask to the freeze-drying apparatus was made and the vacuum pump started. The outside of the flask became covered with a layer of frost due to condensation and freezing of atmospheric moisture, evaporation in vacuo of ice from the frozen material occurred and the water vapour collected in the condenser-trap. The cooling effect of rapid evaporation kept the homogenate frozen

at all stages of the process. As the rate of evaporation diminished, the temperature rose slowly to that of the room and the external frost thawed. The frost disappeared in about seven hours, on average, and often it was found that constant weight was obtained after a further two hours. The dried product, light brown and friable, was removed from the flask by scraping with a wire bent to a suitable angle. Thereafter it was stored in jars with air-tight bakelite lids. Three or four samples were taken of each rat carcase analysed; replicates agreed within 2%.

Skin

The skin was spread out on a Petri dish, inner side uppermost, and dried in an oven at 50°C till it reached constant weight; this took approximately one week. On one occasion, skin was frozen-dried but the time taken was too great to make this method practicable for routine use.

Heat of combustion

Carcase and skin

For estimation of the heat of combustion of carcase, pellets of 1.5 - 2.0g were used for bomb calorimetry and replicates agreed within 2%. For skin,

two pieces of skin, weighing together 1.0 - 2.0g, were placed in the crucible with their inner sides next to the fuse wire; rarely was there any difficulty in obtaining complete combustion. Replicates agreed within 6%.

RESULTS OF CARCASE ANALYSIS

The results of carcase analysis for water, fat, nitrogen and heat of combustion are set out in Tables 25 - 27. Protein is taken as nitrogen x 6.25. Data on water, fat and protein, collected from various sources and often re-calculated, are shown, along with the present work, as a percentage of the body weight and of the fat-free body weight (Figs. 50 and 51); agreement about the general pattern is evident.

The ash content of the carcases was not measured. In one series of data, values for rats from 4 to 16 weeks of age are given as 2.9 - 3.1% (Buckner & Peter, 1922). Other values are slightly higher (3 - 5%) (Mitchell & Carman, 1926; Chanutin, 1931; Pickens et al, 1940; Li et al, 1948).

The mean body content of water, fat and protein found in the present work is expressed in a histogram in Fig. 49, where the decrease in the percentage of water and the increase in the percentage of fat in the bodies of the rats with age is clearly shown. The relative contribution of fat to the total caloric content of the body increased with age (Fig. 52). During growth, while calories from both protein and fat increased in amount, their contribution to the total caloric content differed

at different ages. The contribution from protein increased rapidly at first in young rats while that from fat was slower. This relatively rapid increase in total calories from protein and slower increase in total calories from fat occurred when expressed both on the basis of total calories (Fig. 53) or on the basis of calories per 100g body weight (Fig. 54). Later as the rats approached maturity, the contribution of calories from protein remained almost static, while the calories from fat continued to rise. The graph of kcal/rat plotted against body weight rises steeply (Fig. 55). There is, however, a less pronounced slope to the graph of kcal/100g body weight plotted against body weight (Fig. 56).

An estimate of the composition of increments in body weight can be derived by subtracting the total bodily constituents of older rats from those of littermates killed and analysed at an earlier age, and thus deriving the composition of one gram increase in weight at different ages (Table 28 and Fig. 57). This estimate can only be approximate, since values from rats of different initial bodily composition are, of necessity, used, since each rat cannot serve as its own control. Nevertheless, this procedure gives some general indication of the facts. In younger rats (0 - 30 days), there was less fat (0.04g/g weight increase) and more water

(0.7g/g weight increase) laid down, in older rats (115 - 228 days), more fat (0.28g/g weight increase) and less water (0.45g/g weight increase). The amount of protein per g weight increment did not alter greatly from birth to maturity (0.15 - 0.20g/g weight increase).

It had been hoped to provide confirmatory evidence, by means of metabolic studies, of the composition of the tissue added during growth and approximate correspondence of results was anticipated. However, rather unexpected results were obtained. It appeared that the weight gains during the period in the metabolic apparatus and in the animal house were of different composition (Tables 28 and 29 and Figs. 58 - 60). In the metabolic apparatus, nitrogen and energy were retained and body weight increased, but body water did not increase correspondingly (p. 87). Thus relative dehydration occurred.

In the animal house it was presumed that water was retained and that the balances of nitrogen and energy were negative. In effect, therefore, the rats were at one time considered to be gaining solids and at another time gaining fluid. The approximate composition of body weight increment/day/g body weight gain is shown in Fig. 61, where it is seen that, in the metabolic apparatus, protein and energy gain is greater than is shown from carcase analysis; on the other hand, loss of water occurs in the metabolic apparatus instead of gain

of water which is shown by direct analysis of carcase composition. The data from these two types of study are not strictly comparable because of slight differences in the time intervals during which the gains in weight occurred, but at least the general trend in the two circumstances is demonstrated.

The rats entering the metabolic apparatus presumably had a normal bodily composition but no direct evidence for this was available. On three occasions, a rat which had spent five days in the metabolic apparatus was analysed at the same time as a littermate from the animal house. No significant differences in composition were found, but unfortunately two of the rats analysed had spent the night prior to being sacrificed in the animal house, owing to technical difficulties with the metabolic apparatus. In no case was the dehydration in the metabolic apparatus sufficiently severe to be apparent from the external appearance of the animals, although it was detectable by the method of metabolic balance study.

A typical example gives an approximate estimate of the extent of the dehydration. A rat of 115 days with a body weight of 233 g (Table 25) has an absolute water content of 153g and a percentage water content of 65.5%. With a total negative water balance over 5 days of -3.5 g and a total weight gain of +15g, the rat has

then a body weight of 248g, an absolute water content of 149.5g and a percentage water content of 60.3%.

The extent of the dehydration can also be expressed on a fat-free basis. If the initial fat-free weight of the rat was 212g, the percentage water content on a fat-free basis is 72.1%. If an approximate gain in fat/g gain in weight for a rat of this age is +0.3g, the fat gained over 5 days would be 4.5g, for a body weight gain of 15g. After 5 days then, the fat-free body weight gain would be 222.5g. With an absolute water content of 149.5g (see above), the percentage water content on a fat-free basis would now be 67.2%. From the present example, therefore, there was a fall of about 5% in the percentage of water in an adult rat at the end of a 5-day period in the metabolic apparatus, either on the basis of total body weight or of fat-free body weight.

Because of the existence of relative dehydration, direct comparison between the metabolic and analytical studies could not be made, but on the common basis of dry body weight increment the pattern of weight gain during growth was examined. (This computation was made only in Series III, since in this series all the estimations were consecutively without interruption). Although absolute values are not comparable, the same trend was present in both types of study. In both cases nitrogen retained per g dry body weight increment decreased

with age, and kcal derived from fat (in the carcase analysis) and non-protein kcal (in the metabolic study) increased with age (Fig. 62). The percentage of kcal derived from protein per dry body weight increment was greater in young rats and decreased in older animals (Table 29). At 30 - 35 days, kcal from protein per dry body weight increment were 99.8%; at 110 - 115 days, the corresponding value was 32.5%. The percentage of kcal from non-protein sources altered in the reverse direction (0.2% and 67.5% for younger and older rats, respectively).

DISCUSSION

The substance of the foregoing work was the interrelation of the components of energy exchange, of water exchange and of nitrogen exchange during growth. An attempt has also been made to relate these to the increments of body weight and the composition of these increments in terms of energetic materials during the same growth periods.

It is of interest to attempt to resolve the proportions of the total energy expenditure which are composed by basal energy expenditure, energy cost of food intake and muscular activity. Some estimate of this can be made, provided it is recognised that this division into component parts is somewhat artificial. As regards basal metabolic rate, there is quite a wide range of values in the literature, due to strain differences and technical variations, but the trend in basal values at different ages is followed in general by the present data on total energy expenditure (p.77). A few of the different values for basal metabolic rate have been selected for inclusion in Fig. 63 (and also Figs. 64 and 65). If one accepts the values of Benedict (1938) as being technically the most satisfactory, the excess of the present value for total over these basal values (at 200g body weight) is 80%, but this

figure becomes much less if any of the other data are taken. Comparisons of estimates on different series of animals is limited in value, but one is led to make some such approximations because of the paucity of data in the same rats of total and basal levels of metabolism. In one case in which total metabolic rate was measured (in a direct-indirect calorimeter with food and water ad lib. in small individual cages with freedom of movement for 19 - 22 hours) and compared with basal metabolic rate the difference was 26% (Black & Murlin,1939).

To derive the energy cost of food utilisation, the multiple regression equation (p.78) can be used as Morrison (1955) did, putting F = 0, which enables a line to be drawn indicative of the metabolism of the fasting rat. This line bears an almost constant ratio to the line representing total metabolism and to the lines of basal metabolic values from various sources (Fig. 63). The excess of total over "fasting" energy expenditure is 21% at 100g body weight and 16% at 200g, which is the heat attributable to the energy cost of food intake. This compares with Morrison's (1955) value of 22% which is probably more reliable, since in his data there were values of almost zero food intake. Also it is less justifiable to put F = 0 in this case since weight change is complicated by a somewhat greater change in age.

For comparison, values of S.D.A. with ad lib. feeding as reference standard are of the same order of magnitude (Kriss, Forbes & Miller, 1934; Kriss & Smith, 1938). Comparison of the excess of non-fasting over fasting metabolic rate in the same animals at rest (Kibler & Brody, 1942) gives a value of 9.8%, which agrees with earlier work on S.D.A. where the standard of reference was the fasting level (p.29).

The contribution of activity to total energy expenditure is difficult to assess but, in non-fasting rats, comparison of periods of 8 hours in which the rats were observed to be inactive with periods in which there was activity gave a difference of 11% (Kriss & Smith, 1938). In another case, inactivity was promoted by the use of a very bright light, and the difference in oxygen consumption between the rats with and without activity in the non-fasting state (over 7 hours)was 15% (calculated from the data of Black, French & Swift, 1949). In estimating caloric requirements for rats an increment of 25% was added to the basal energy value for activity (Metta & Mitchell, 1954). Comparison of the data in the present series with non-fasting, resting values (Kibler & Brody, 1942) gives an approximate value for activity of 15% which agrees with Morrison's (1956) estimate of 15 - 20%. It is obviously impossible to

separate absolutely movements of general activity from those associated with obtaining and eating food, and there will be considerable variations in different rats, and, from time to time, in the same rat. A decision about the relative contribution of activity to total metabolism at different ages cannot be reached on the present evidence because no measurements of activity were made under the conditions of the metabolic experiments.

With regard to diurnal variation in energy expenditure, oxygen consumption is not exactly proportional to energy expenditure because of variations of R.Q., though there is an indication from four-hourly estimations in rats on a stock diet ad lib. (Burr & Beber, 1937) that there is substantial constancy of R.Q. throughout the day. A high correlation between oxygen consumption and activity has been found in mice (Fuhrman, McLin & Turner, 1946); these animals, though non-fasting, were not actively ingesting food.

Comparison with Morrison's (1955) results for female (non-pregnant) rats shows general agreement for the diurnal changes and for the total mean swing of oxygen consumption (p. 83). There is, however, a slight difference in timing of the peak for oxygen consumption, which occurred four hours earlier in the present work (6 p.m. - 2 a.m.), and an additional trough is noted (6 a.m. - 10 a.m.) as well as the one common to both series.

There is no clear-cut explanation for this difference, though it is possibly related to the influence of oestrous changes; a sex difference in level of activity in revolving wheels has also been reported (Hitchcock, 1926). There was no major difference in experimental procedure, for the daily change-over and the evening refilling of the spirometer were carried out no more than one hour earlier in the day. The rats in the present series were younger than Morrison's animals, but there is no difference apparent in the daily pattern of oxygen consumption with age, apart from the one set of observations at 30 - 35 days (Fig. 25). The lack of periodicity of oxygen consumption in these young animals seems to be due to incomplete development of the diurnal pattern of activity which has been described as beginning shortly before weaning (Richter, 1927).

Comparison with other estimates of diurnal metabolic rhythm, as distinct from activity records, shows substantial agreement, though Herring & Brody (1938) found a larger diurnal swing (25 - 30%) which has been tentatively explained on the basis of short period measurements (Morrison, 1955). However, in another study of recording of heat production, using analyses of gas collected continuously and estimated at 4-hourly intervals, the diurnal swing can be calculated to be of the same order (25 - 30%) (Burr & Beber, 1937). In this latter

work, food was constantly available ad lib. They found the peak of oxygen consumption to be between 8 p.m. and 4 a.m. and the trough between 12 noon and 4 p.m.; activity records followed the same trend. A diurnal cycle in metabolism is also shown in the records of Black, French, Cowan & Swift, 1949b), though their results are not comparable because of the different mode of feeding - a maintenance diet, fed in two portions, at 8 a.m. and 8 p.m.

The conclusion that the increase in energy expenditure was wholly accounted for by the increase in body weight and food intake (p. 82) makes some contribution to the solution of the problem of changes in metabolic rate with age (p. 12). That there was no apparent change in tissue metabolism during the period of growth studies might appear unexpected, but it is still not impossible that, for example, a true increase in metabolism might exist which could be offset by a decrease in another tissue and therefore be masked in the gross summation of all the metabolic processes. In other words, the final apparent metabolic rate represents an algebraic sum of metabolic responses to variations such as hormonal effects and changes in tissue metabolism. This situation is analogous with the much simpler problem considered by Morrison (1956) where he

suggested that in pregnant rats there may be a truly raised metabolic rate in the maternal tissues alone, but the net fall in the rate of energy expenditure which occurs arises because of a rapidly increasing mass of foetal tissue with a low rate of metabolism. Similarly, Kleiber (1947b) found during starvation in rats that the change in metabolic rate differs in different tissues. A reduction in activity might obscure any real increase in tissue metabolism but any change in activity is also unknown in this work. It may also be true that the sensitivity of this statistical method of analysis is limited by the use of the non-specific index of body weight with its lack of homogeneous components at different ages. Body weight, however, even with its disadvantages, is the best available reference standard in the present circumstances.

It is interesting that in the tissue loss of fasting rats a relation was shown similar to that found in the present study (p. 82) between energy expenditure, body weight and food intake (Cumming & Morrison, 1955) in that the change in total energy expenditure could be entirely accounted for by changes in body weight and food intake. The existence of this similar relationship during fasting and growth seems not unrelated to a comparison between the changes in concentrations of the major chemical components which has been made in these

two states (Nash, 1942). Except for fat, the changes in the concentrations of the main chemical components during starvation resemble the changes which occur during growth. Calculations have shown that the concentrations in well fed adult rats of protein, water and minerals on a fat-free basis correspond to the concentrations of these components of starved rats at much younger ages. That the changes in the relative concentrations of the chemical constituents during growth should resemble the changes which occur during starvation is due to the removal of the chemically younger reducible portion (p.106) during starvation.

Speculation can be made about the possibility of similarity between the metabolic pattern of growth and starvation, with control in both cases by a complex interplay of hormones, such as has been demonstrated in the case of growth (White, 1956). A resemblance of the basic metabolic pattern in both these states has been suggested because in both the fasting animal and in the non-fasting animal to which anterior pituitary extract has been given there is partial replacement of combustion of carbohydrate and protein by oxidation of fat (Young, 1945). The influence of growth hormone on carcase composition where there is retention of protein and lack of deposition of fat (Lee & Ayres, 1936; Samuels, Reinecke & Bautman, 1943;

Levin, 1944; Li, Simpson & Evans, 1949; Levin & Farber, 1952) is a further indication of some similarity between growth and fasting.

It seems possible that production of growth hormone is stimulated by fasting, influencing predominantly catabolism of fat; release of nitrogen in fasting is probably due to excess production of A.C.T.H. (Szego & White, 1949). A substance stimulating combustion of fat produced by the anterior pituitary has been excreted in starving animals (Best & Campbell, 1936, 1938; Szego & White, 1949; Weill & Ross, 1949). It was thought to be related to growth hormone, but it has recently been shown to be independent of it (Rosenberg, 1953). In addition to anterior pituitary hormones, thyroid hormones influence metabolic processes in fasting as well as in growth; thyrotropic hormone is depressed in fasting (D'Angelo, 1951). At different stages of life, starvation has dissimilar results, due presumably to the differing hormonal balance at various ages. McCance & Strangeways (1954) found that young infants during starvation derive a much lower proportion of their calories from protein than do adults and old men (see p.141). Although from the above evidence only tentative suggestions about hormonal control of growth and starvation are at present available, it seems, however, not unreasonable to speculate that the similarity between the metabolic

patterns of growth and starvation may eventually be shown to be represented with fine precision at the cellular level.

The question of whether there is an alteration of metabolic rate with tissue gain and tissue loss does not receive a final answer from the literature on the subject. In healthy men on surfeit feeding, measurements of total and basal metabolism respectively (Wiley & Newburgh, 1931; Munro, 1950) have not shown any change although other reports have indicated an increase in basal values (Müller, 1911; Kleitman, 1926).

There is a suggestion of a true alteration of tissue metabolism in the loss of tissue during prolonged undernutrition (a reduction of tissue metabolism) and the gain of tissue in recovery after dietary restriction (an increase of tissue metabolism). This was shown when the B.M.R. measured in these circumstances was expressed in units of actively metabolizing tissue, instead of the more classical units of body weight or surface (Keys et al., 1950). Actively metabolizing tissue is defined by these workers as gross weight minus the sum of fat, bone mineral and extracellular fluid. While this is probably an excellent approximation, the validity of summarily dismissing fat from the reckoning may be questioned on the grounds that the structural fat remaining in the body may be more actively metabolizing

than the fat present in the control period. The assumption that changes in E.C.F. are sufficiently without influence on cell metabolism to be disregarded has also been questioned (Editorial, 1957). Keys et al. (1950) did not consider any variation of intracellular hydration but they recognized that active tissue mass is not a homogeneous continuum. The implication of true alteration of tissue metabolism is not necessarily at variance with the conclusions of the present work, since the conditions were comparable neither in the circumstances of tissue loss or gain nor in the method of measuring metabolic rate.

A possible extension to the growing animal of the constancy in the adult of the ratio of energy intake to energy output at thermoneutrality (Cowgill, 1928; Gasnier & Mayer, 1939; Adolph, 1947; Kennedy, 1950) has recently been suggested by Mayer & Vitale (1957). They found that on an adequate diet the thermochemical efficiency (ratio of calories deposited to calories ingested) was constant from weaning to puberty (70 - 80 days). The value expressed as a percentage was 25%. The present direct measurements of total energy intake and output with the linear relationship between them found during growth from 30 to 115 days (p. 84) is consistent with this postulate. Rats younger than 30 days tend to have a different ratio because of a

greater retention of energy relative to expenditure.

Estimates which have been made of energy expenditure and intake in adult men and children show approximately the same ratio (Bedale, 1923; Passmore, Thomson & Warnock, 1952; Garry, Passmore, Warnock & Durnin, 1955; Edholm, Fletcher, Widdowson & McCance, 1955). In the case of the children who were studied at school, however, (Bedale, 1923) the energy retention estimated was too small to account for normal growth over long periods. In this connection, the subsequent finding of slower growth in some children at boarding school compared with the growth during the vacation is likely to be relevant (Widdowson & McCance, 1944). Studies on man are limited in value because of the short period estimates of energy expenditure and the approximations involved in computing total energy expenditure from these values.

The present work confirms that the percentage of ingested nitrogen retained decreased with age (Allison, 1951). There is a strong stimulus for retention of nitrogen during active growth associated with a great increase in cell proliferation. Later, there is less formation of new cells and weight gain is due to a greater extent to accumulation of fat. The hormonal control of nitrogen retention is complex (p. 16) and at present not fully understood.

The retention of nitrogen shown in the metabolic balance studies (p. 92) is noted also in the analyses of carcases. The conclusions from the study of carcase analysis (p. 121) are in accord with the proposition (Mayer, 1949a) that as the organism ages, part of its protein and water is progressively replaced by fat. There is thus an accompanying change in energy content. That is to say, not only do body weight gains differ at different ages but also gains in body weight at different ages have different thermochemical values. For example, from 30 to 60 days from carcase studies 1 g gain in weight contains approximately 0.17 g protein, 0.04 g fat and 0.70 g water, while at 80 - 115 days 1 g gain in weight is composed of 0.21 g protein, 0.12gfat and 0.62 g water. Both from metabolic studies and from carcase analyses the dry weight increment is at first predominantly protein (up to about 60 days of age) and later predominantly fat (p. 125). The approximate constancy of energetic efficiency in the age range studied (30 - 115 days) (p. 90) is in agreement with the findings of Mayer, Vitale & Taira (1951) and Mayer & Vitale (1957).

Interest in the ratio of the energy content of a total organism (in kcal) to its mass (in g) has evoked the proposition that this ratio should be used to give a measure of metabolic age and so to relate growth and ageing numerically (Worrall, 1955). Although it has been

clearly demonstrated in the present work that the $\frac{\text{energy}}{\text{mass}}$ ratio increases with age (p. 122)as can also be seen from the data of Mitchell & Carman (1926) if they are rearranged, it is difficult to see any direct application of this information, such as its use as a reference standard instead of chronological age. In any case, the rat is rather an unsuitable animal to use in studies on ageing, since throughout its life growth is continuous, although it proceeds at a slower rate as life advances. Studies of this kind on growth may throw some light on problems of ageing, but although ageing can be deferred (McCay, 1952) or hastened (Kennedy, 1957) by dietary means, it does not therefore imply that similar mechanisms are in action in growth and ageing; it can only be concluded that one is the natural sequence of the other in time. It is, however, interesting to note that tissues undergo changes of senility in the reverse order of that in which they were developed (Hammond, quoted by McCay, 1952).

There is much need for clarification of the mechanism of control of the transition from protein synthesis to fat synthesis during growth. Setting aside the complexity of polyglandular interaction, it is presumed that growth hormone with its tendency to cause accumulation of protein and water is active in early life and that this is superseded by A.C.T.H. and steroid hormones which inhibit growth and cause accumulation of

fat and diminution of water content (Li, Simpson & Evans, 1949). Older animals are more sensitive to the effects of growth hormone than weanlings, presumably because in the younger animals the maximal response to growth hormone is already taking place (Browne, 1951). The influence of the N-retaining action of growth hormone is also suggested by the fact that in starvation a much lower proportion of calories is supplied by protein in the newborn than in the adult (McCance & Strangeways, 1954). Part of the explanation of the extension of the life span by prolonged undernutrition (McCay, Maynard, Sperling & Barnes, 1939; McCay, 1952), may be that if the normal change from protein to fat synthesis is inhibited due to lack of food intake, the normal hormonal pattern of ageing cannot be set into operation.

The present work seeks to emphasize the fact, often formerly reluctantly recognised in practice, that body weight is an indefinite term because it can be composed at different times of components in varying proportion. In some nutritional studies, estimation of the actual chemical composition and energy content of the added weight has been realised to be necessary (Kon, 1931; Hamilton, 1939a; Allison, 1951; Weeks, 1957) and there is now a growing appreciation that, for body weight to be fully meaningful, analysis of its components is required. For instance, weight gain can occur on a

calorically deficient diet if fat is oxidized and replaced by protein with water accompanying it in the usual proportions (Reifenstein, Albright & Wells, 1945). Body weight may remain static although its composition may alter, particularly due to changes in body water or conversion of carbohydrate to fat or vice versa (Keys et al., 1950). The amount of nitrogen retained has been found to be consistent with the observed increment in body weight in normal rats (Forbes et al., 1946c) and in rats treated with growth hormone (Young, 1945). In undernourished children and adults during refeeding after starvation and in normally nourished men, retention of nitrogen occurs with no change or with actual loss of weight (Mitchell, 1949; Patwardhan, Mukundan, Rama Sastri & Tulpule, 1949; Karambelkar, Patwardhan & Sreenivasan, 1950; Holmes, Jones & Stanier, 1954). The same occurrence has also been noted in cattle (Blaxter & Wood, 1951). The reason for the retention of nitrogen with no change in body weight is due possibly to loss of water (Macy et al., 1942), extracellular fluid, intracellular fluid or fat (Holmes et al., 1954), as protein is deposited. Nitrogen retention, however, may not always be synonymous with protein synthesis (Munro & Chalmers, 1952). These examples emphasize that caution must be exercised in interpreting the significance of body mass, and it is

not surprising that there has been disagreement about the caloric equivalent of gained or lost weight (Wishnofsky, 1952; Pollack, 1953).

The difference noted between the gains in weight in rats maintained on the one hand in the metabolic apparatus and on the other hand in the animal house (p.123) requires to be considered. During metabolic studies, the gain in weight was due to fat and protein, laid down, as it were, at the expense of water, because of the occurrence of relative dehydration (p. 87). It was thus shown, somewhat unexpectedly, that it is possible for some tissue constituents to be assembled in a much more concentrated form than normally, more concentrated, in fact, than previously described. The only parallel situation encountered has been the nature of the gain in weight in rats refed after a short fast (Cumming & Morrison, 1956) (see below). There are analogous findings in overfeeding of thin young men, when the gain in weight appeared to be due only to fat and protein, without additional water (Passmore, Meiklejohn, Dewar & Thow, 1955), although another study of overfeeding showed rather different results (Keys, Anderson & Brožek, 1955). Conversely, there is some evidence that in undernutrition excess hydration of the cells can occur, as well as extracellular hydration (Gopalan, Venkatachan & Srikantia, 1953).

The cause of this deposition of tissue which contains less than its usual amount of water provokes some speculation. It can be suggested that relative dehydration is the primary influence, and there are many instances of fat replacing water in the tissues and vice versa (Bozenraad, 1911; Haldi, Giddings & Wynn, 1942; Da Costa & Clayton, 1950; Keys et al ., 1950; McCance, 1951). In studies on total metabolism, deposition of fat has been found post-partum in rats (Morrison, 1956) and on refeeding after a short fast (Cumming & Morrison, 1956). Confinement in the metabolic chamber and consequent reduction in activity may assist the fat deposition (Ingle, 1949).

The cause of the relative dehydration, however, is not definitely established. Excessive drying seems unlikely, though the relative humidity (p. 53) in the metabolic box would on most occasions be lower than that in the animal house, for the reason that the water balance was positive, or nearly so, in experiments with non-pregnant, adult female rats, with the same conditions of ventilation. In pregnant animals, however, relative maternal dehydration has occurred and the conditions of experiment were suggested as a possible cause (Morrison, 1956). In the present work, a probable explanation is related to alteration in the consistency of the diet. In the metabolic box, food was administered

in a dry form, while in the animal house, water was added to give a consistency of a thick paste in order to avoid spillage and waste. Estimates of food intake in the animal house were not made, however, but it is interesting to note that less satisfactory growth with wet mash, judged solely by body weight measurements, has been reported (Bruce, 1950). The rats entering the metabolic box were possibly not conditioned to drinking enough fluid to maintain their water balance, after having been supplied previously with moist food. If the periods of metabolic study had been longer than 5 days it is possible that the animals might have adjusted their intake of water. No difference in the fat content of two groups of animals eating solid or liquid diet ad lib. has been noted after 14 days (Cohn, Joseph & Shagro, 1957).

It is possible to speculate also on whether the conditions of confinement may not result in diuresis (Gaunt, Birnie & Eversole, 1949) without compensatory polydipsia, since animals adapted to stress have a diuresis to administration of a measured amount of water. This is not equivalent, however, to information about the water balance in stress, which does not seem to have received systematic study.

It is not known whether the dehydration is extra- or intra-cellular, though the intracellular water loss

is the more likely if one considers the dehydration to result from a lack of ingested water combined with intake of a balanced diet adequate in salts. Direct comparison of other data on water intake cannot be made since this depends on specified environmental and dietary conditions and on loss of water by various routes. However, water intake in the present work was lower (p. 94) than the values given by Richter & Brailey (1929) for animals of a similar age range but intake was greater than the amount taken by adult animals fed a cubed diet (Bruce, 1950) or a diet fairly similar in composition to the present one (Dicker & Nunn, 1957). In none of these cases was the complete water balance measured, though in the work of Dicker & Nunn some unjustifiable assumptions seem to have been made about the state of hydration of the experimental animals.

Urinary water loss in normal, adult rats has been described as less than 20% of the total water intake (Dicker & Nunn, 1957) and 25% of the extrarenal water loss. Taking mean values of all data in the present work, the corresponding results are 30% and 50% which appears to suggest that the urinary water loss is disproportionately high, but such comparisons are of very limited, if not negligible, value, especially when the total water intake described by Dicker & Nunn is less (18.6g) than in the present work (24.4g).

It is difficult to compare the vaporized water loss with other estimates because of differences in methods and duration of measurement. By direct weighing of the rat, vaporized water has been estimated to be 10.8g/100g rat/day (Heller, 1947), 13.2g/100g rat/day (Dicker & Nunn, 1957) and 13.2g/day for adult rats (weight not given) (Greene & Luce, 1934). By passing a current of air over the rat and freezing out the water evaporated from it, a value of 26.3g/100g rat/day was derived (Schmidt-Nielsen & Schmidt-Nielsen, 1950). Another estimate is given as 9.4g/100g/day (Zak & Leiner, 1944), expressed as insensible weight loss, of which water loss may constitute 82 - 102% in man, depending on the R.Q. (Johnston & Newburgh, 1930). A value found for vaporized water loss in dry conditions (with accompanying dehydration and inanition) is much less (6.8g/rat/day) (Swann & Collings, 1943), but this is not relevant, since it is known that the vaporized water is affected by dehydration and inanition (Manchester, Husted & McQuarrie, 1931). Vaporized water is not, however, influenced by the temperature range 20 - 30° in adult rats (Heller, 1949) or by non-extreme changes in humidity (Levine & Wilson, 1927).

The constancy of vaporized water loss in the body weight range of rats 100 - 200g (p. 97) is in agreement

with the findings of Morrison (1955) who has already discussed this phenomenon and postulated that it may be explained by a decrease in the water permeability of the skin surface. It could also be suggested that in animals without sweat glands it may be that there is some inefficiency of temperature regulation, and that some of the heat loss in excess of the heat loss contributed by the evaporation of water can be considered as leakage. In younger rats, the graph of vaporized water on body weight parallels that of energy expenditure on body weight. A somewhat similar relationship between plasma volume and body weight in rats (Metcoff & Favour, 1944; Belcher & Harriss, 1957) may have a bearing on the pattern of vaporized water loss. The proportion of heat lost by evaporation of water in the present work (approximately 25%) (Table 23) is in agreement with values for the adult rat (Greene & Luce, 1931; Greene, 1934; Morrison 1955) and for other species (Soderstrom & Du Bois, 1917; Benedict & Root, 1926; Levine & Wilson, 1927; Newburgh, Johnston, Lashmet & Sheldon, 1937; Lee, 1940). Likewise the percentage of the total vaporized water lost in the expired air is similar to the values of other workers (Greene & Luce, 1931; Greene, 1934; Morrison, 1955).

From the literature there is little indication of the possible effects on metabolic rate of animals

supplied ad lib. with food but with restriction of water. Metabolic studies made on cats fed uncooked meat but no added water might have yielded interesting results but the respiratory studies were too infrequent to be conclusive (Caldwell, 1931). No change is reported in the total metabolism of dogs in dehydration (Straub, 1899) but this is contradicted by the statement attributed to Marriott but without reference, that "in the struggle for water between blood and the tissues the metabolic rate is slowed" (Underhill & Fisk, 1930). When water is restricted, food intake is voluntarily reduced and vice versa (Kleitman, 1927; Rupel, 1929; Strominger, 1947; Dicker, 1949; Fábry, 1956). The gross pathological features of inanition which have been described when water is restricted (Kudo, 1920, 1921; Jackson & Smith, 1931; Quimby, Phillips & White, 1948) would have the effect of lowering the basal metabolic rate (p. 23). The striking results of Crampton & Lloyd (1954) emphasize the adverse effects of limiting the intake of fluid. In their experiments, when this was reduced to half the amount normally ingested, food intake was reduced voluntarily by 25%, gain in body weight was inhibited by 50% and the efficiency of the ration (g gain in weight/g food intake) was reduced by 30%. Effects on total metabolism of water restriction with food ad lib. are liable to be complicated by the increase

in activity which is stated to occur in some circumstances (p. 33) (Richter, 1927; Hitchcock, 1928; Richter & Rice, 1954).

Since dehydration in the present work is not so severe as in the instances quoted above with marked water restriction and external evidence of dehydration, it is unlikely that the changes mentioned would be taking place. In fact, it has been shown here by statistical analysis on the basis of individual days, that the relationship between energy expenditure and body weight and food intake is not affected (p. 88). Similarly in studies on fasting rats when the fall in hydration of fat-free tissue fell by 1.5%, this was not considered per se to influence energy expenditure (Cumming & Morrison, 1956). However, it is not known exactly in what way metabolic processes in the organism may be modified in these circumstances. One cannot legitimately apply to the state of relative dehydration the conclusions of studies at tissue level concerning metabolic rate and body fluids, but it may eventually prove to be relevant that as metabolic rate increases (in kidney slices) the I.C.F. decreases and the E.C.F. increases (Robinson, 1950). In man, when the effects of variation of total body water are removed (by a statistical device), a higher metabolic rate is

associated with a lower volume of I.C.F. (Wedgewood *et al*., 1953). Although in the present work a decrease in the I.C.F. has been postulated (p. 145), the corollary cannot be inferred that there is some resultant small increase in metabolic rate; the complexity of the situation is far too great. In this study of growth more questions appear to be unanswered than answered, for, although some facts and their meaning emerge clearly, the deeper significance of other metabolic patterns remains unknown.

SUMMARY

1. Total metabolism of growing male rats was measured successively for 24 hours for five-day periods from the age of 30 to 115 days at intervals of ten days (i.e. 9 periods each of five days). Three such series are described with tabular and graphical data on the components of energy, water and nitrogen exchange.

2. Total energy expenditure of male rats from 30 to 115 days varied linearly with body weight and absorbed intake of energy. Analysis of co-variance of the data indicated that the increase in energy expenditure during growth was wholly attributable to changes in body weight and food intake.

3. The diurnal pattern of oxygen consumption was estimated.

4. Energy and nitrogen balances were variable but uniformly positive.

5. Water balance over the five-day periods did not differ markedly from zero, but because of the increase in body weight during this time a relative dehydration occurred. This did not affect the relationship between energy expenditure, body weight and food intake.

6. Carcases of rats from birth to maturity were analysed for water, nitrogen, fat and heat of combustion.

7. Both from carcase analysis and from metabolic studies, the nitrogen retained per dry body weight increment decreased with age, while fat and non-protein calories increased.

8. The difference in the composition of body weight gained during growth is emphasized.

9. The significance of metabolic changes during growth and the pattern of weight gain at different ages is discussed.

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SOME ASPECTS OF THE METABOLIC PATTERN OF GROWTH

by

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VOLUME TWO

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(33) Food consumption 114

(34) Energy balance 126

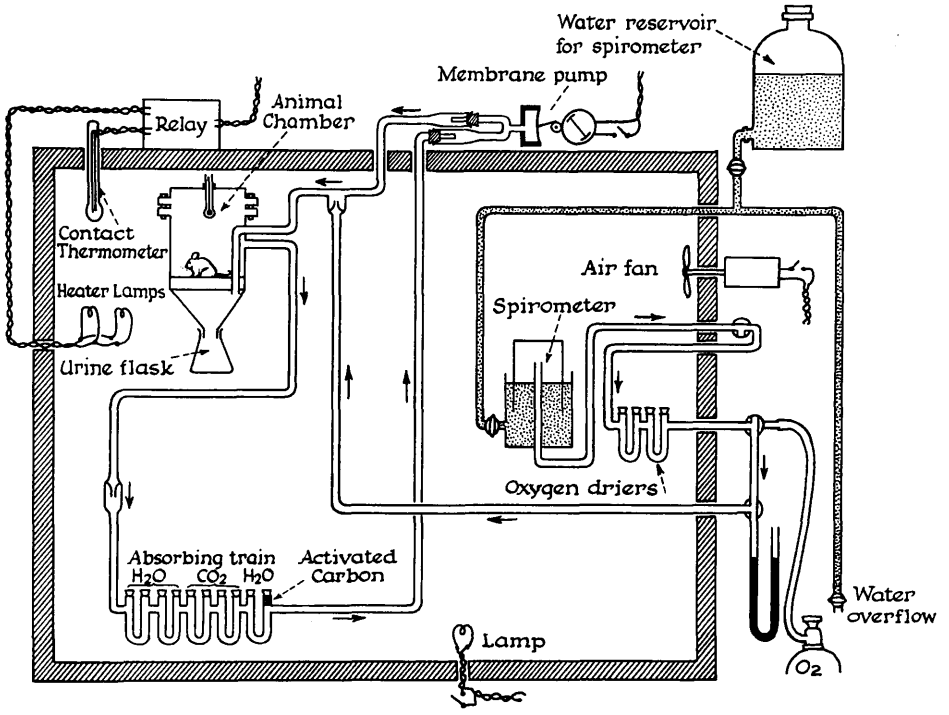
(35) R.Q. and times of runs 138

(36) Nitrogen balance 149

(37) Components of water intake 161

(38) Components of water loss 173

(39) Water balance 184

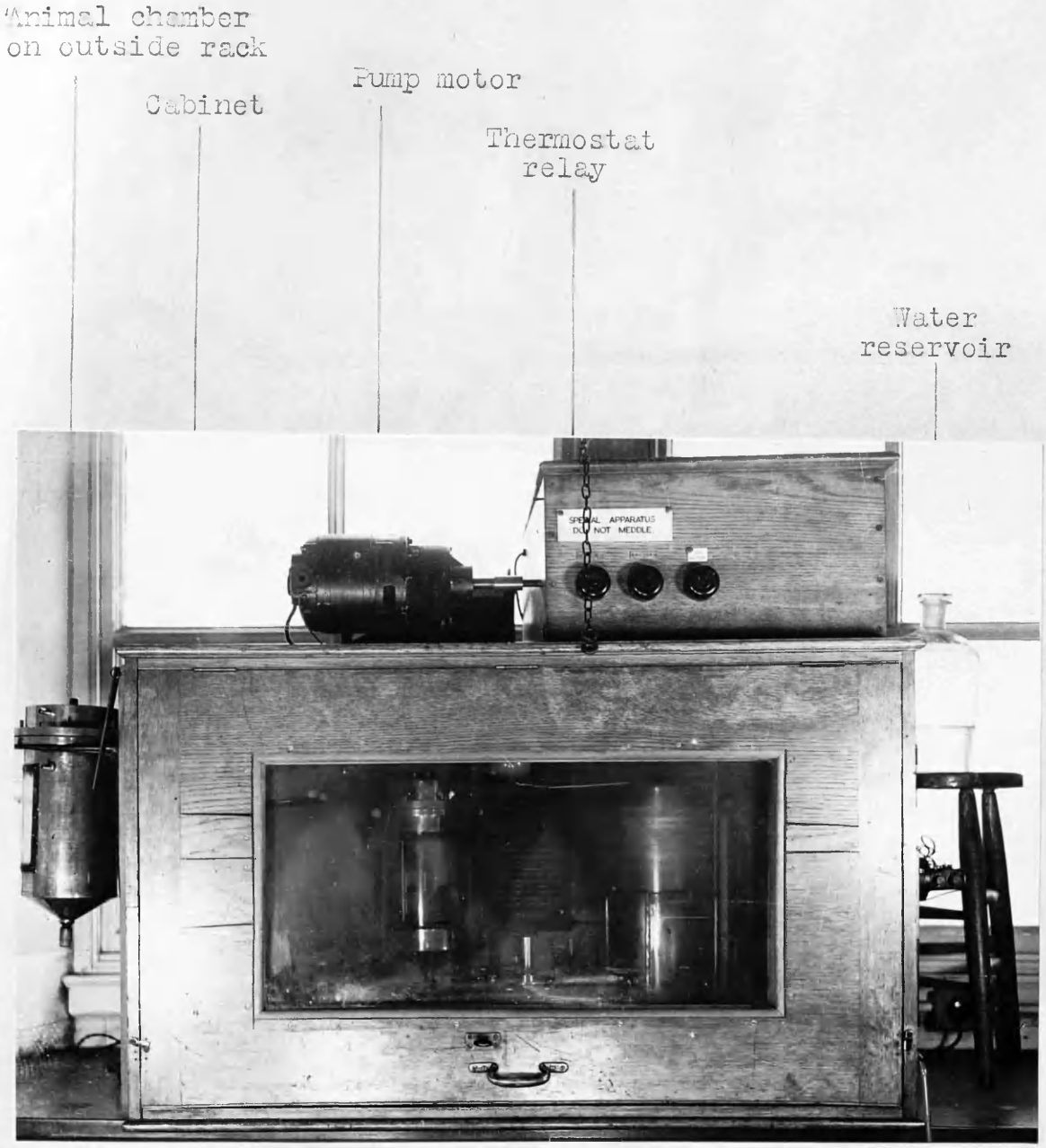


Metabolic Apparatus

Arrows show direction of air flow.

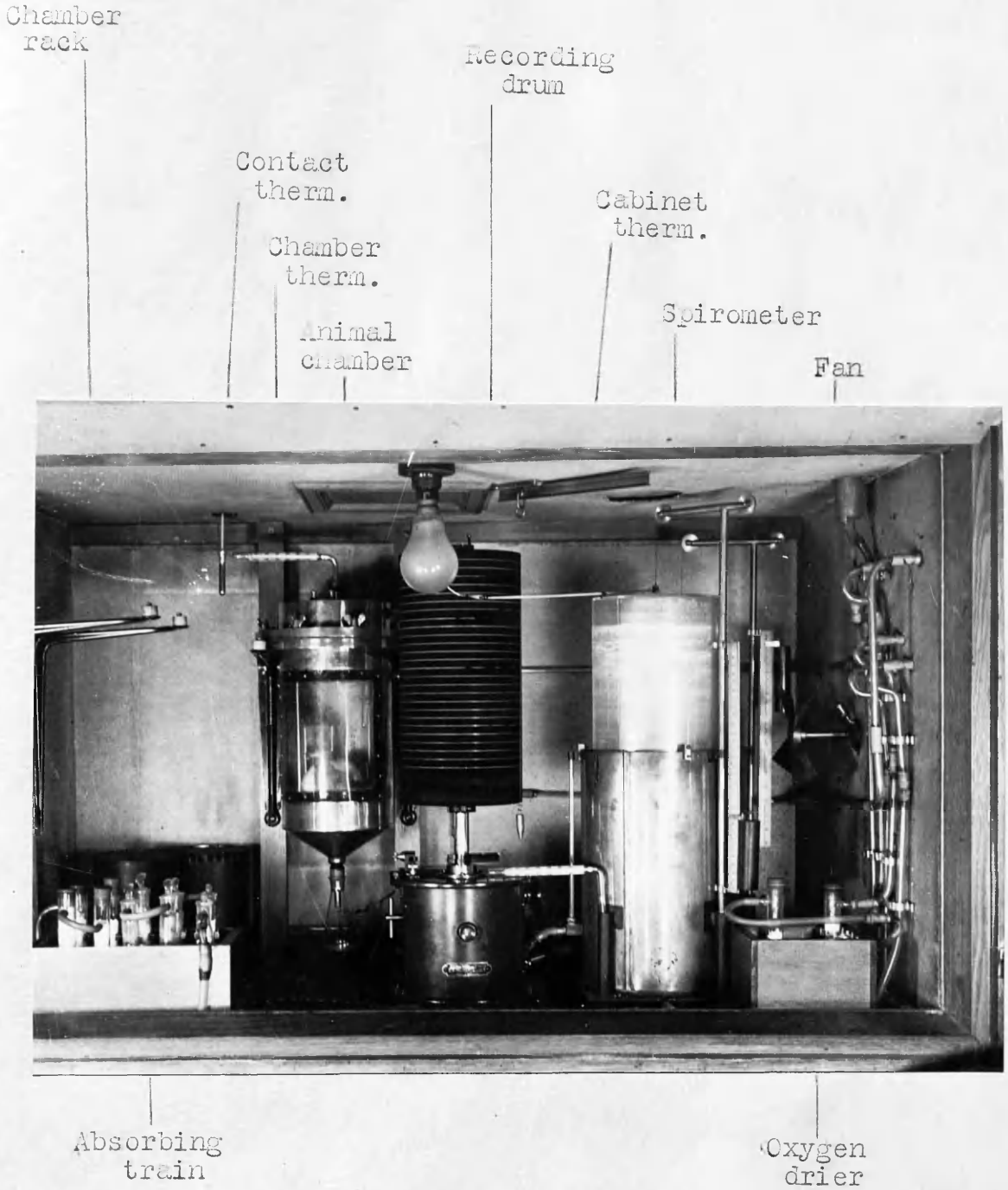
Diagram of closed-circuit respirometer

Figure (1)



Photograph of metabolic apparatus

Figure (2)



Photograph of contents of cabinet of metabolic apparatus

Figure (3)

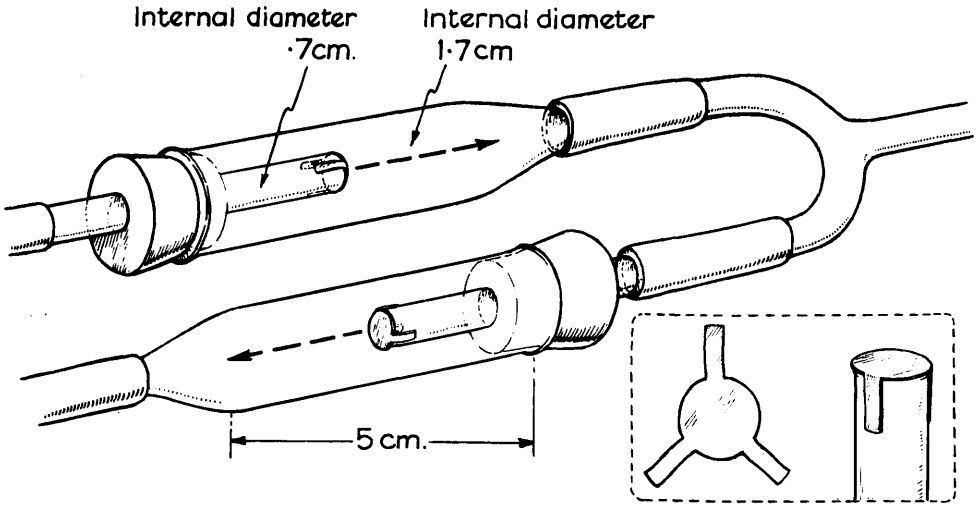
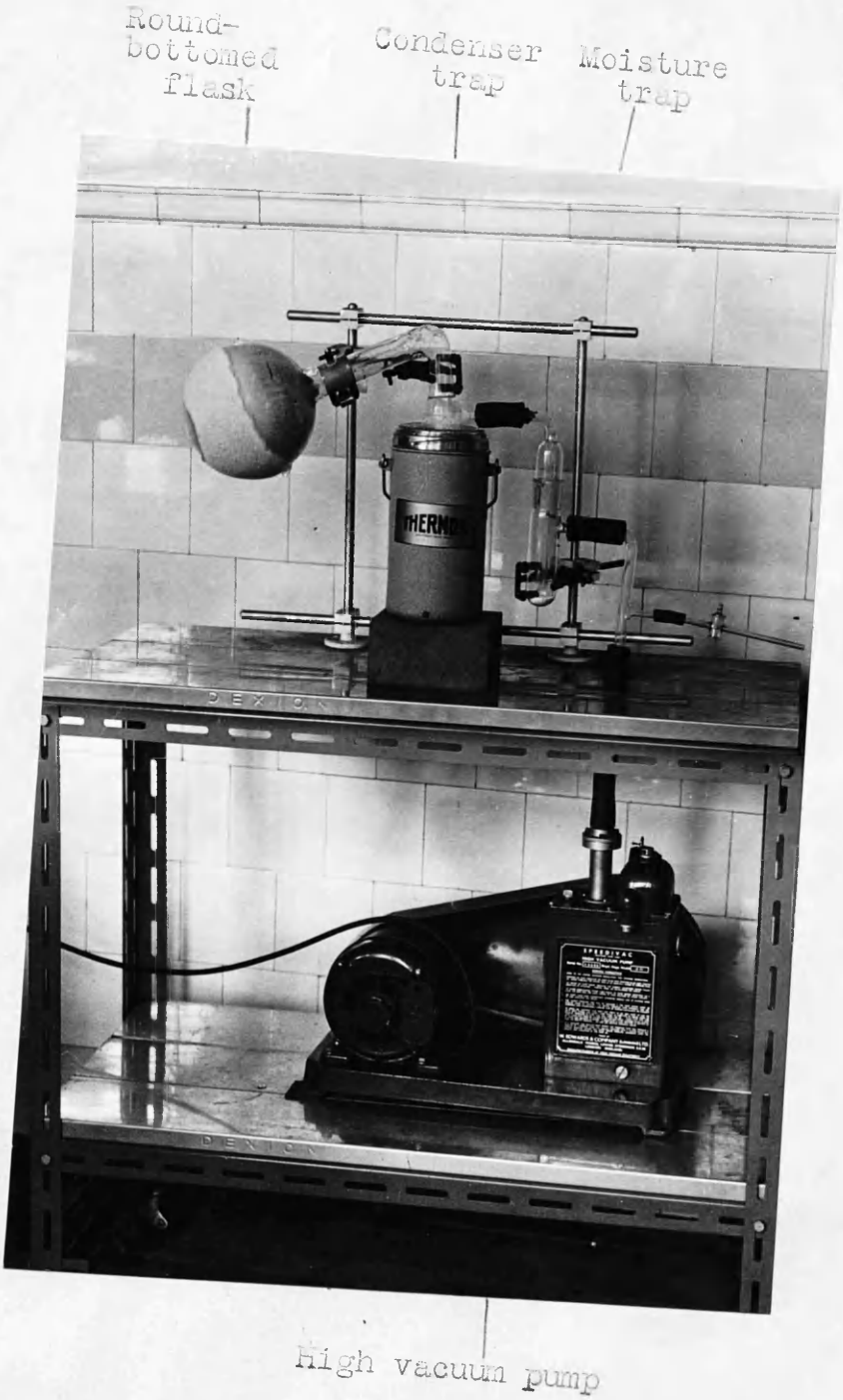


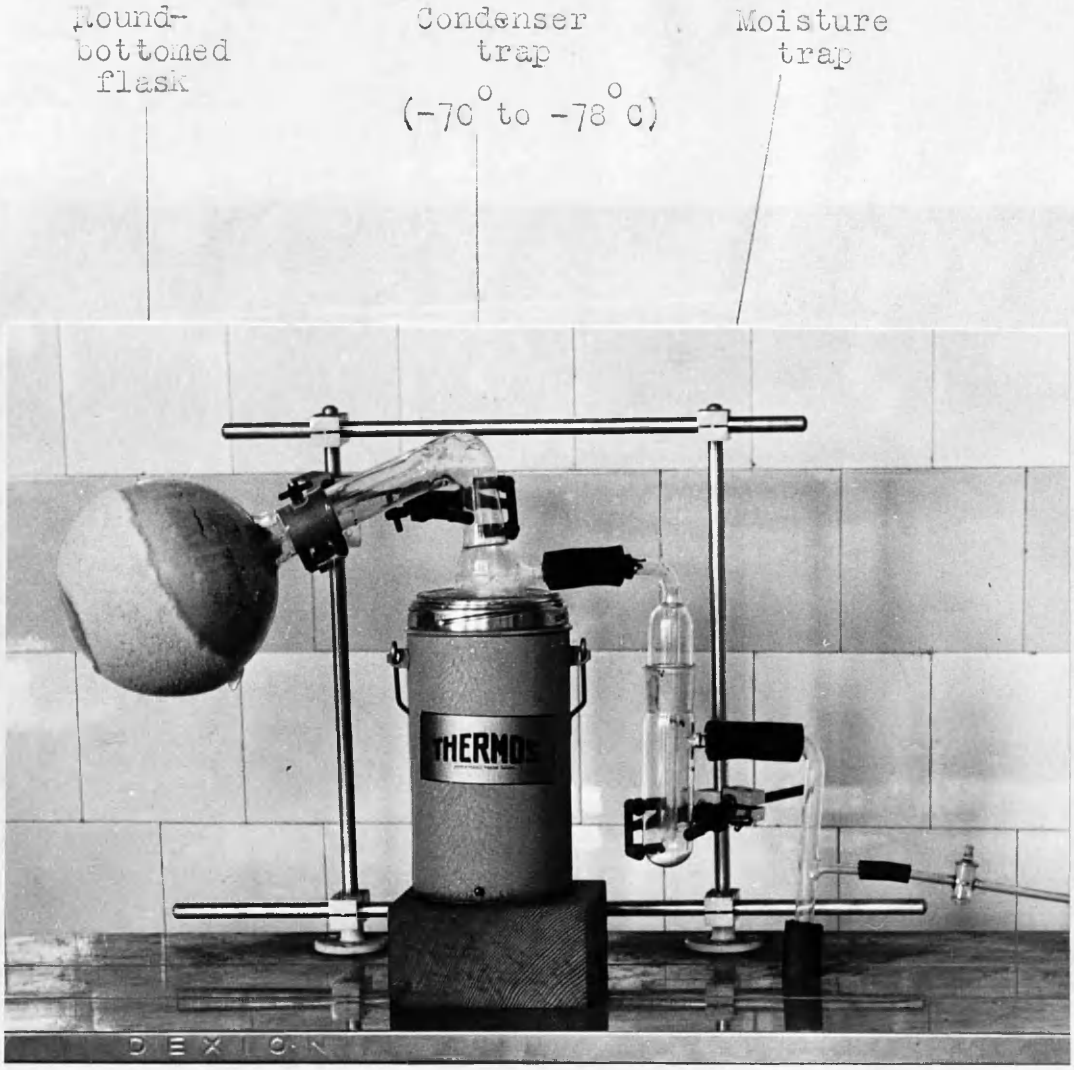
Diagram of Flap valves

Figure (4)



Apparatus for freeze-drying

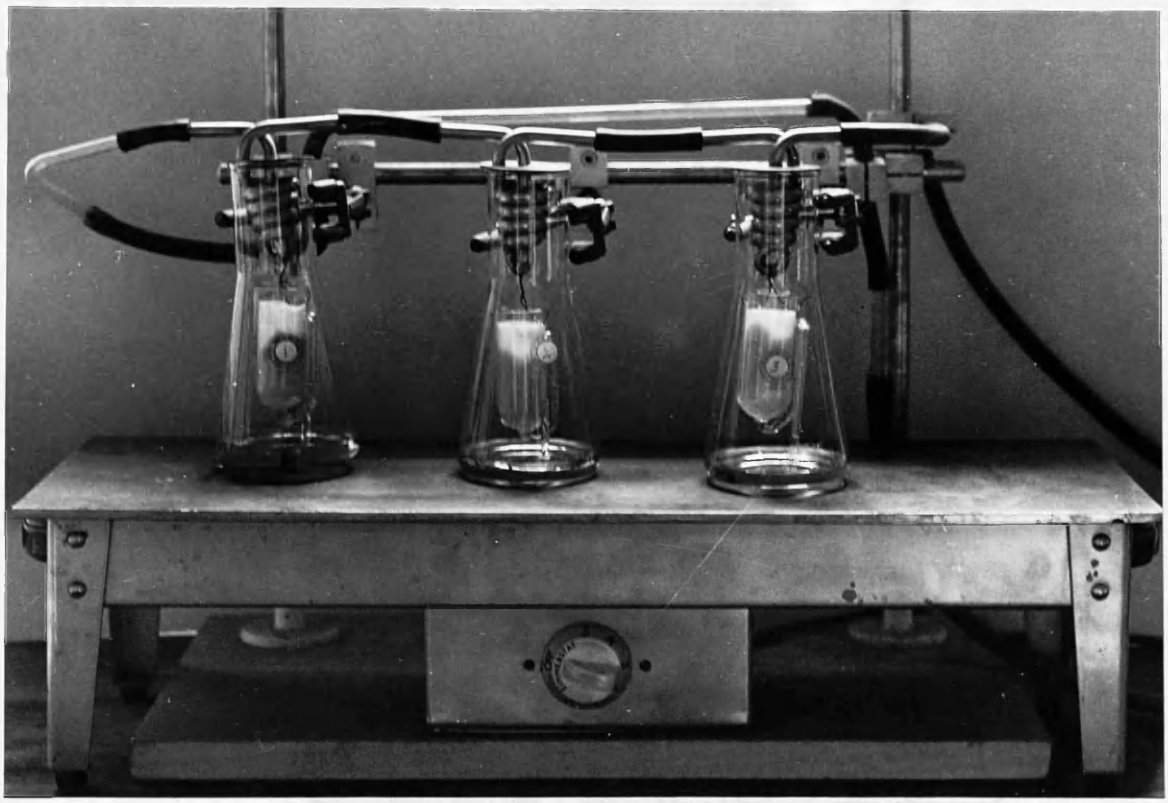
Figure (5)



Apparatus for freeze-drying

(enlarged view)

Figure (6)



Soxhlet apparatus for fat estimations

Figure (7)

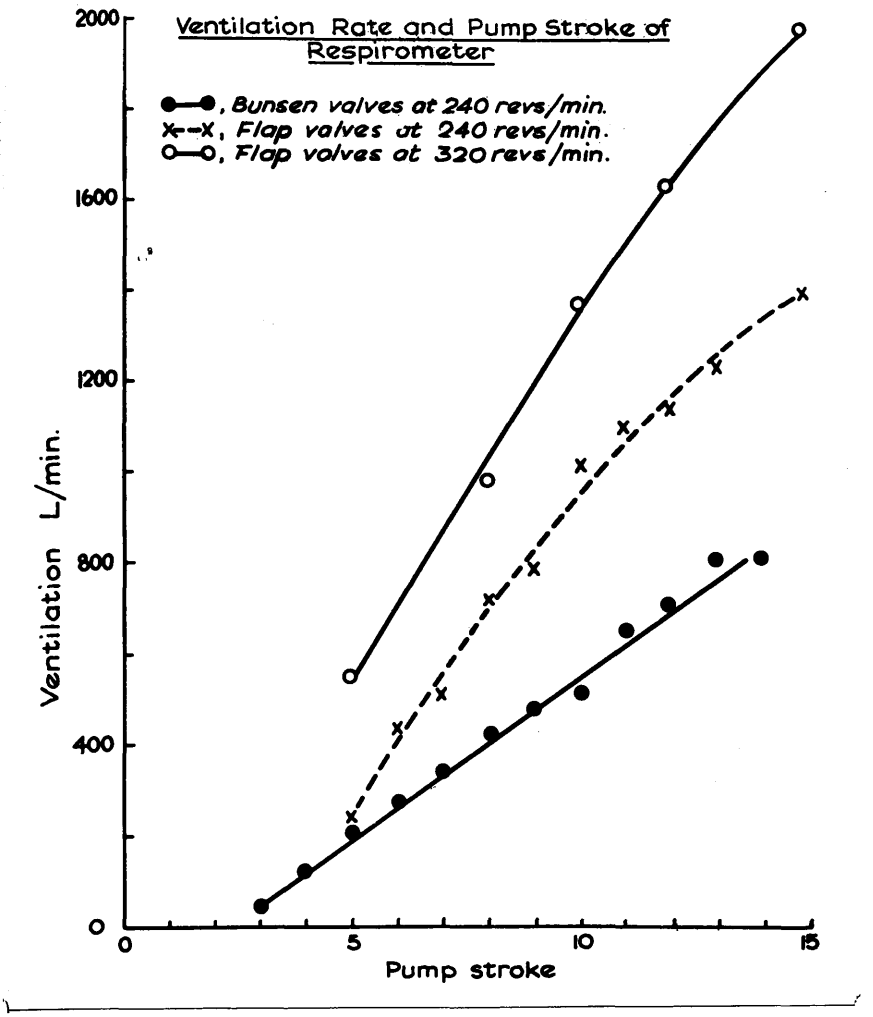
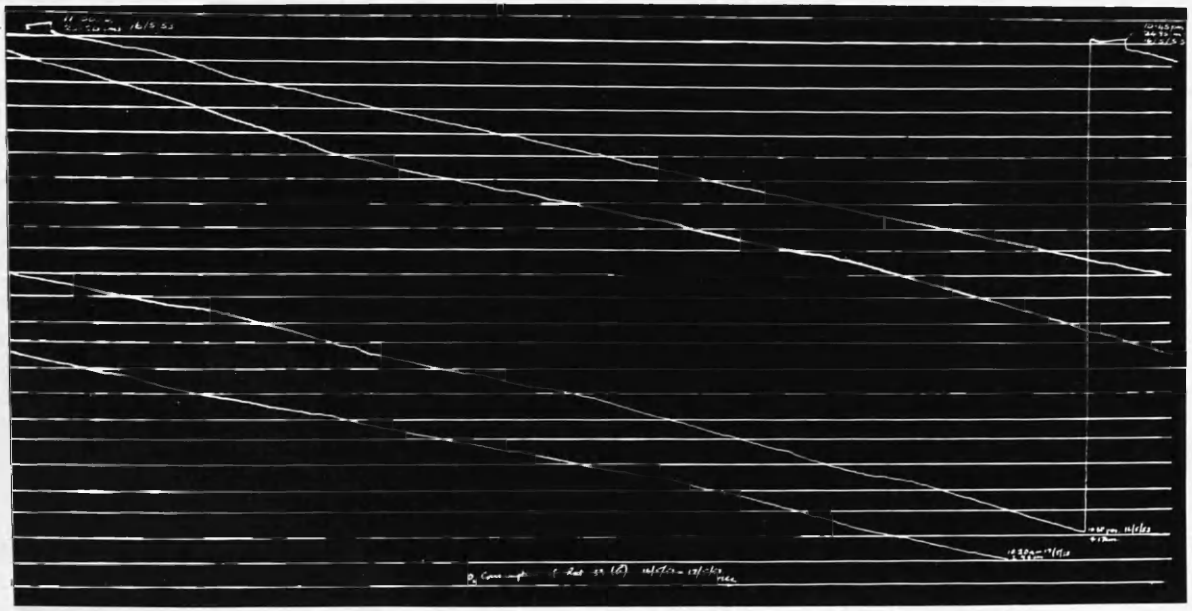
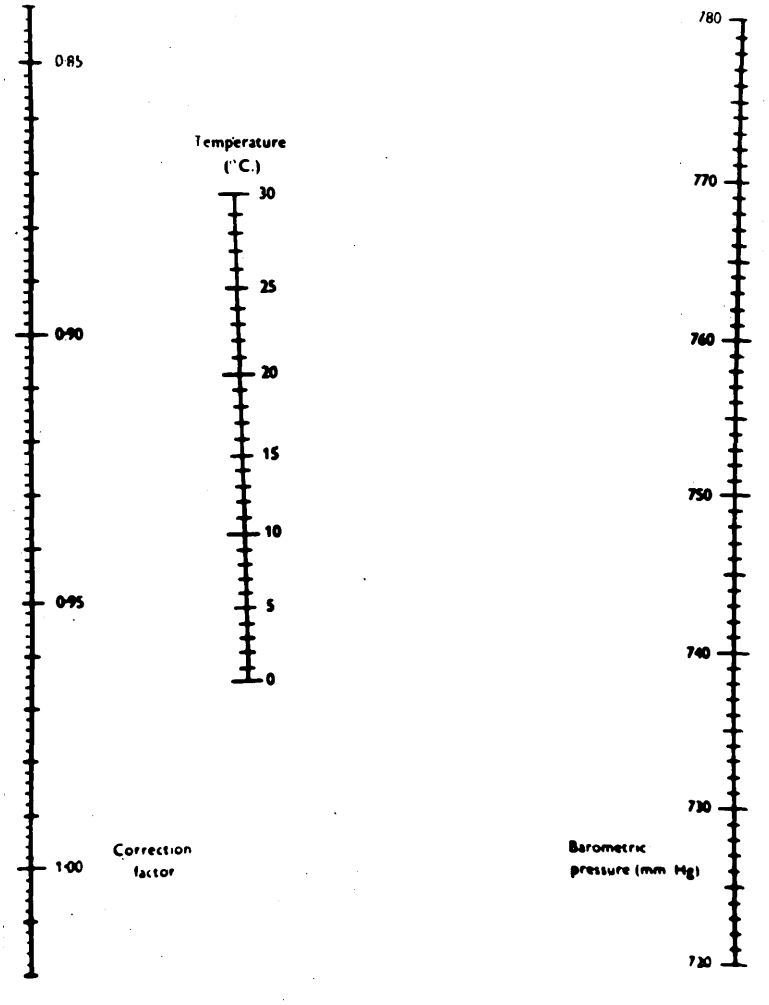

Ventilation Rate and Pump Stroke of Respirometer
●—●, Bunsen valves at 240 revs/min.
x--x, Flap valves at 240 revs/min.
o—o, Flap valves at 320 revs/min.
Ventilation L/min.
2000
1600
1200
800
400
0
0
5
10
15
Pump stroke

Figure (8)

Figure (9)



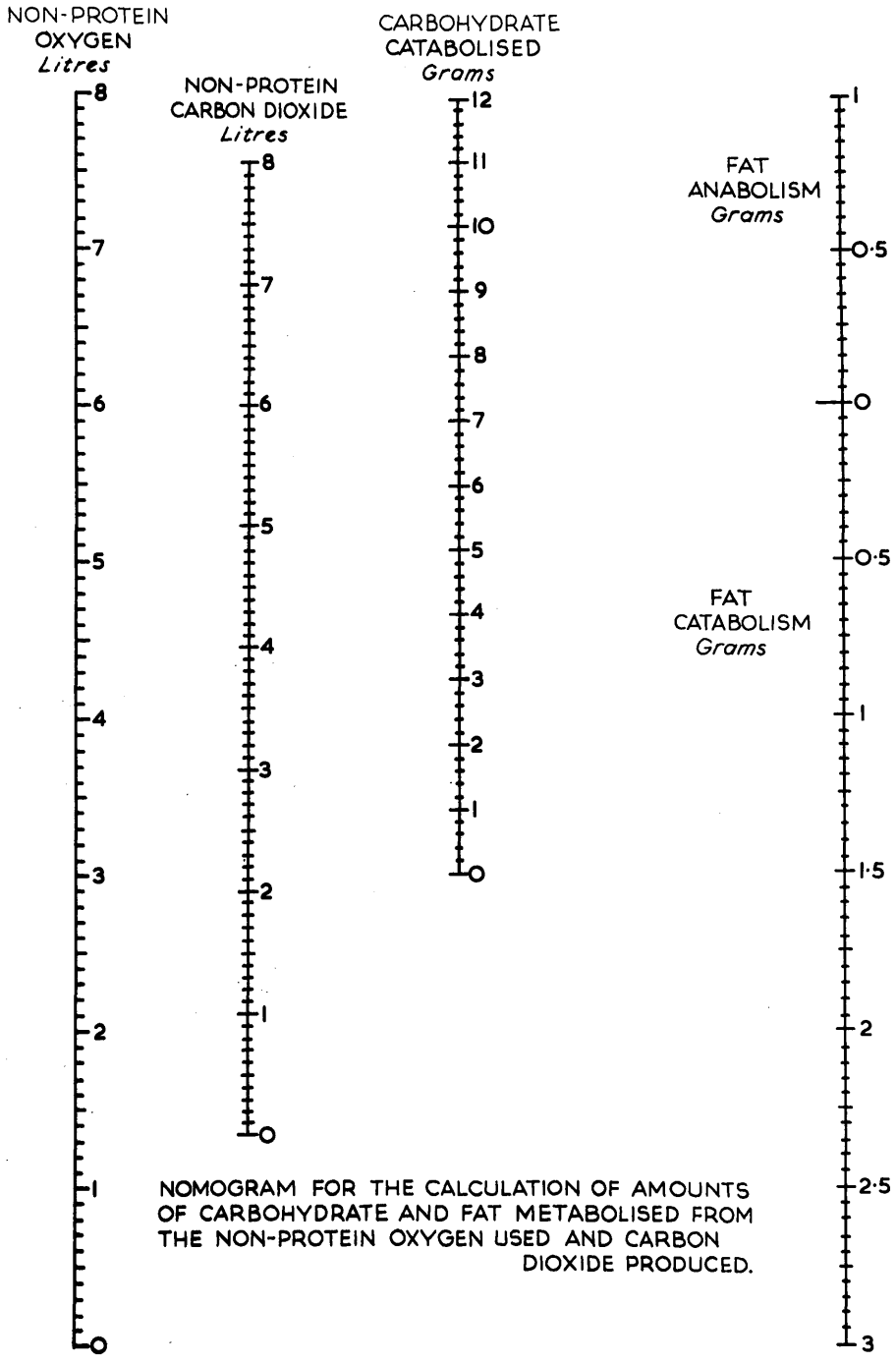
Specimen of trace of oxygen consumption



Nomogram for derivation of correction factor for reduction of gas volumes to S.T.P.

(After Weir, 1949)

Figure (10)



NOMOGRAM FOR THE CALCULATION OF AMOUNTS OF CARBOHYDRATE AND FAT METABOLISED FROM THE NON-PROTEIN OXYGEN USED AND CARBON DIOXIDE PRODUCED.

Figure (11)

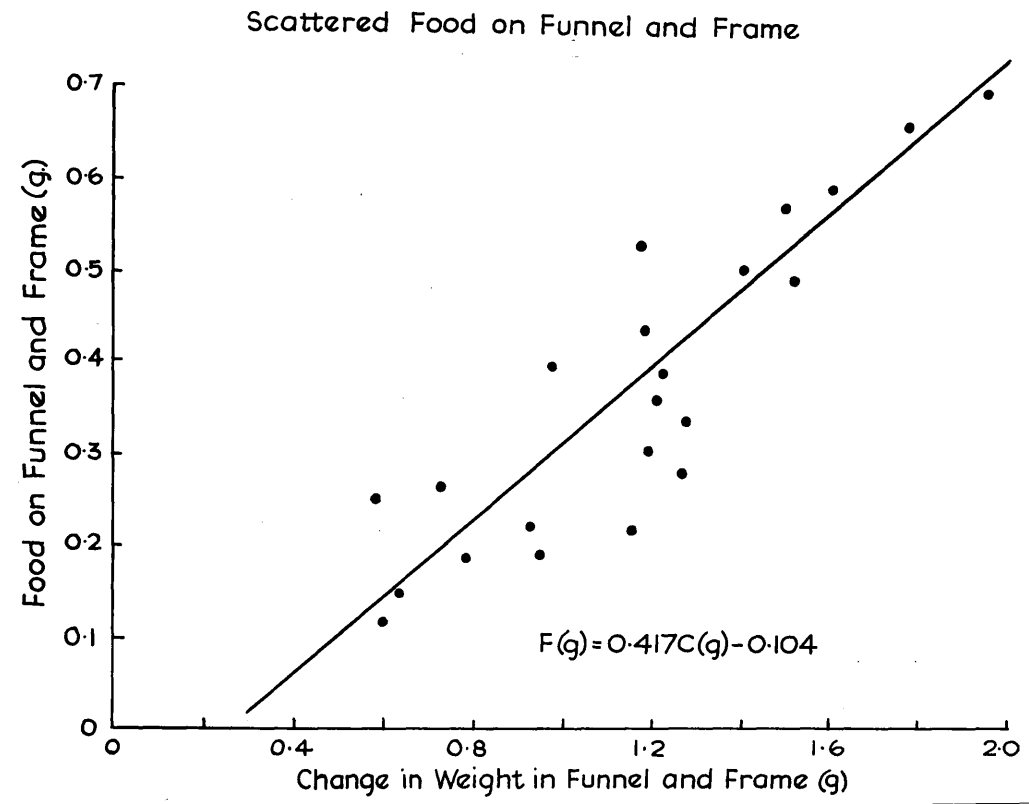

Scattered Food on Funnel and Frame
Food on Funnel and Frame (g.)
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
0
0·4
0·8
1·2
1·6
2·0
Change in Weight in Funnel and Frame (g)
F(g) = 0·417C(g) - 0·104

Figure (12)

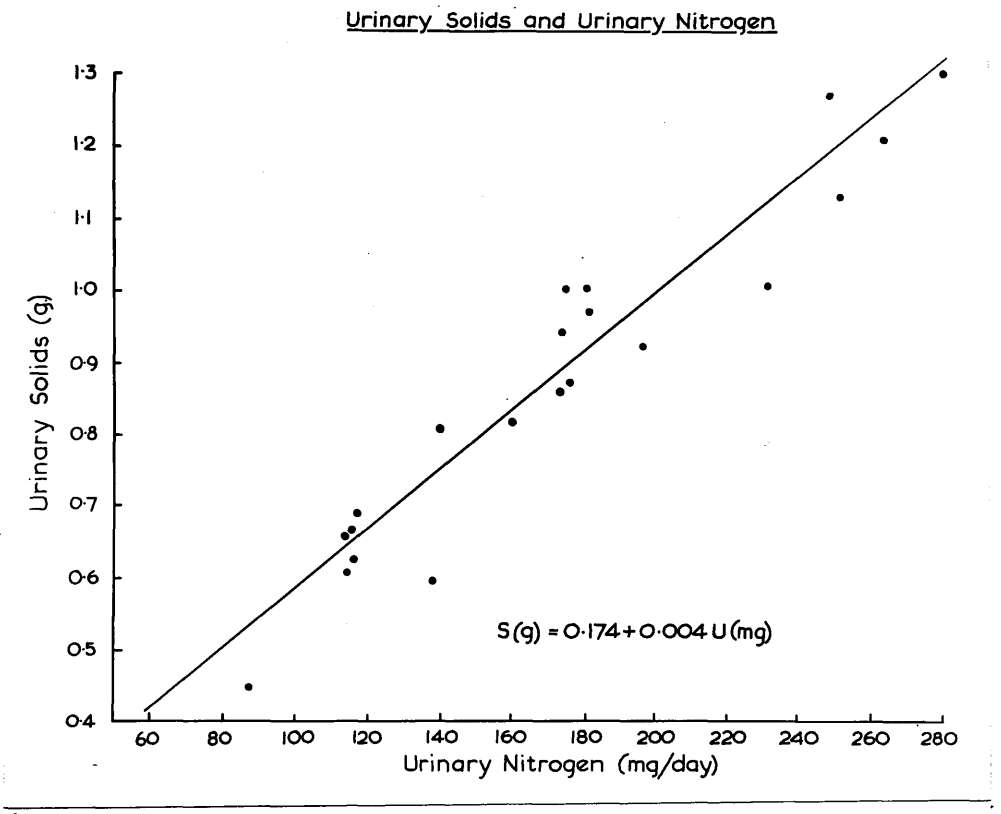

Urinary Solids and Urinary Nitrogen
Urinary Solids (g)
1·3
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
60
80
100
120
140
160
180
200
220
240
260
280
Urinary Nitrogen (mg/day)
S(g) = 0·174 + 0·004 U(mg)

Figure (13)

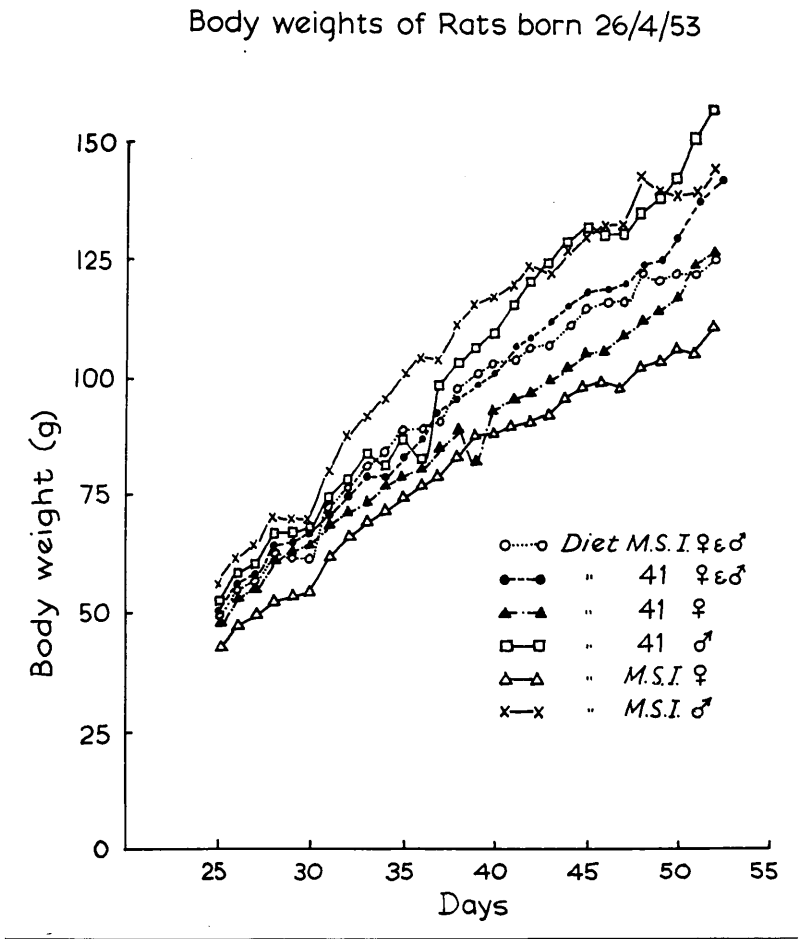

Body weights of Rats born 26/4/53
Body weight (g)
150
125
100
75
50
25
0
25
30
35
40
45
50
55
Days
Diet M.S.I. ♀♂
" 41 ♀♂
" 41 ♀
" 41 ♂
" M.S.I. ♀
" M.S.I. ♂

Figure (14)

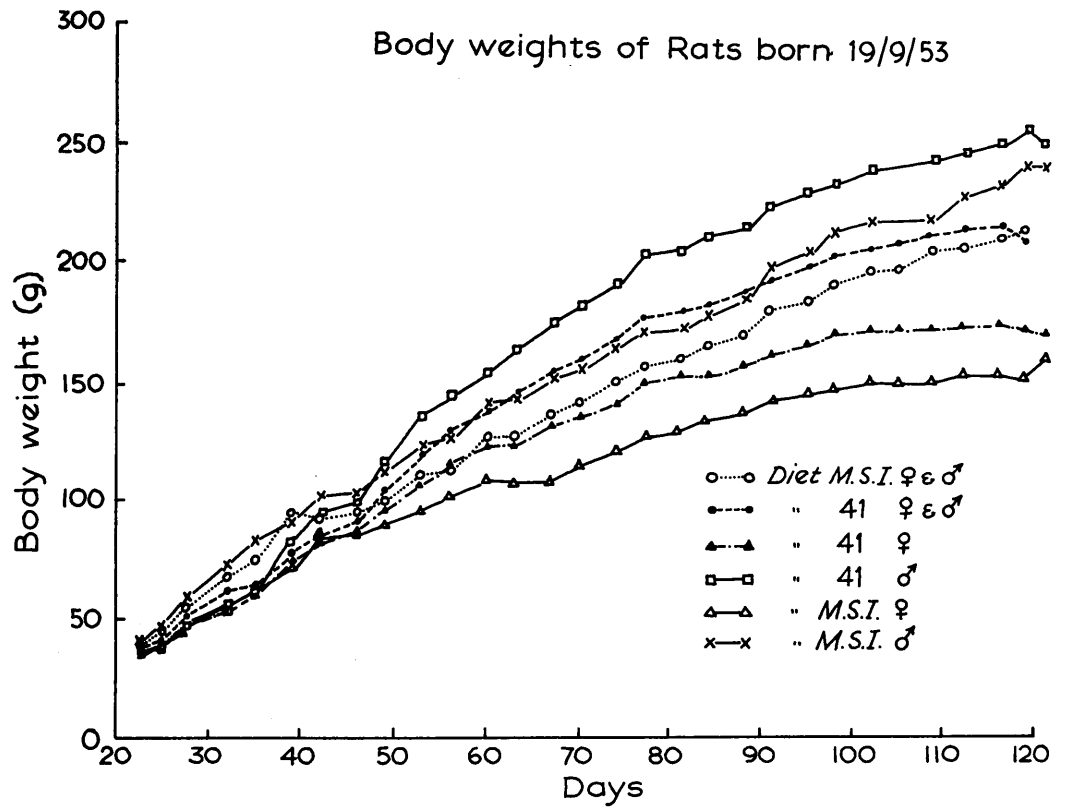

Body weights of Rats born 19/9/53
Body weight (g)
300
250
200
150
100
50
0
20
30
40
50
60
70
80
90
100
110
120
Days
Diet M.S.I. ♀ & ♂
" 41 ♀ & ♂
" 41 ♀
" 41 ♂
" M.S.I. ♀
" M.S.I. ♂

Figure (15)

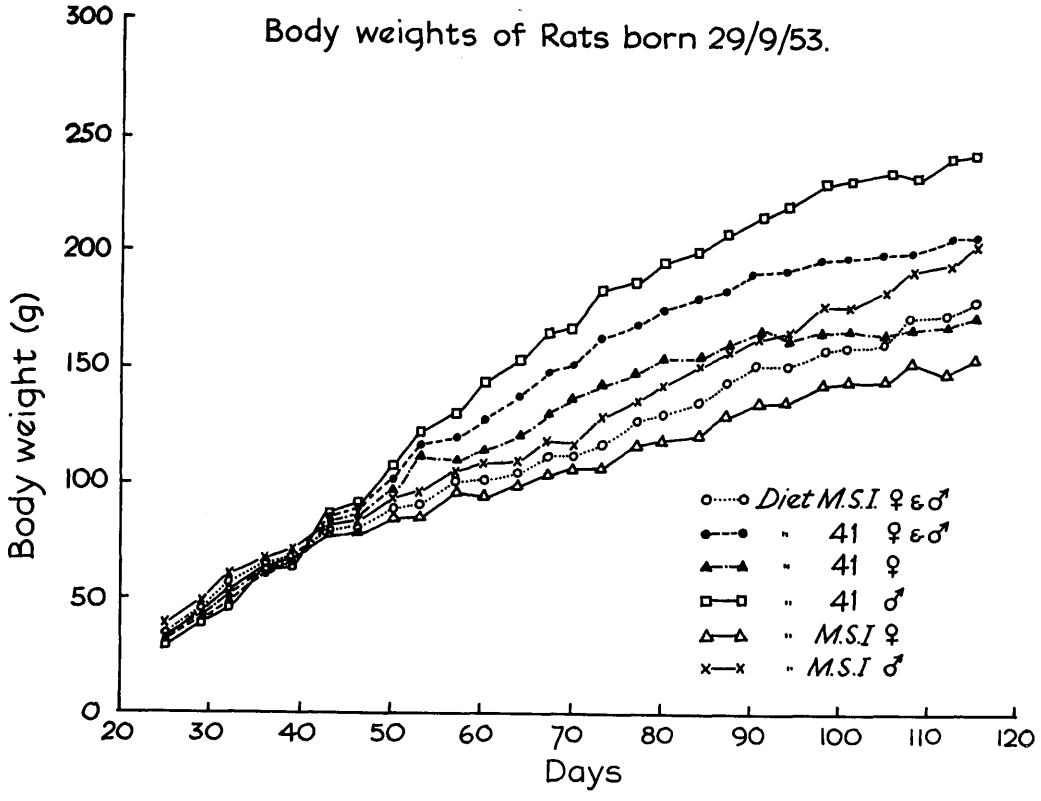

Body weights of Rats born 29/9/53.
Body weight (g)
300
250
200
150
100
50
0
20
30
40
50
60
70
80
90
100
110
120
Days
Diet M.S.I ♀ & ♂
" 41 ♀ & ♂
" 41 ♀
" 41 ♂
" M.S.I ♀
" M.S.I ♂

Figure (16)

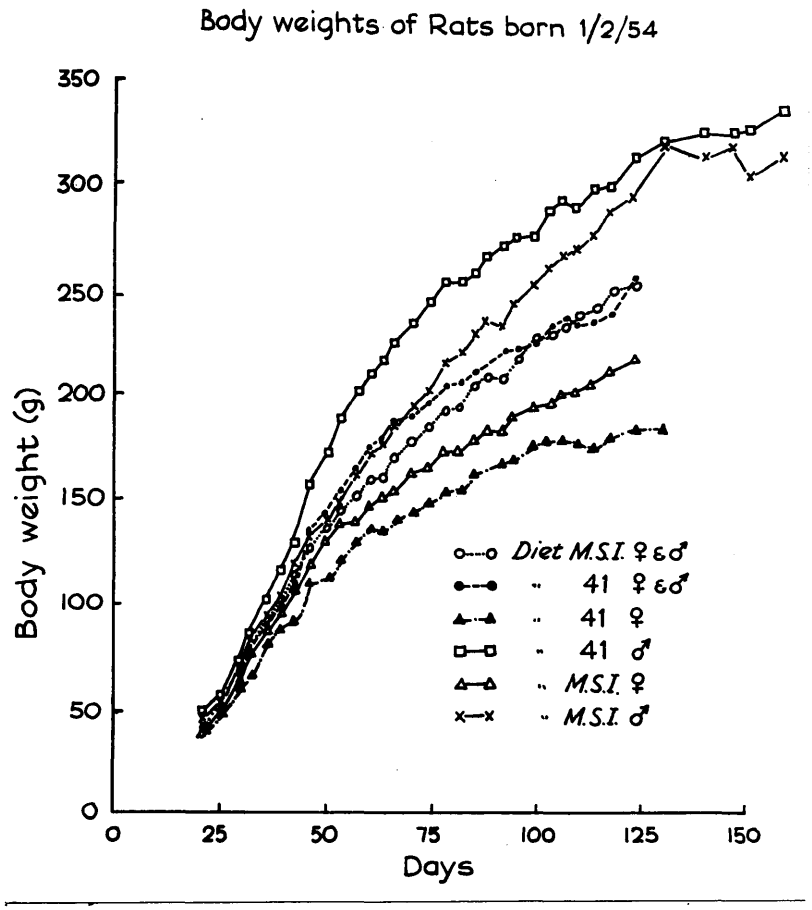

Body weights of Rats born 1/2/54
Body weight (g)
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
Days
Diet M.S.I. ♀♂
" 41 ♀♂
" 41 ♀
" 41 ♂
" M.S.I. ♀
" M.S.I. ♂

Figure (17)

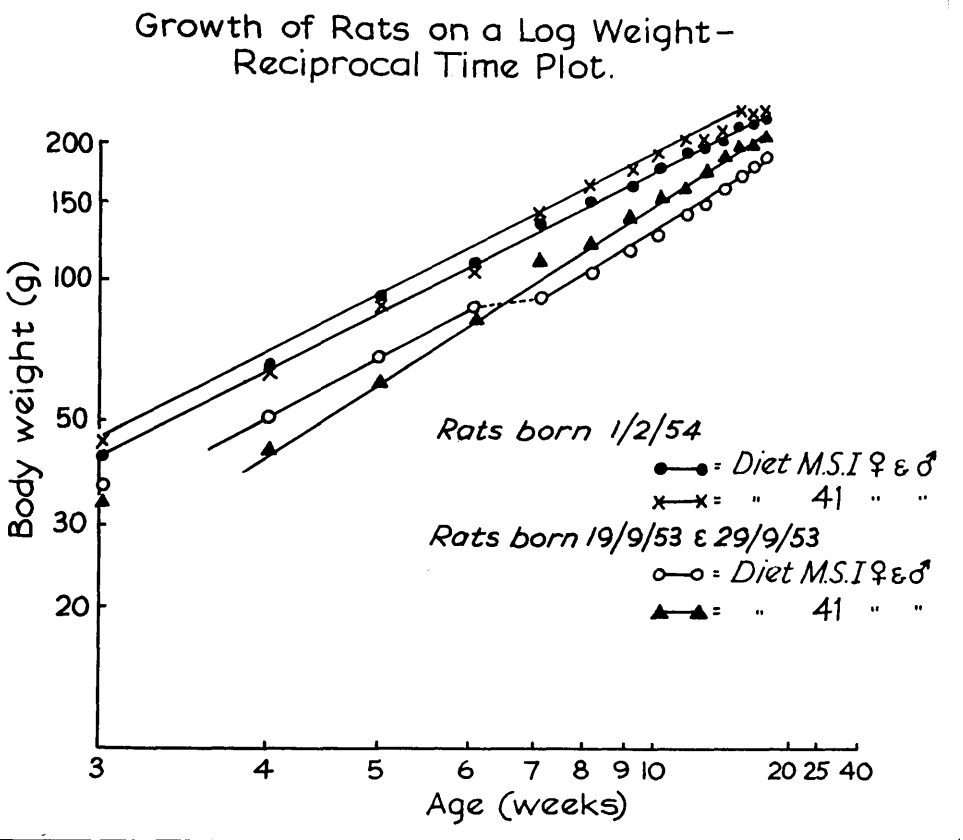
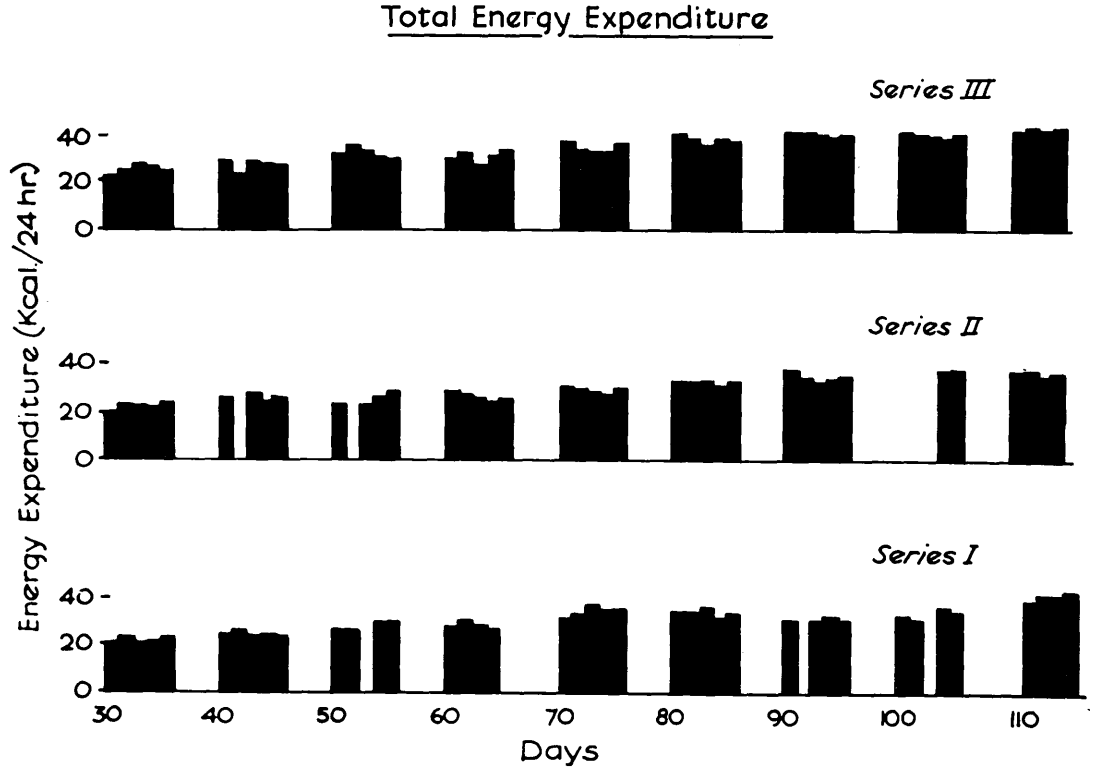

Growth of Rats on a Log Weight–Reciprocal Time Plot.
Body weight (g)
200
150
100
50
30
20
3
4
5
6
7
8
9
10
20
25
40
Age (weeks)
Rats born 1/2/54
= Diet M.S.I ♀ & ♂
= " 41 " "
Rats born 19/9/53 & 29/9/53
= Diet M.S.I ♀ & ♂
= " 41 " "

Figure (18)



Daily total energy expenditure

Figure (19)

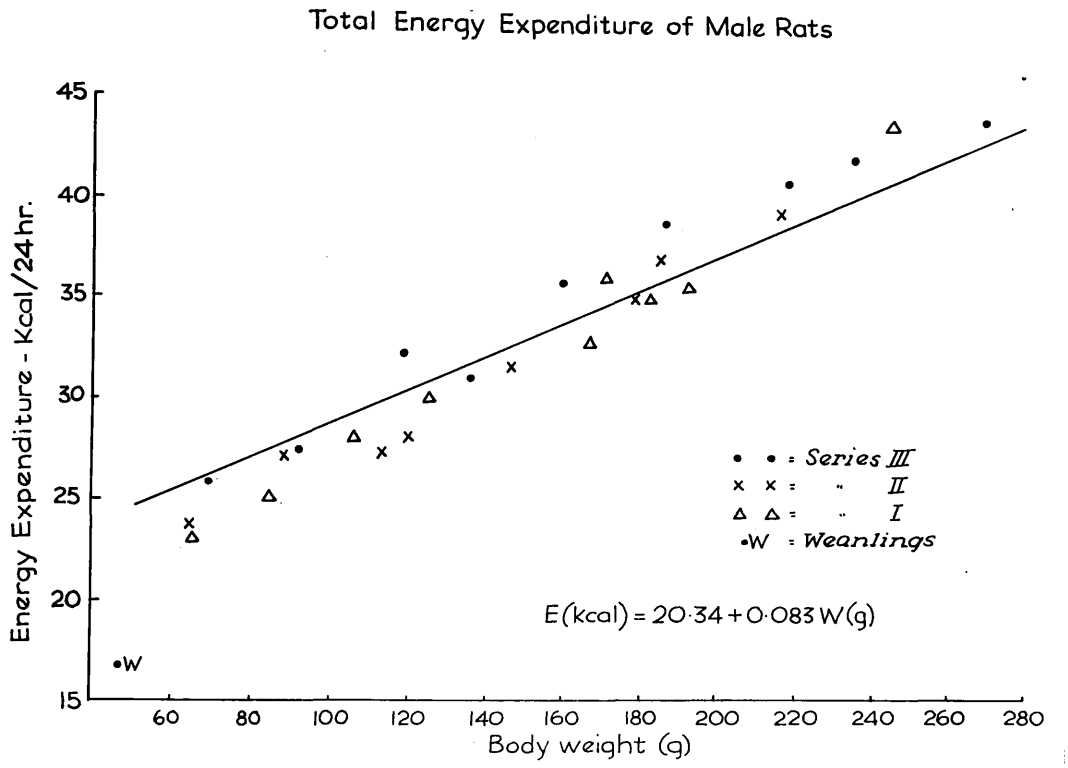
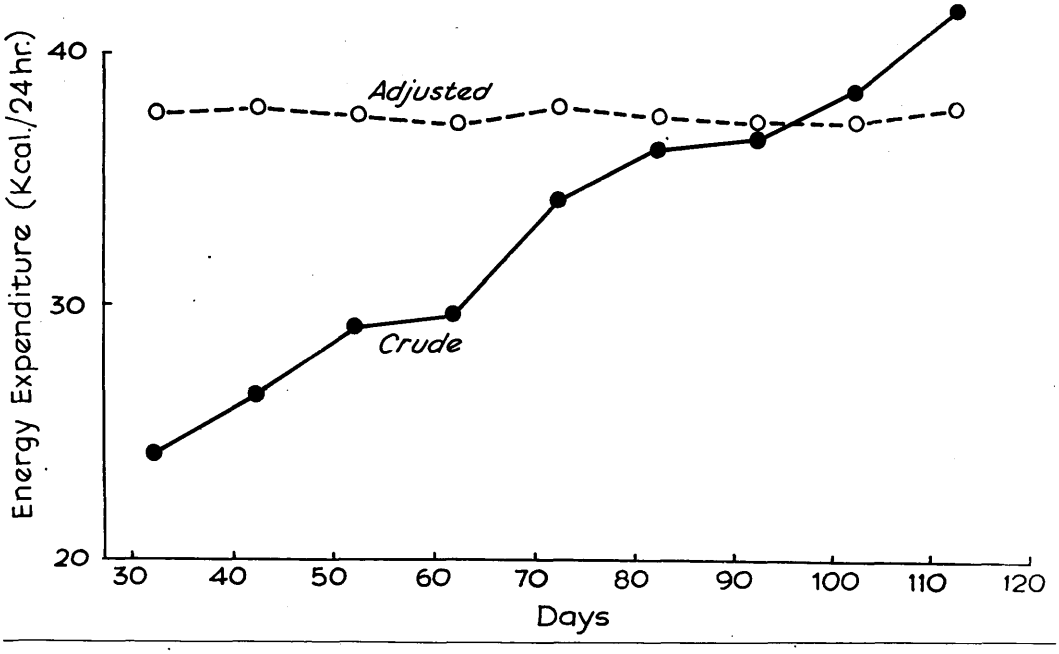
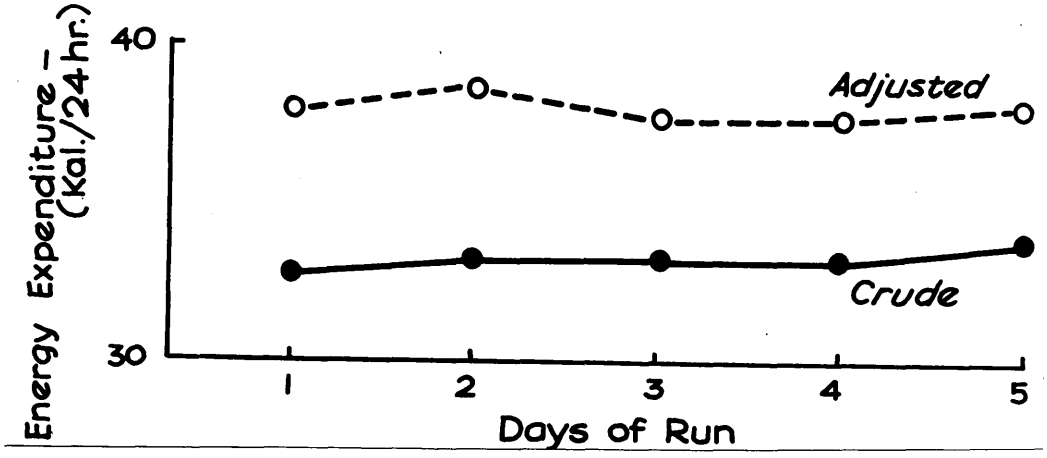

Total Energy Expenditure of Male Rats
Energy Expenditure - Kcal/24hr.
45
40
35
30
25
20
15
60
80
100
120
140
160
180
200
220
240
260
280
Body weight (g)
• • = Series III
× × = " II
△ △ = " I
•W = Weanlings
E(kcal) = 20·34 + 0·083 W(g)
•W

Figure (20)



Energy expenditure with age (actual and adjusted to standard body weight and standard food intake)

Figure (21)



Energy expenditure on 5 days of run (actual and adjusted to standard body weight and standard food intake)

Figure (22)

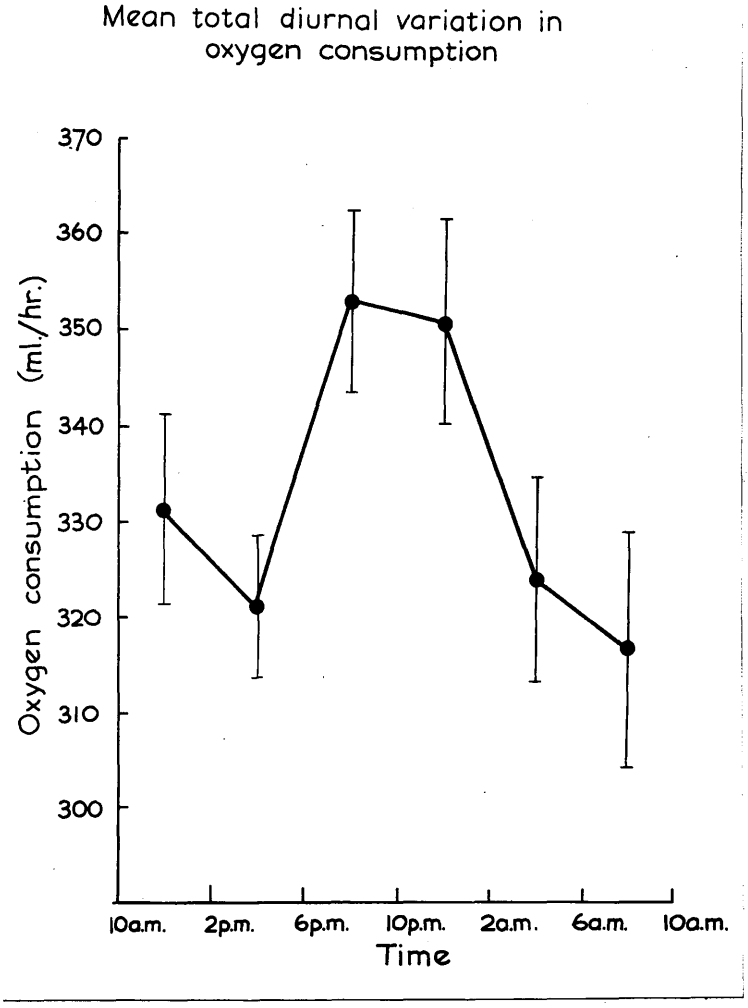

Mean total diurnal variation in oxygen consumption
Oxygen consumption (ml./hr.)
370
360
350
340
330
320
310
300
10a.m.
2p.m.
6p.m.
10p.m.
2a.m.
6a.m.
10a.m.
Time

Figure (23)

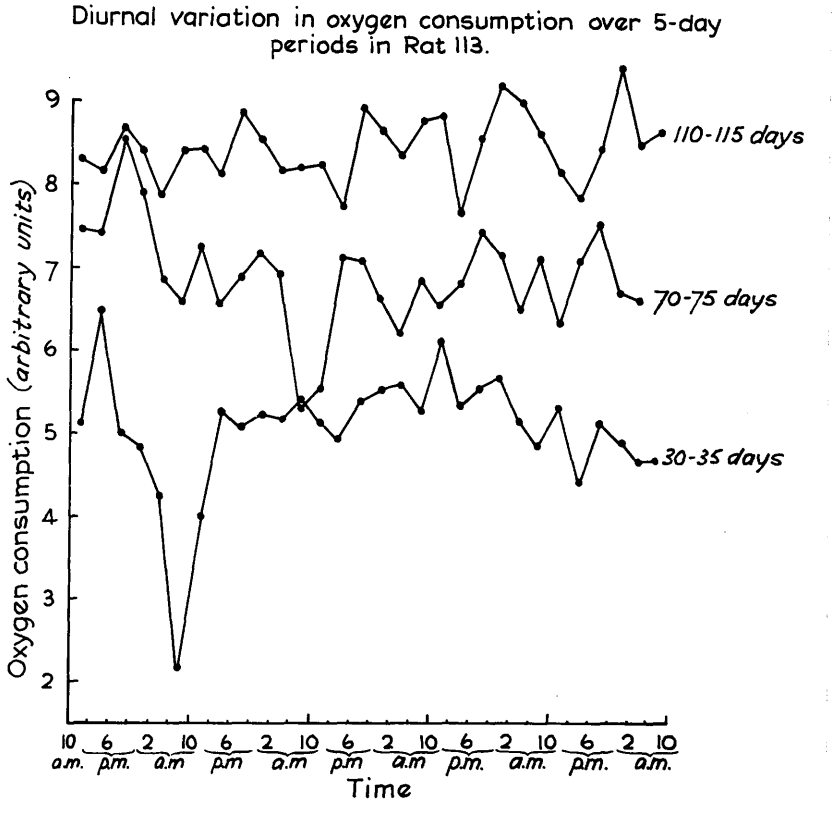

Diurnal variation in oxygen consumption over 5-day periods in Rat 113.
Oxygen consumption (arbitrary units)
9
8
7
6
5
4
3
2
110-115 days
70-75 days
30-35 days
10 a.m.
6 p.m.
2 a.m
10
6 p.m
2 a.m
10
6 p.m
2 a.m
10
6 p.m.
2 a.m.
10
6 p.m.
2 a.m.
Time

Figure (24)

Mean diurnal variation in oxygen consumption in two rats.

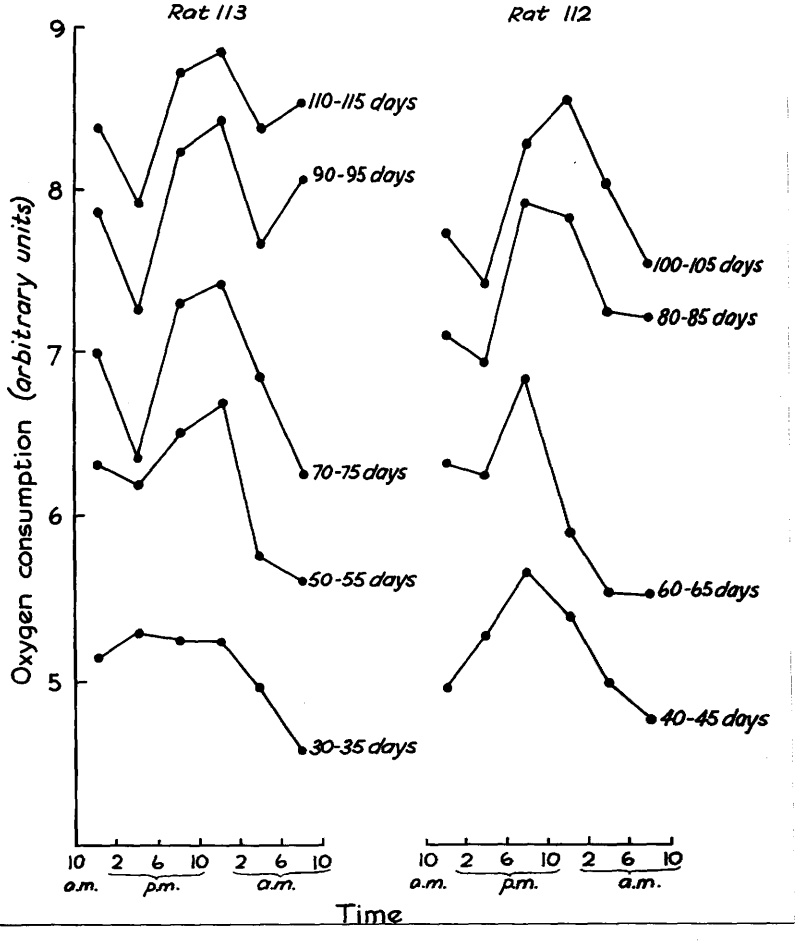
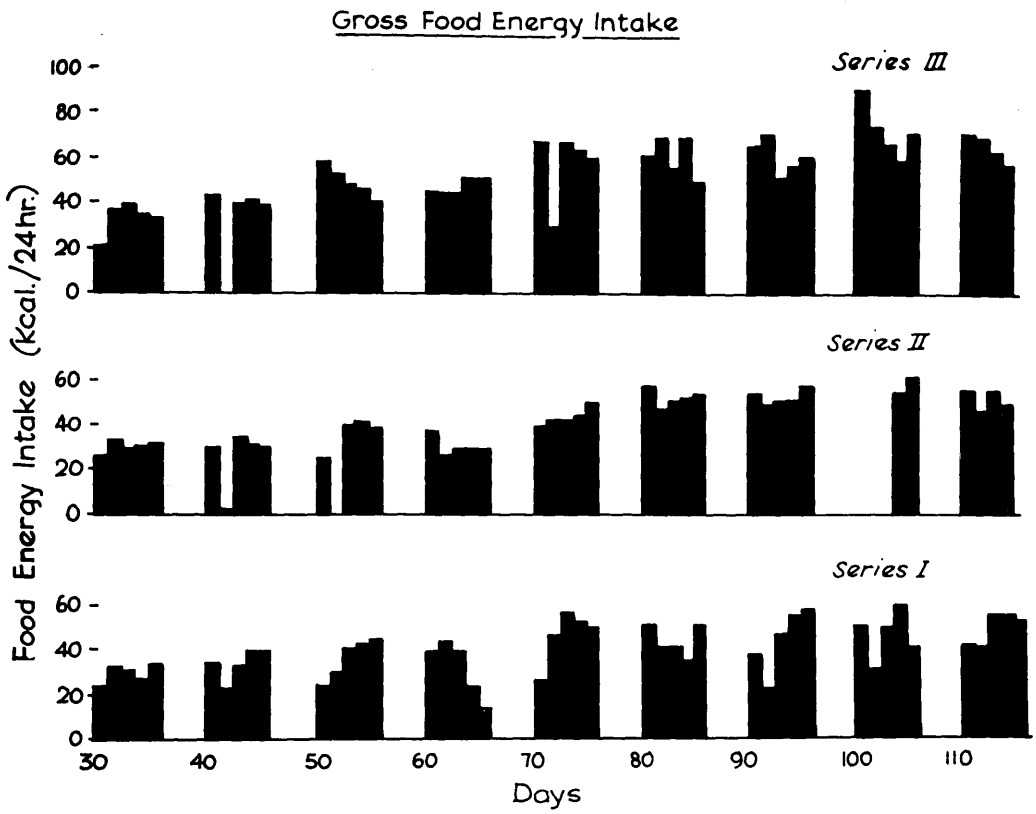


Figure (25)



Daily gross food energy intake

Figure (26)

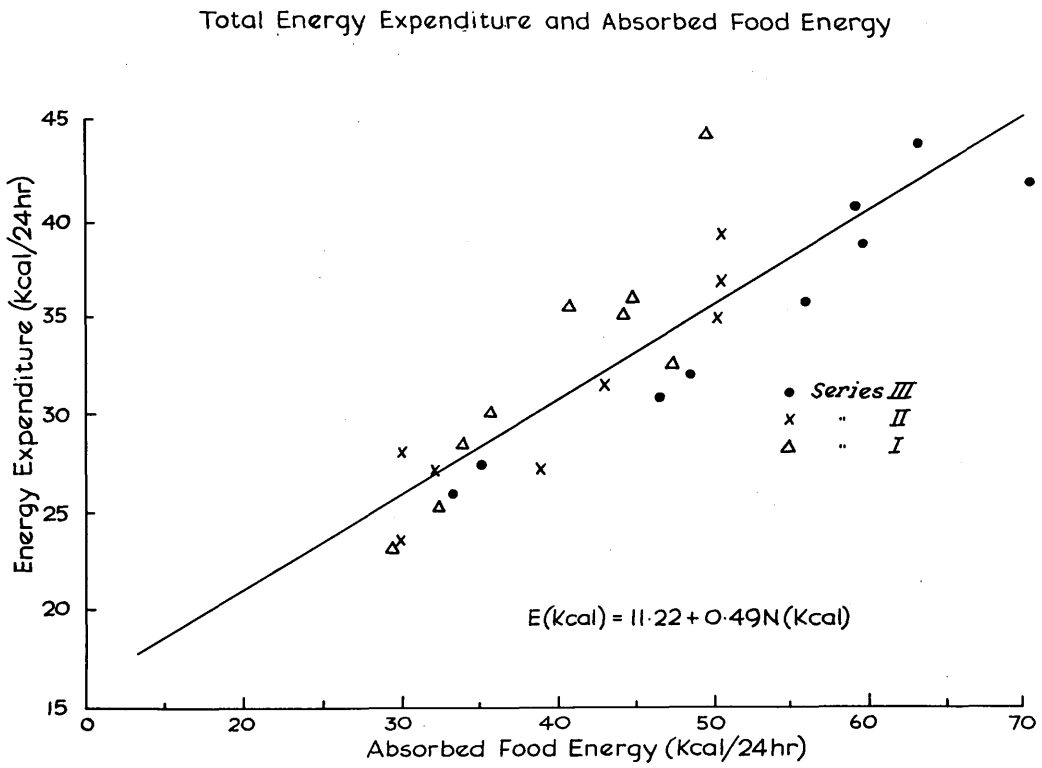
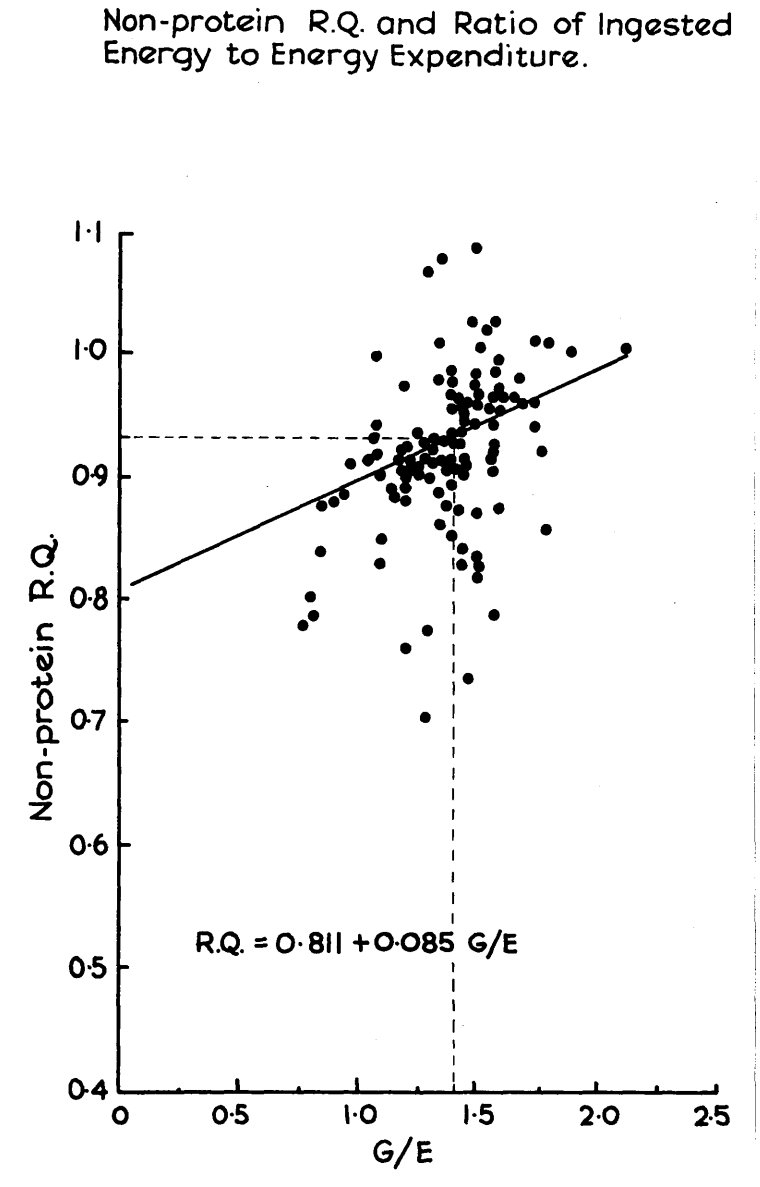
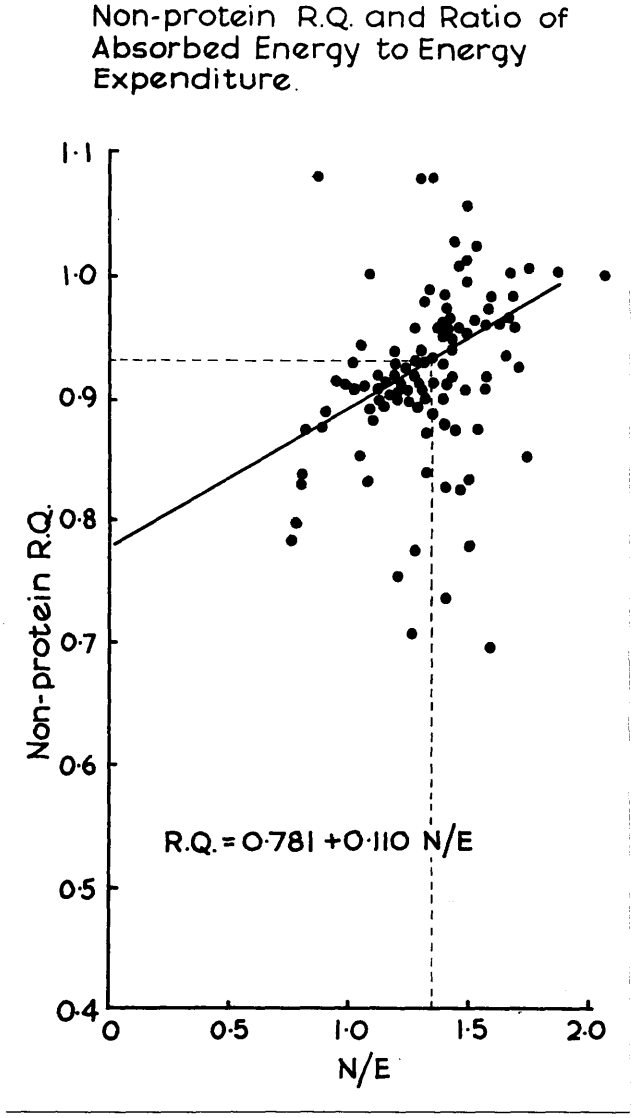

Total Energy Expenditure and Absorbed Food Energy
Energy Expenditure (Kcal/24hr)
45
40
35
30
25
20
15
0
20
30
40
50
60
70
Absorbed Food Energy (Kcal/24hr)
Series III
" II
" I
E(Kcal) = 11·22 + 0·49N(Kcal)

Figure (27)



Non-protein R.Q. and Ratio of Ingested Energy (G) to Energy Expenditure (E)

Figure (28)



Non-protein R.Q. and Ratio of Absorbed Energy (N) to Energy Expenditure (E)

Figure (29)

Faecal Energy and Ingested Energy

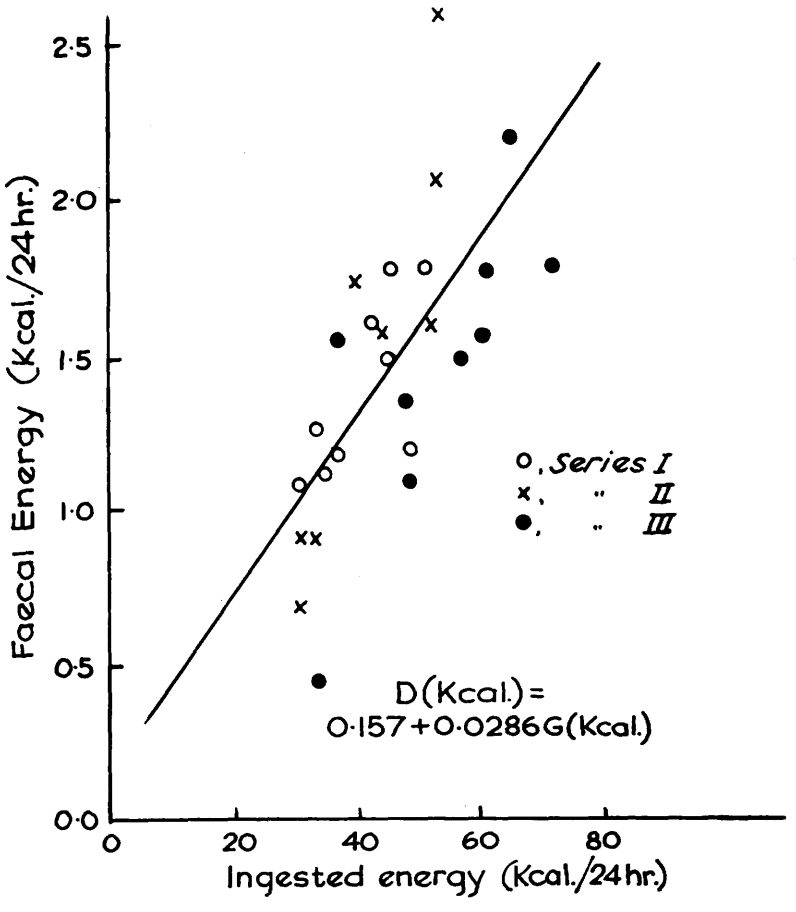


Figure (30)

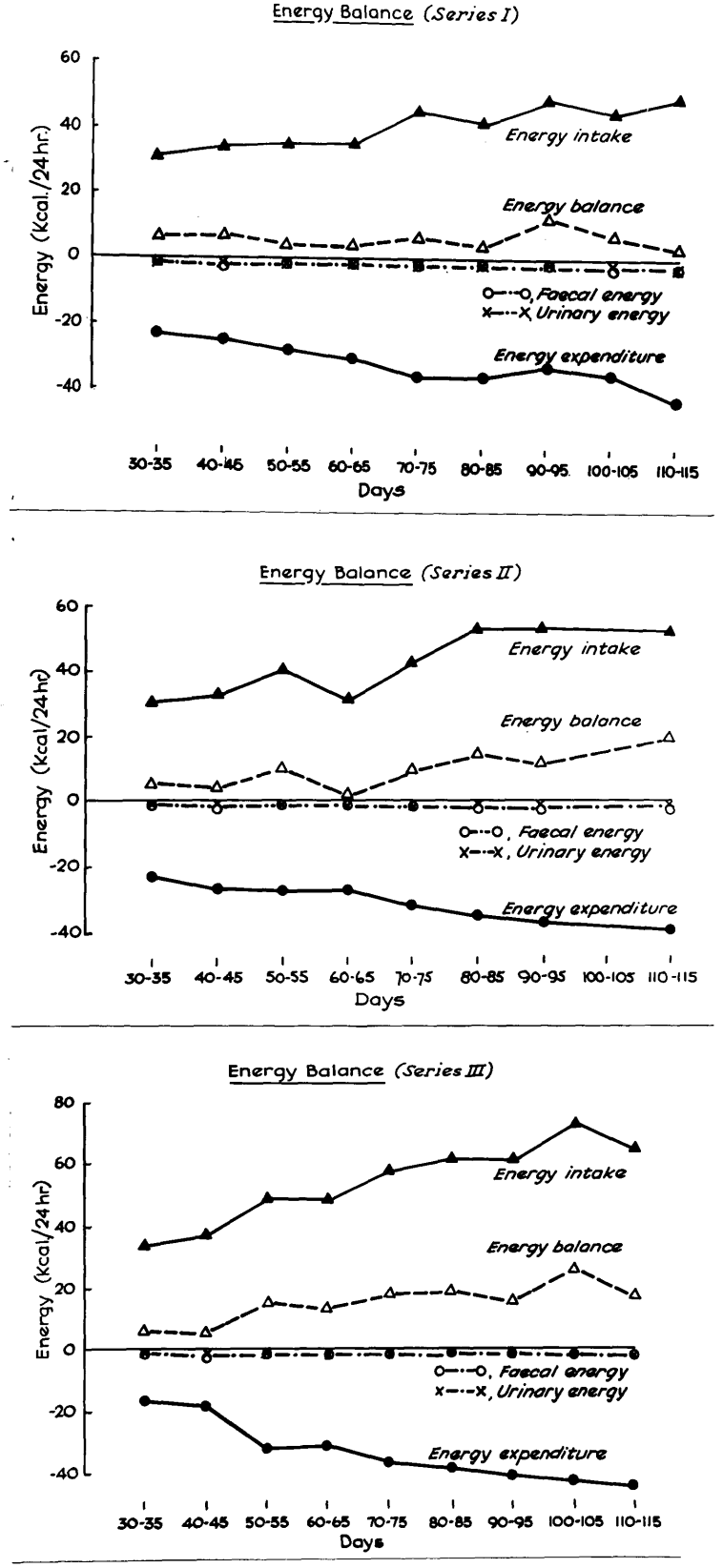

Energy Balance (Series I)
Energy (Kcal./24hr.)
60
40
20
0
-20
-40
Energy intake
Energy balance
O---O, Faecal energy
X---X, Urinary energy
Energy expenditure
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days
Energy Balance (Series II)
Energy (Kcal/24 hr)
60
40
20
0
-20
-40
Energy intake
Energy balance
O---O, Faecal energy
X---X, Urinary energy
Energy expenditure
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days
Energy Balance (Series III)
Energy (Kcal/24 hr)
80
60
40
20
0
-20
-40
Energy intake
Energy balance
O---O, Faecal energy
X---X, Urinary energy
Energy expenditure
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days

Figure (31)

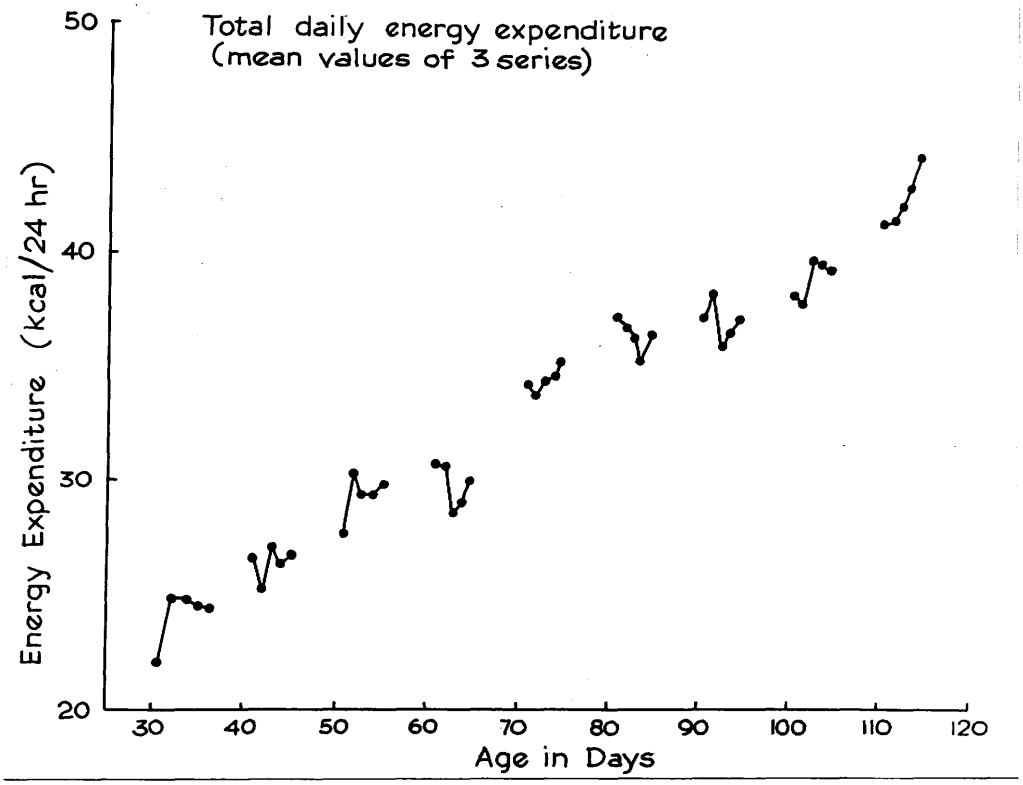

Total daily energy expenditure
(mean values of 3 series)
Energy Expenditure (kcal/24 hr)
50
40
30
20
30
40
50
60
70
80
90
100
110
120
Age in Days

Figure (32)

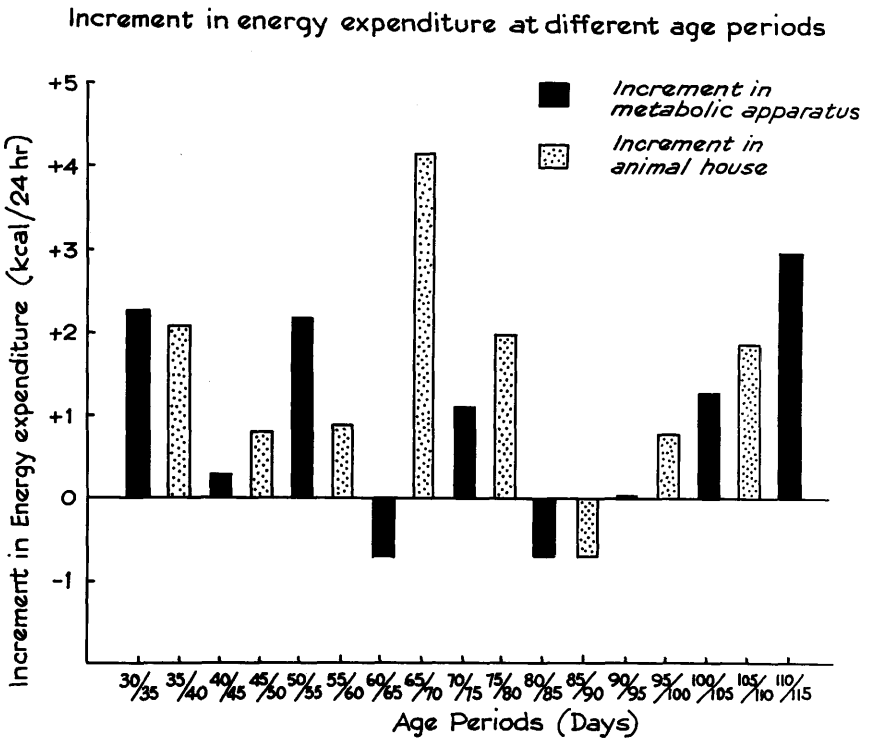
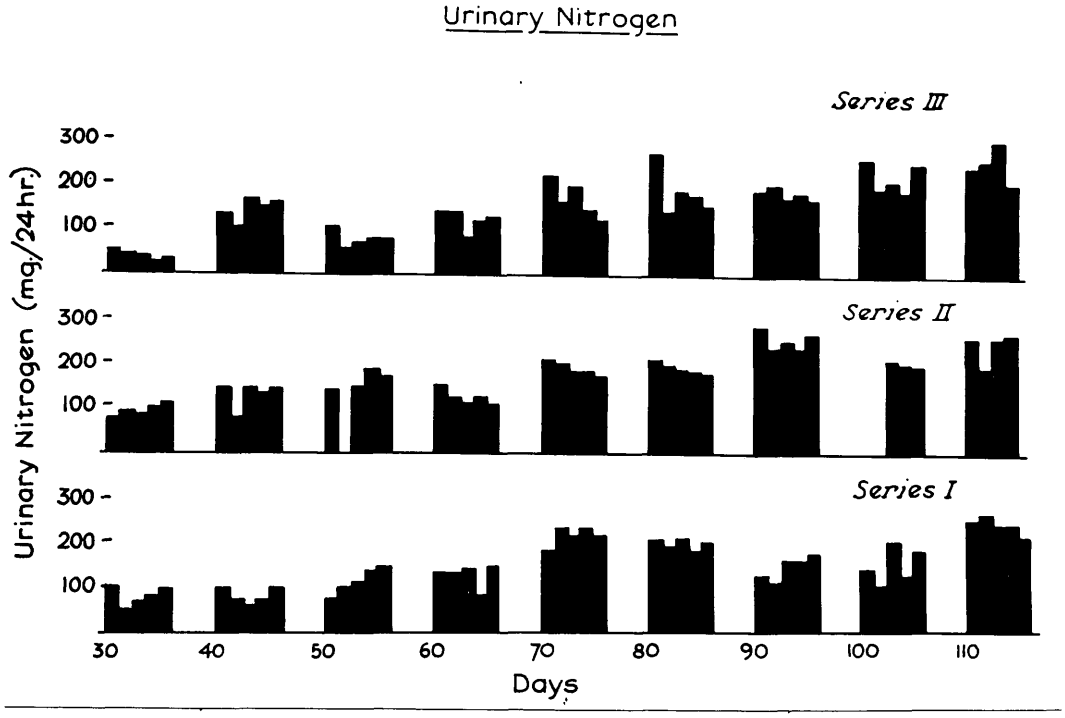

Increment in energy expenditure at different age periods
Increment in metabolic apparatus
Increment in animal house
Increment in Energy expenditure (kcal/24 hr)
+5
+4
+3
+2
+1
0
-1
30/35
35/40
40/45
45/50
50/55
55/60
60/65
65/70
70/75
75/80
80/85
85/90
90/95
95/100
100/105
105/110
110/115
Age Periods (Days)

Figure (33)



Daily Urinary Nitrogen

Figure (34)

Urinary Nitrogen and Ingested Energy

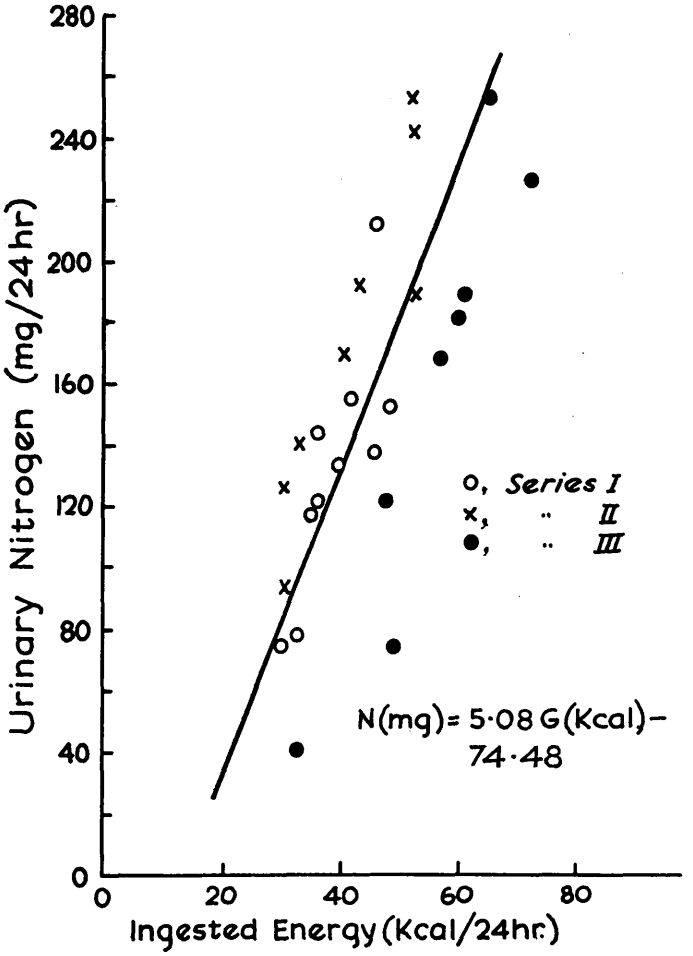


Figure (35)

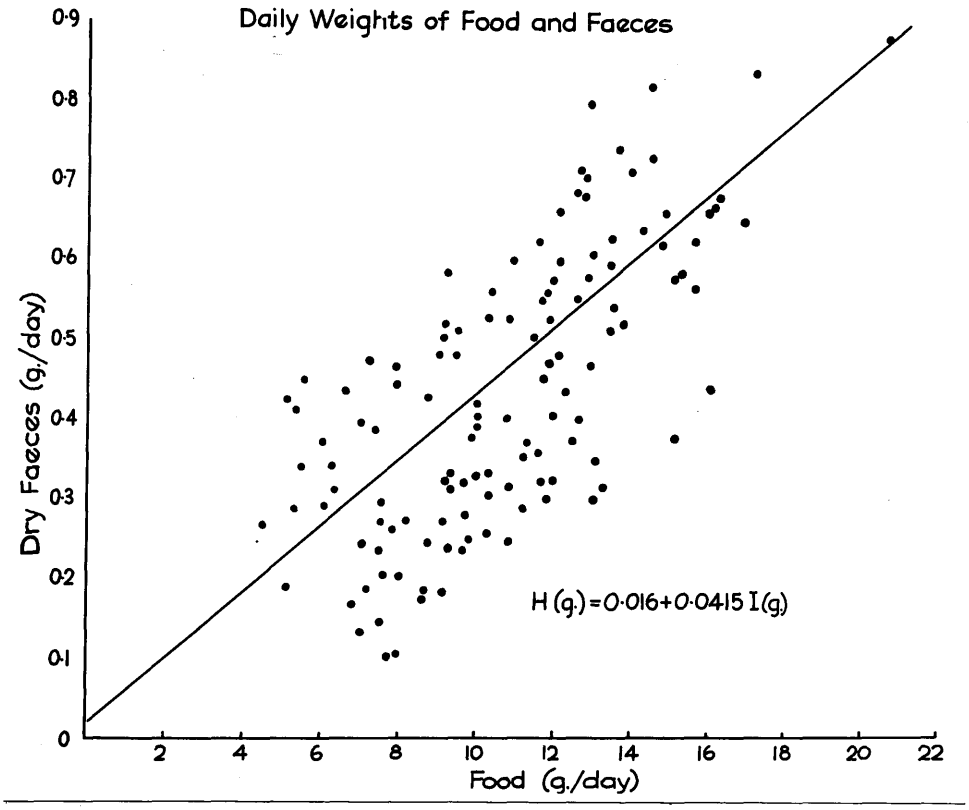
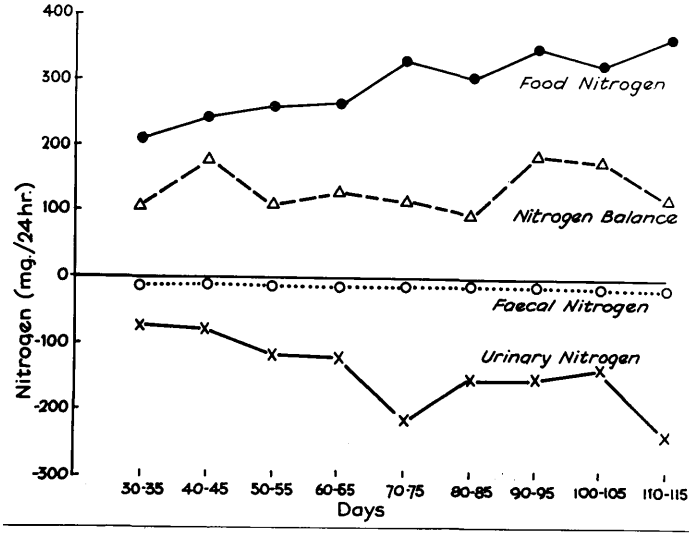
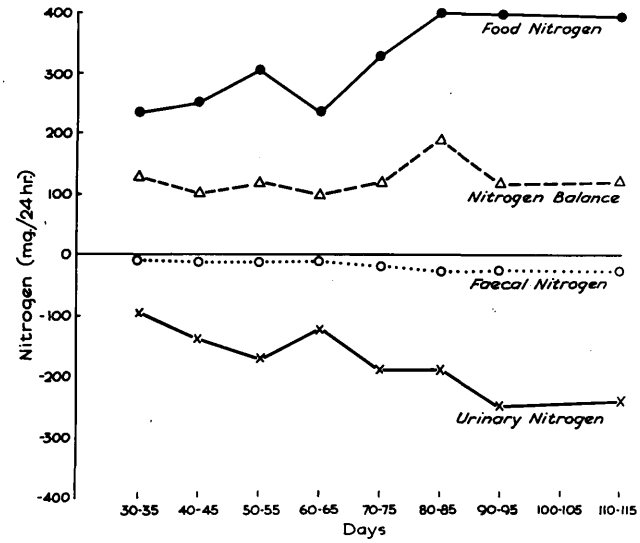

Daily Weights of Food and Faeces
Dry Faeces (g./day)
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0
2
4
6
8
10
12
14
16
18
20
22
Food (g./day)
H (g.) = 0·016 + 0·0415 I (g.)

Figure (36)

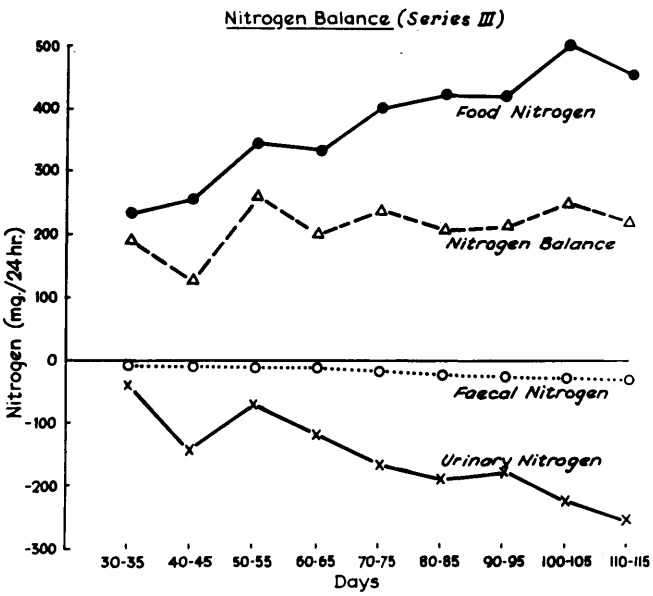
Nitrogen Balance (Series I)

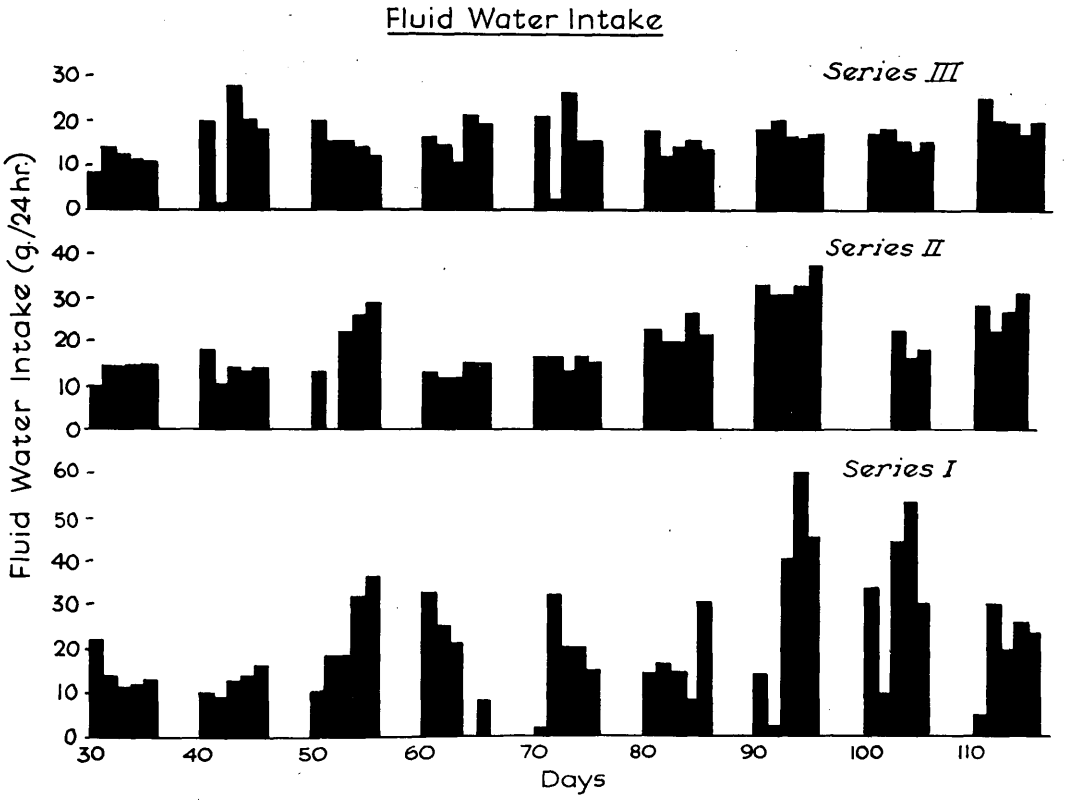


Nitrogen Balance (Series II)



Nitrogen Balance (Series III)





Daily fluid water intake

Figure (38)

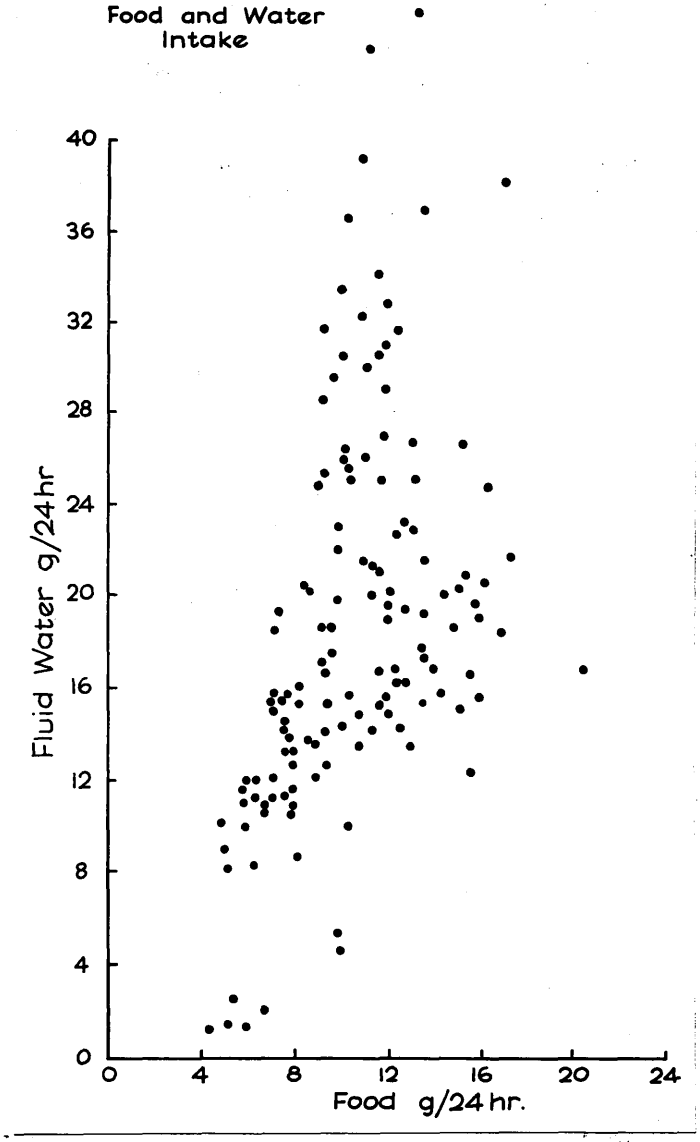
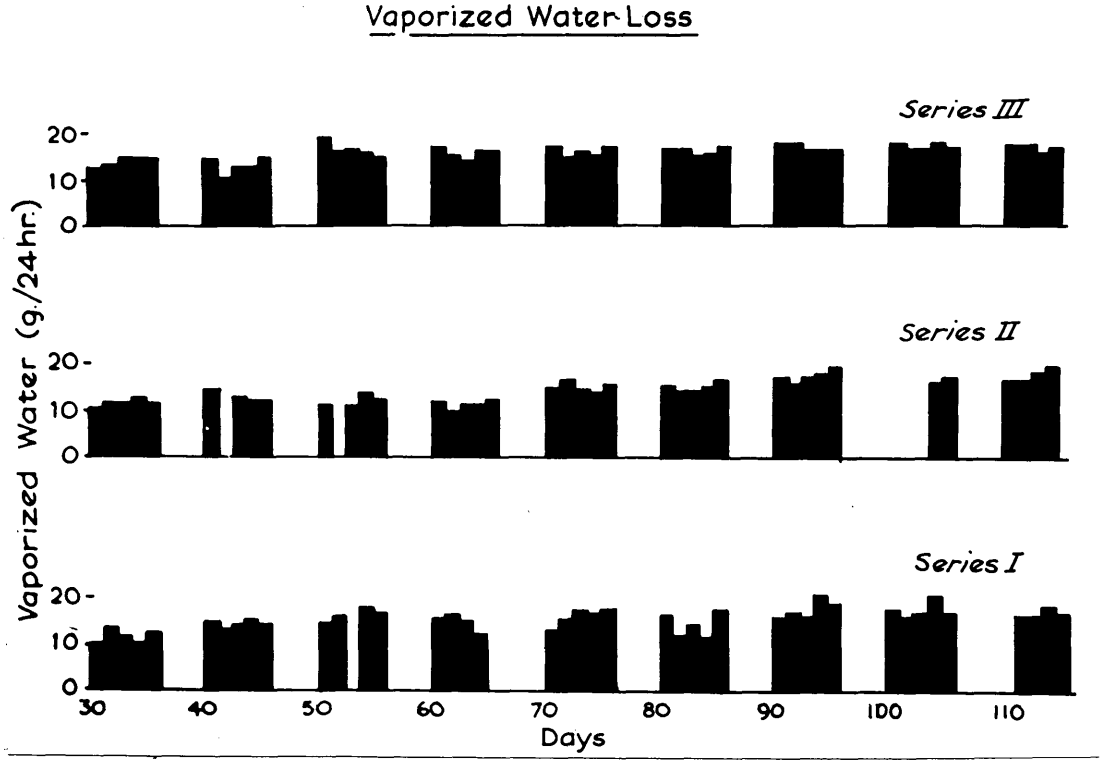

Food and Water Intake
Fluid Water g/24hr
40
36
32
28
24
20
16
12
8
4
0
0
4
8
12
16
20
24
Food g/24hr.

Figure (39)



Daily vaporized water loss

Figure (40)

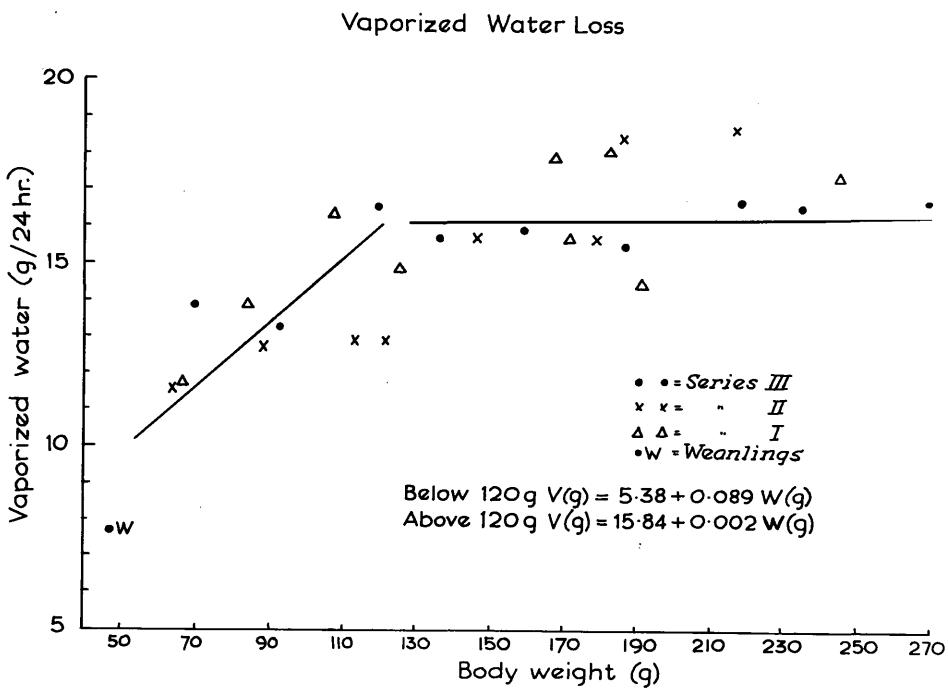

Vaporized Water Loss
Vaporized water (g/24hr.)
20
15
10
5
50
70
90
110
130
150
170
190
210
230
250
270
Body weight (g)
• • = Series III
× × = " II
Δ Δ = " I
•W = Weanlings
Below 120g V(g) = 5·38 + 0·089 W(g)
Above 120g V(g) = 15·84 + 0·002 W(g)

Figure (41)

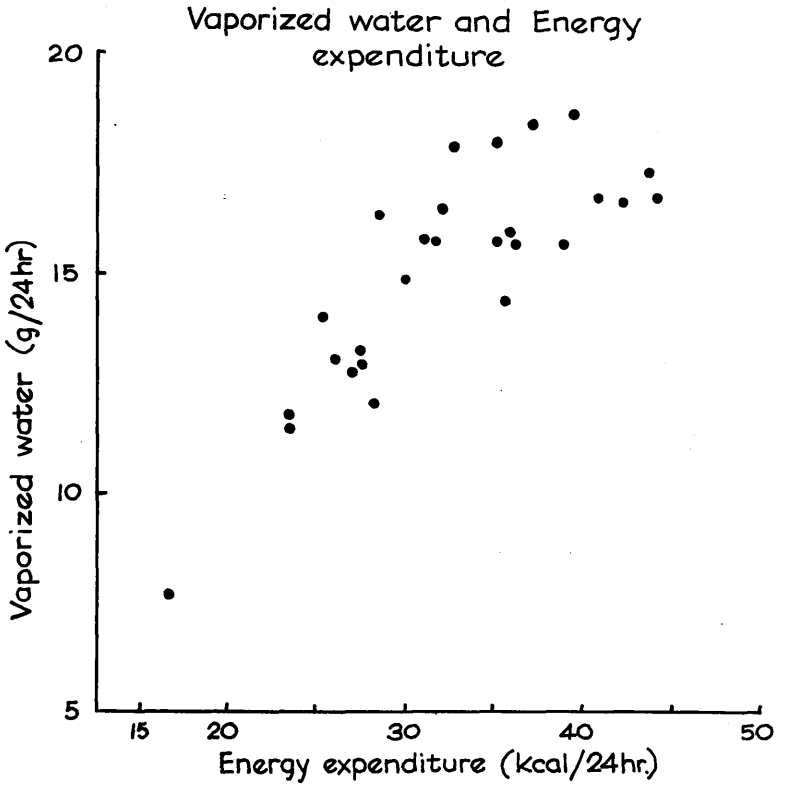
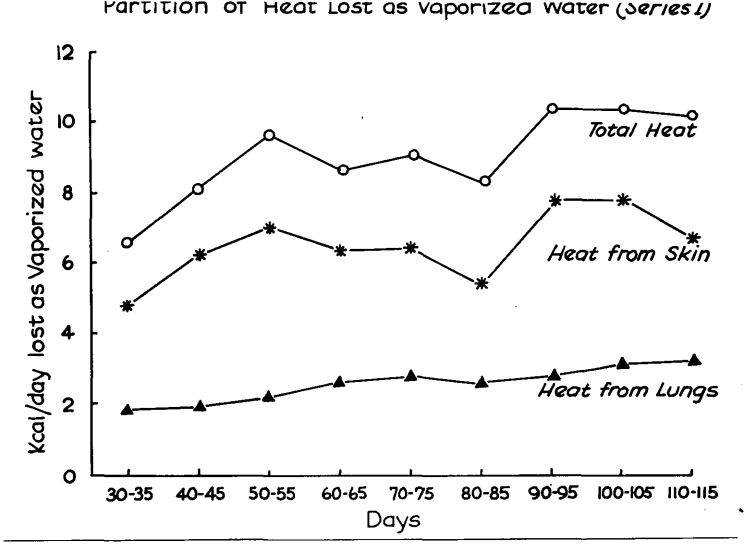
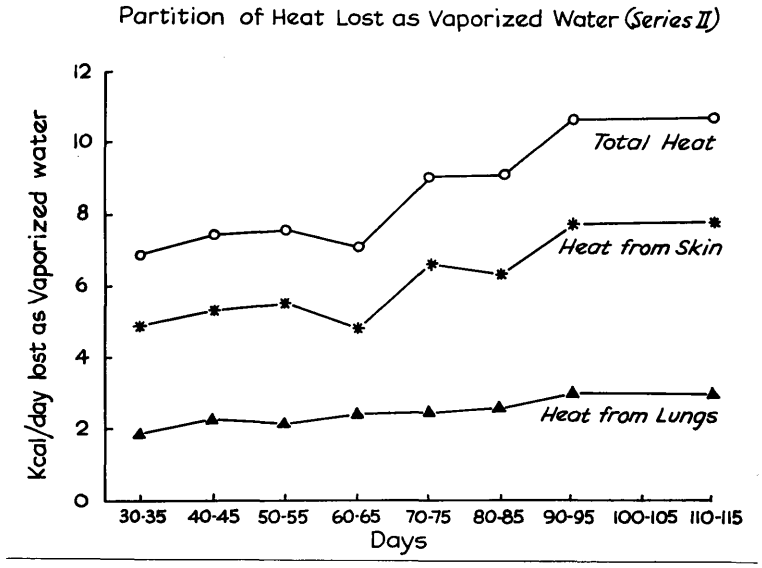

Vaporized water and Energy expenditure
20
15
10
5
Vaporized water (g/24hr)
15
20
30
40
50
Energy expenditure (kcal/24hr.)

Figure (42)


Partition of Heat Lost as Vaporized Water (Series I)
Kcal/day lost as Vaporized water
0
2
4
6
8
10
12
Total Heat
Heat from Skin
Heat from Lungs
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days


Partition of Heat Lost as Vaporized Water (Series II)
Kcal/day lost as Vaporized water
0
2
4
6
8
10
12
Total Heat
Heat from Skin
Heat from Lungs
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days

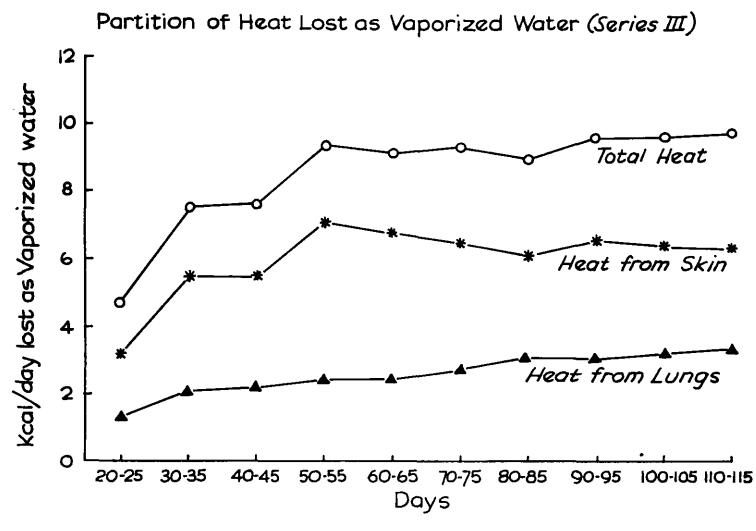
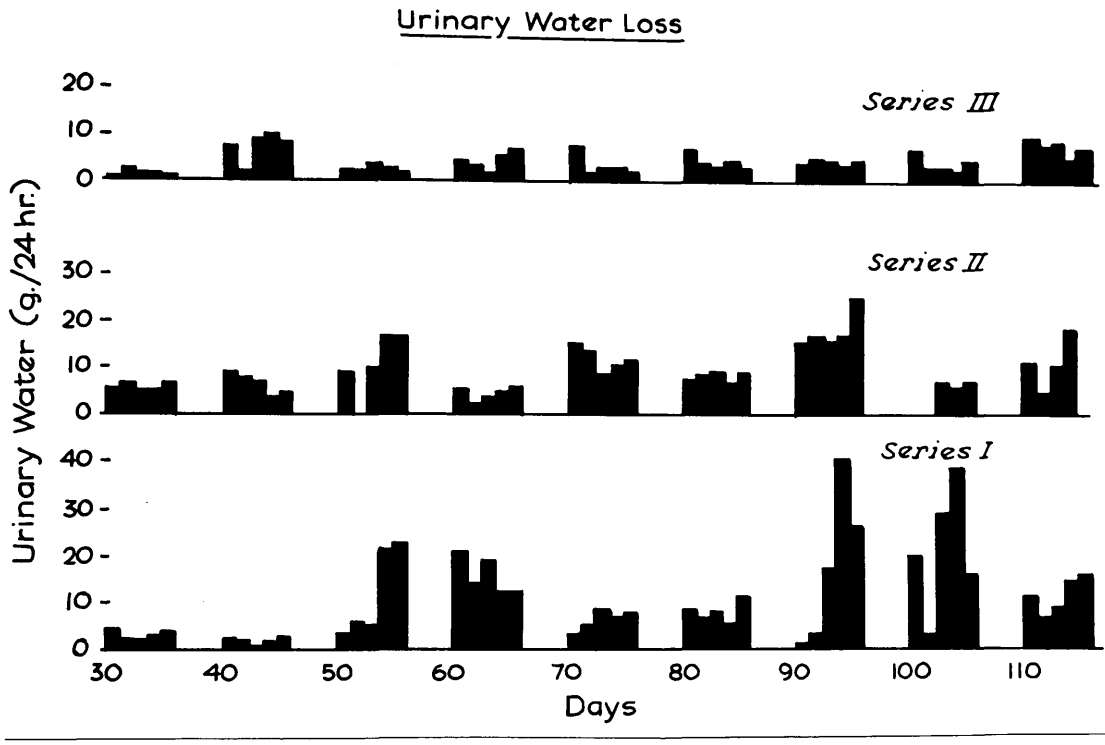

Partition of Heat Lost as Vaporized Water (Series III)
Kcal/day lost as Vaporized water
0
2
4
6
8
10
12
Total Heat
Heat from Skin
Heat from Lungs
20-25
30-35
40-45
50-55
60-65
70-75
80-85
90-95
100-105
110-115
Days

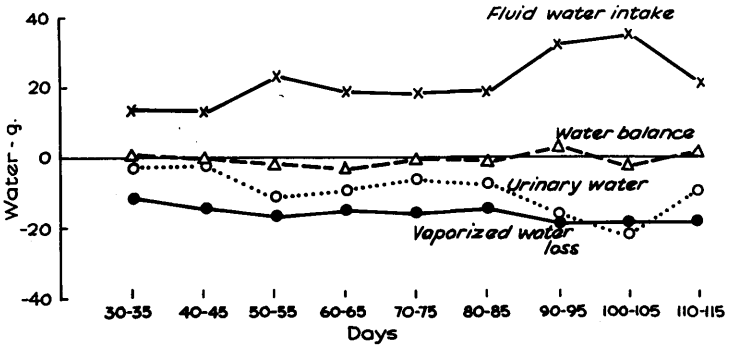
Figure (43)



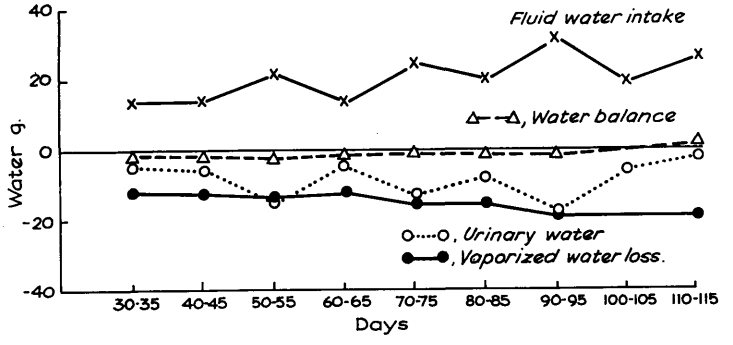
Daily urinary water loss

Figure (44)

Water Balance (Series I)



Water Balance (Series II)



Water Balance (Series III)

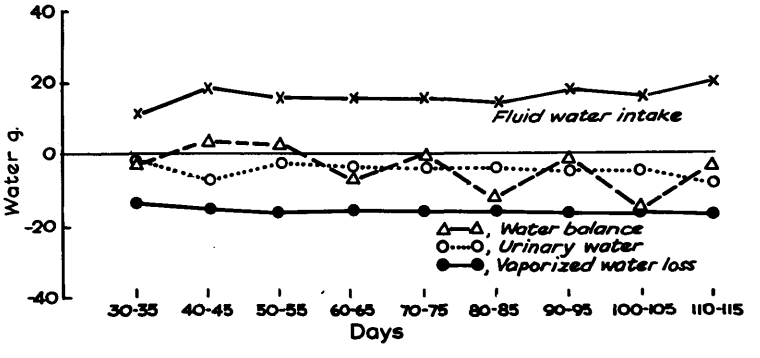


Figure (45)

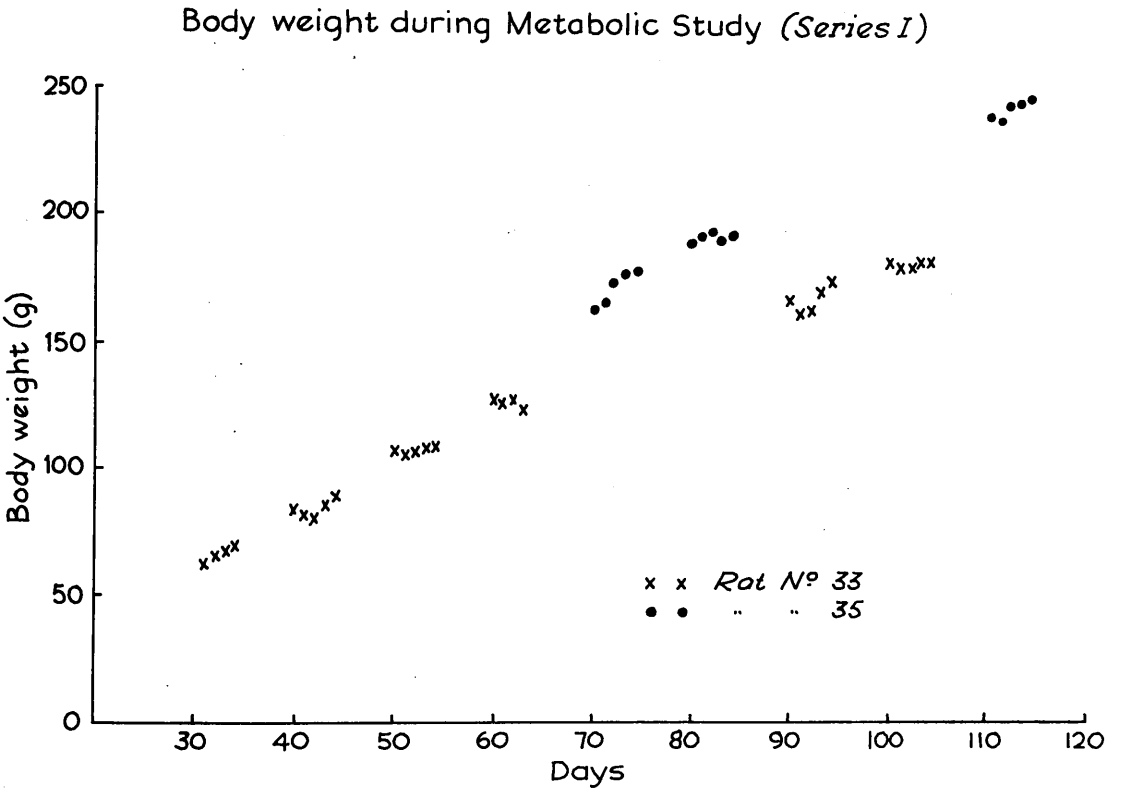

Body weight during Metabolic Study (Series I)
Body weight (g)
250
200
150
100
50
0
30
40
50
60
70
80
90
100
110
120
Days
x x Rat Nº 33
• • " " 35

Figure (46)

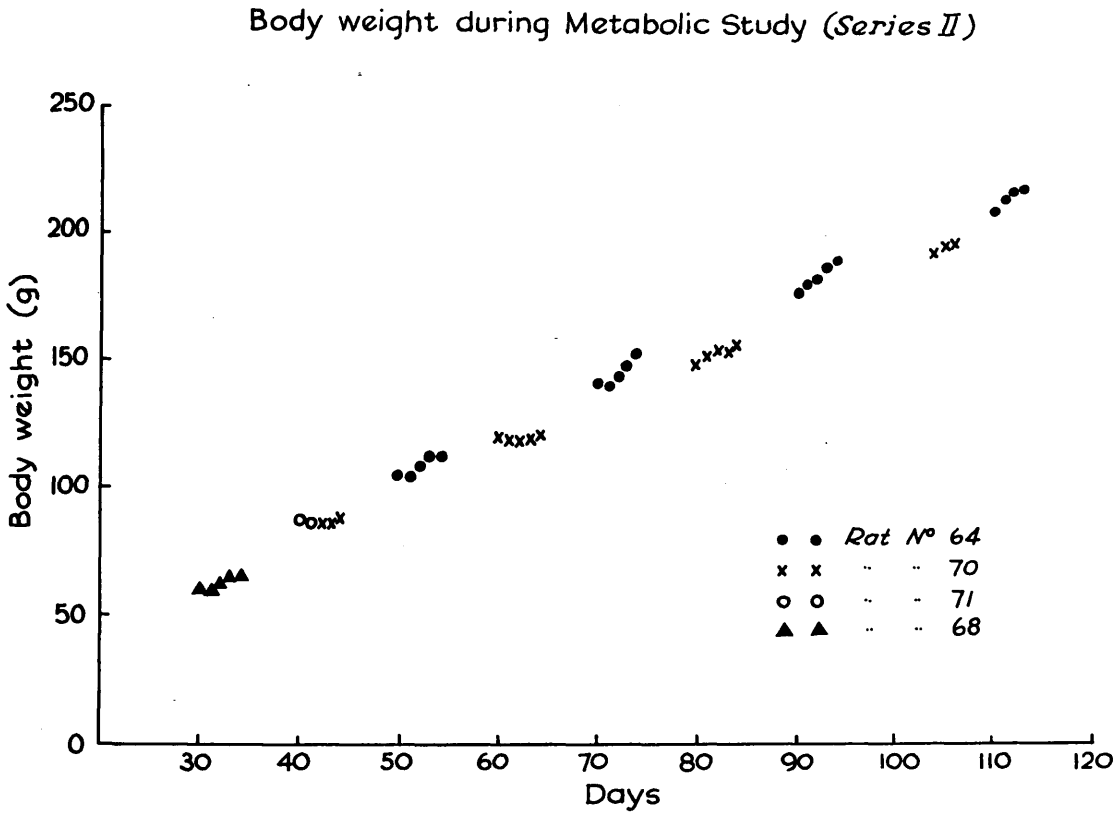

Body weight during Metabolic Study (Series II)
Body weight (g)
250
200
150
100
50
0
30
40
50
60
70
80
90
100
110
120
Days
Rat N° 64
" " 70
" " 71
" " 68

Figure (47)

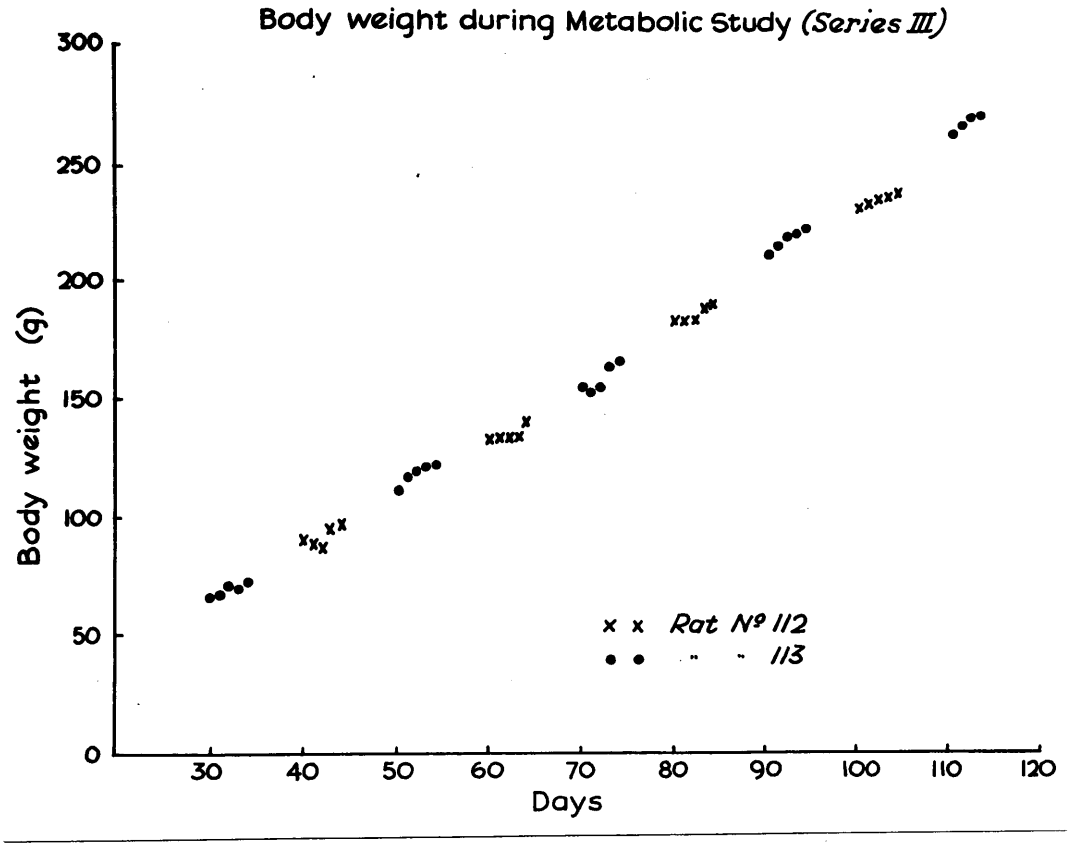
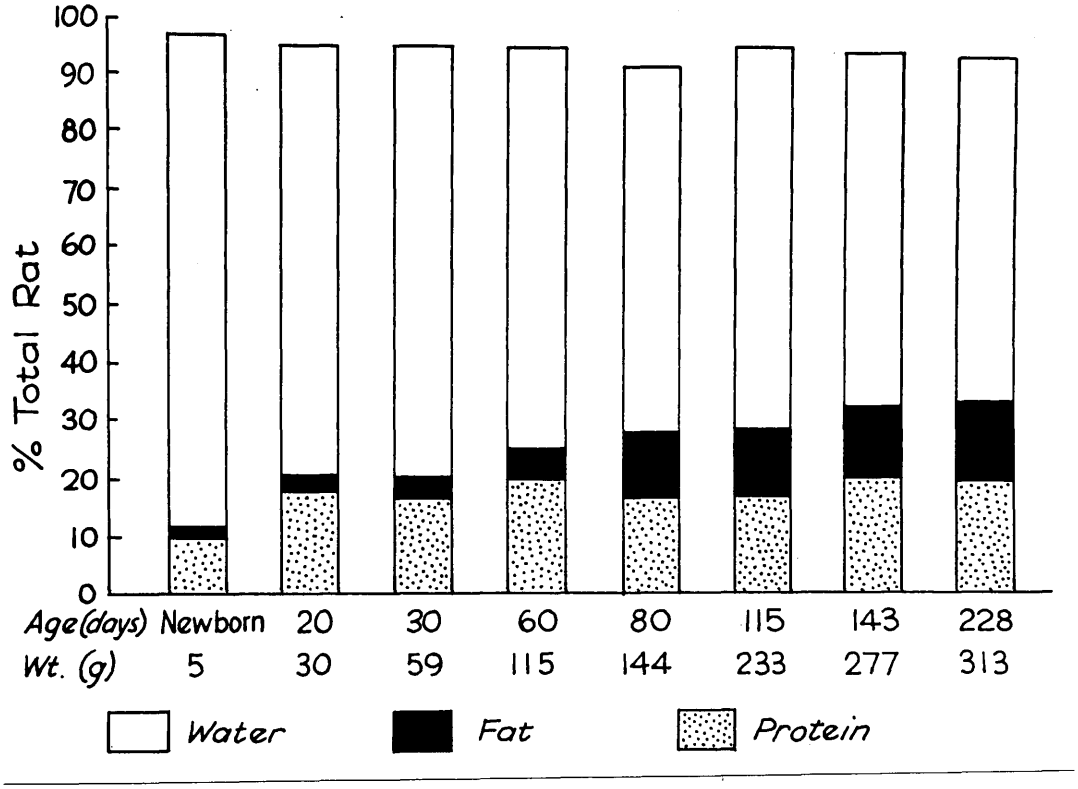

Body weight during Metabolic Study (Series III)
Body weight (g)
300
250
200
150
100
50
0
30
40
50
60
70
80
90
100
110
120
Days
x x Rat Nº 112
• • " " 113

Figure (48)



Body composition of rats at different ages

Figure (49)

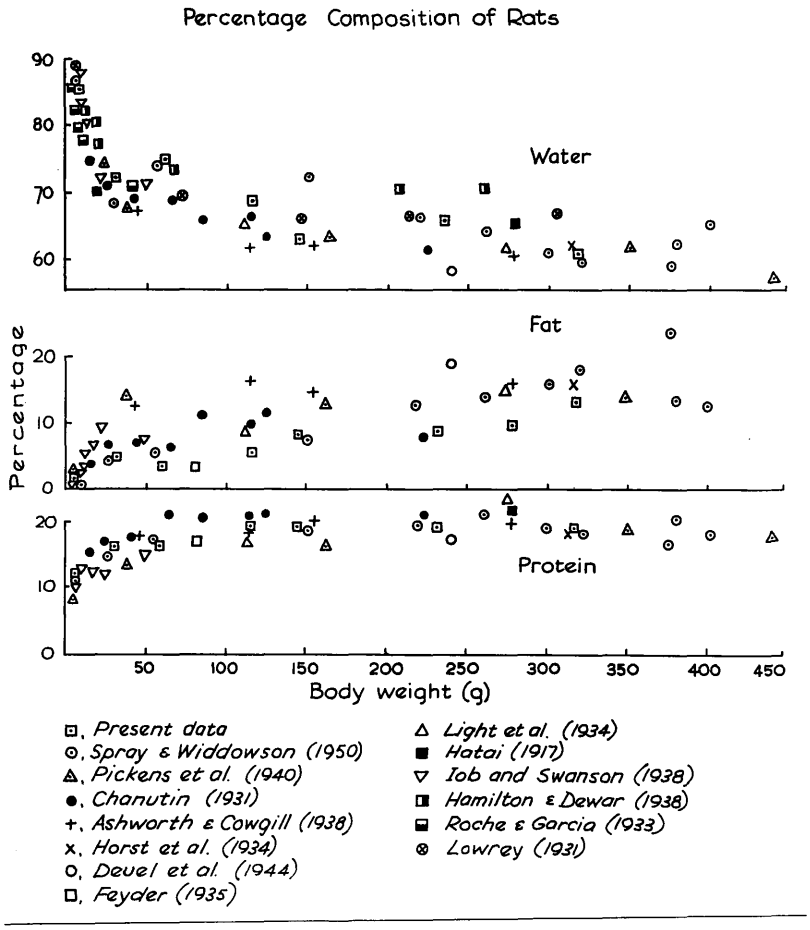

Percentage Composition of Rats
Water
Fat
Protein
Percentage
Body weight (g)
90
80
70
60
20
10
0
50
100
150
200
250
300
350
400
450
□, Present data
⊙, Spray & Widdowson (1950)
△, Pickens et al. (1940)
●, Chanutin (1931)
+, Ashworth & Cowgill (1938)
x, Horst et al. (1934)
○, Deuel et al. (1944)
□, Feyder (1935)
△ Light et al. (1934)
■ Hatai (1917)
▽ Iob and Swanson (1938)
◨ Hamilton & Dewar (1938)
◨ Roche & Garcia (1933)
⊗ Lowrey (1931)

Figure (50)

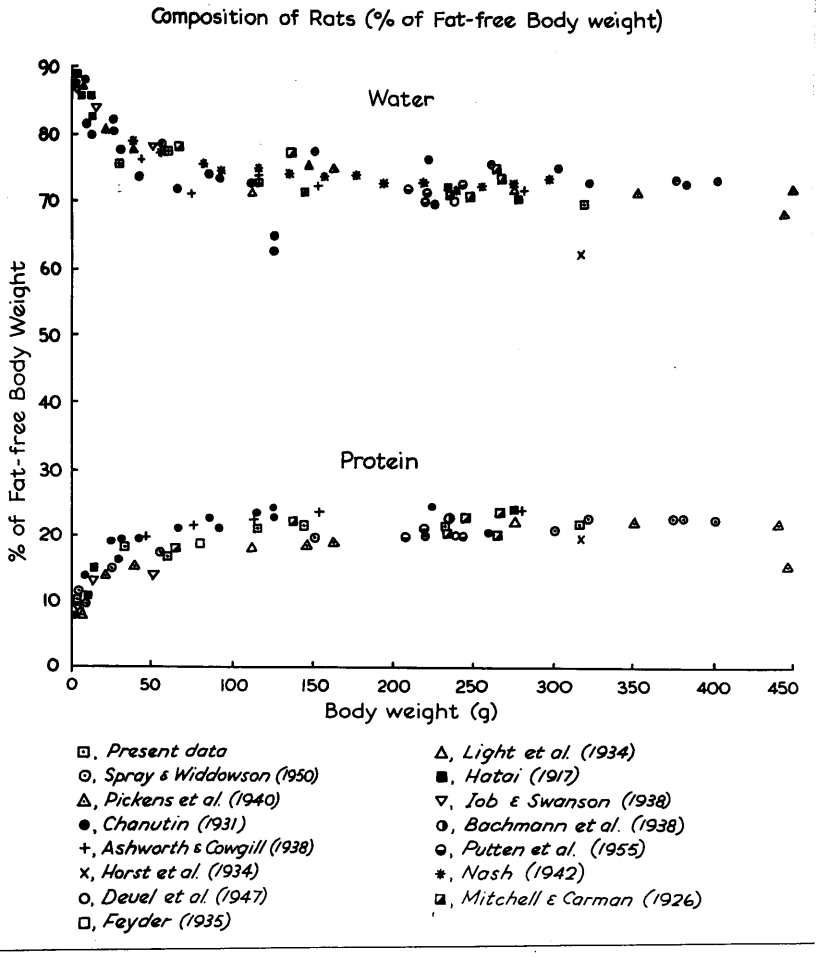
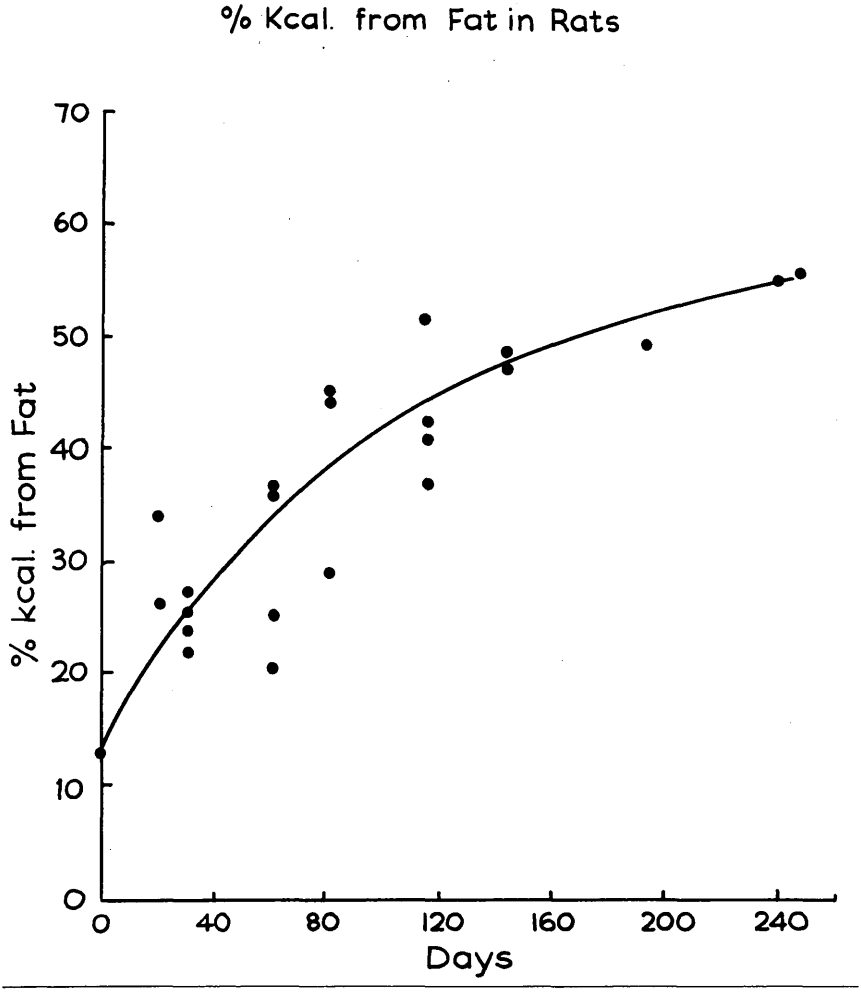

Composition of Rats (% of Fat-free Body weight)
Water
Protein
% of Fat-free Body Weight
Body weight (g)
0
10
20
30
40
50
60
70
80
90
0
50
100
150
200
250
300
350
400
450
□, Present data
⊙, Spray & Widdowson (1950)
△, Pickens et al. (1940)
●, Chanutin (1931)
+, Ashworth & Cowgill (1938)
x, Horst et al. (1934)
o, Deuel et al. (1947)
□, Feyder (1935)
△, Light et al. (1934)
■, Hatoi (1917)
▽, Job & Swanson (1938)
◑, Bachmann et al. (1938)
⊖, Putten et al. (1955)
*, Nash (1942)
◪, Mitchell & Carman (1926)

Figure (51)



Percentage of kcal from fat in rats of different ages

Figure (52)

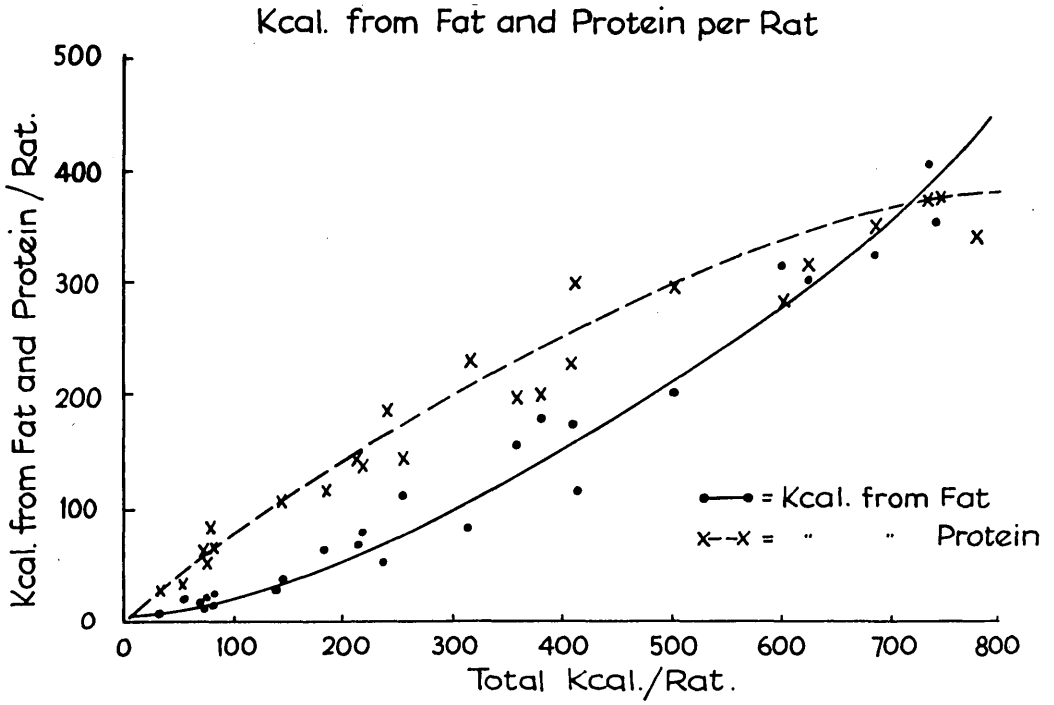

Kcal. from Fat and Protein per Rat
Kcal. from Fat and Protein / Rat.
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
Total Kcal./Rat.
= Kcal. from Fat
x--x = " " Protein

Figure (53)

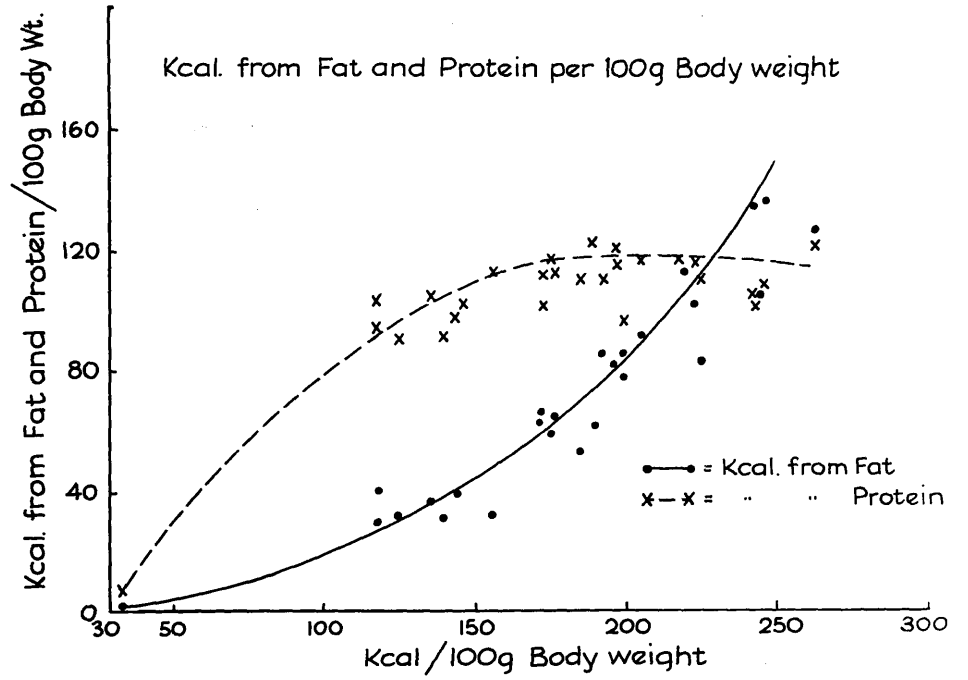

Kcal. from Fat and Protein per 100g Body weight
Kcal. from Fat and Protein/100g Body Wt.
160
120
80
40
0
30
50
100
150
200
250
300
Kcal/100g Body weight
= Kcal. from Fat
= " " Protein

Figure (54)

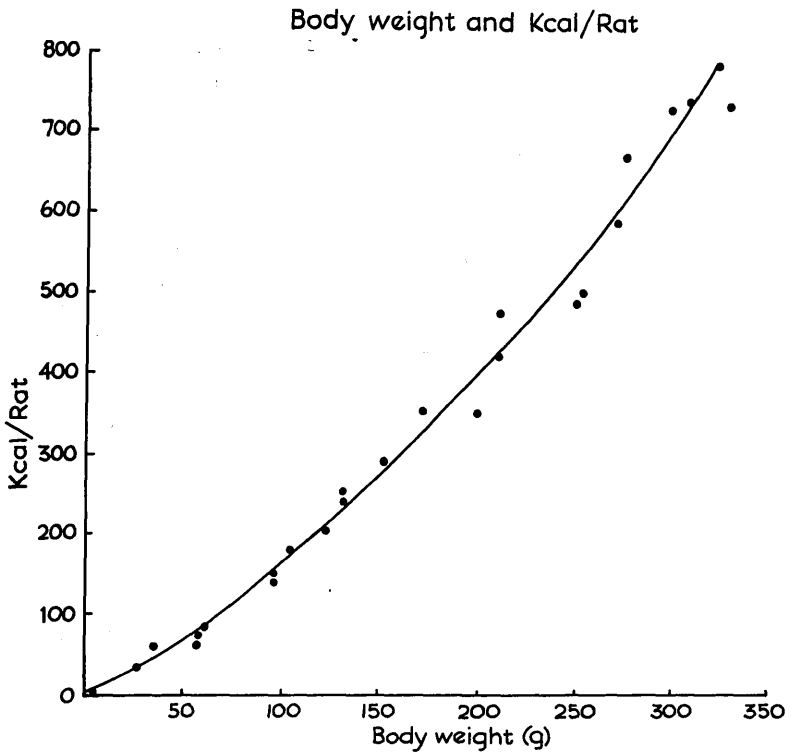

Body weight and Kcal/Rat
800
700
600
500
400
300
200
100
0
Kcal/Rat
50
100
150
200
250
300
350
Body weight (g)

Figure (55)

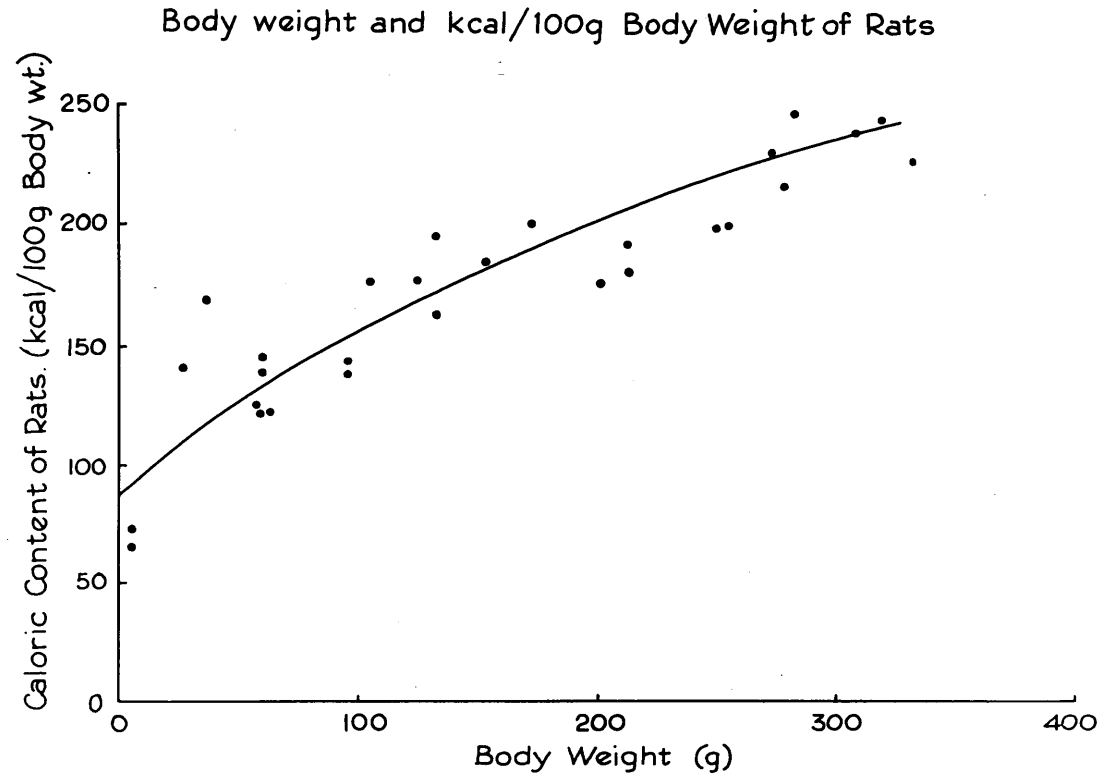

Body weight and kcal/100g Body Weight of Rats
Caloric Content of Rats. (kcal/100g Body wt.)
250
200
150
100
50
0
0
100
200
300
400
Body Weight (g)

Figure (56)

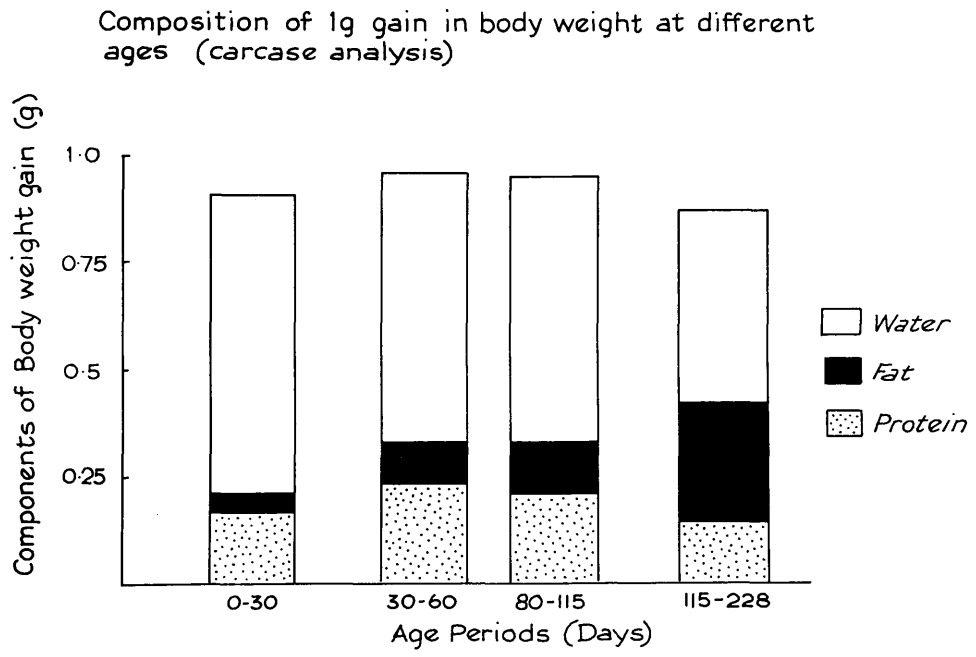

Composition of 1g gain in body weight at different ages (carcase analysis)
Components of Body weight gain (g)
1·0
0·75
0·5
0·25
0-30
30-60
80-115
115-228
Age Periods (Days)
Water
Fat
Protein

Figure (57)

Energy Balance from Carcase Analysis and Metabolic Study (*Series III*

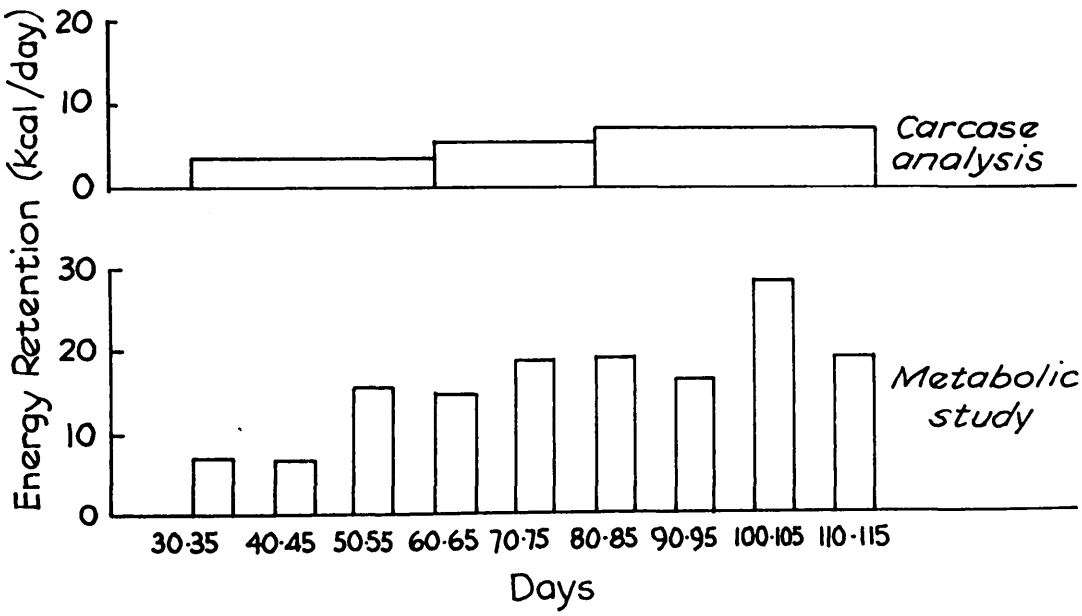


Figure (58)

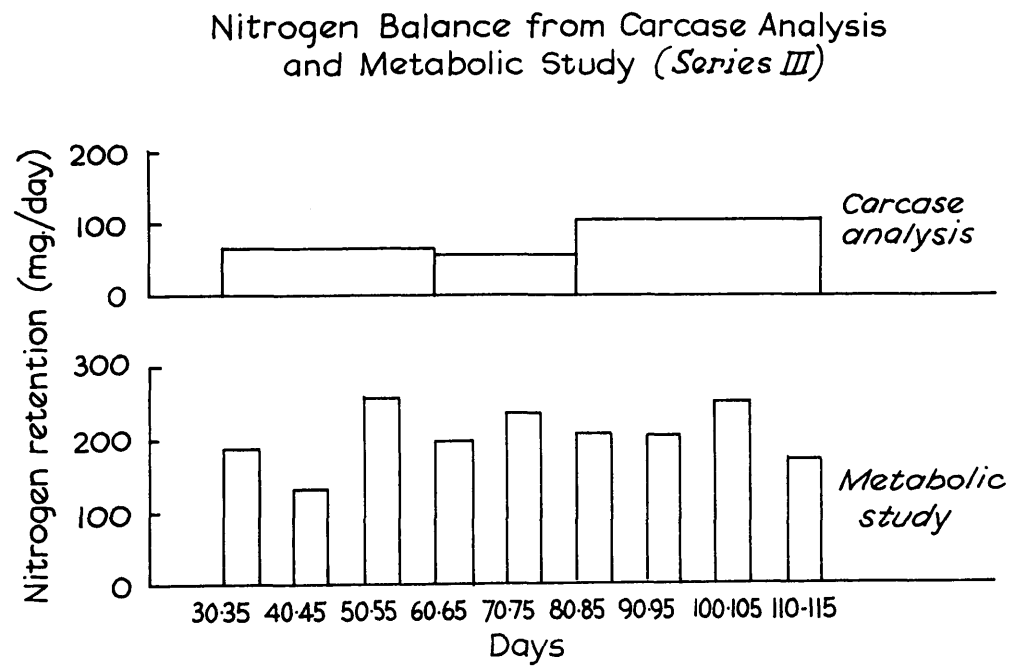

Nitrogen Balance from Carcase Analysis
and Metabolic Study (Series III)
Nitrogen retention (mg./day)
200
100
0
Carcase analysis
300
200
100
0
Metabolic study
30·35 40·45 50·55 60·65 70·75 80·85 90·95 100·105 110·115
Days

Figure (59)

Water balance from Carcase analysis
and Metabolic study *(Series III)*

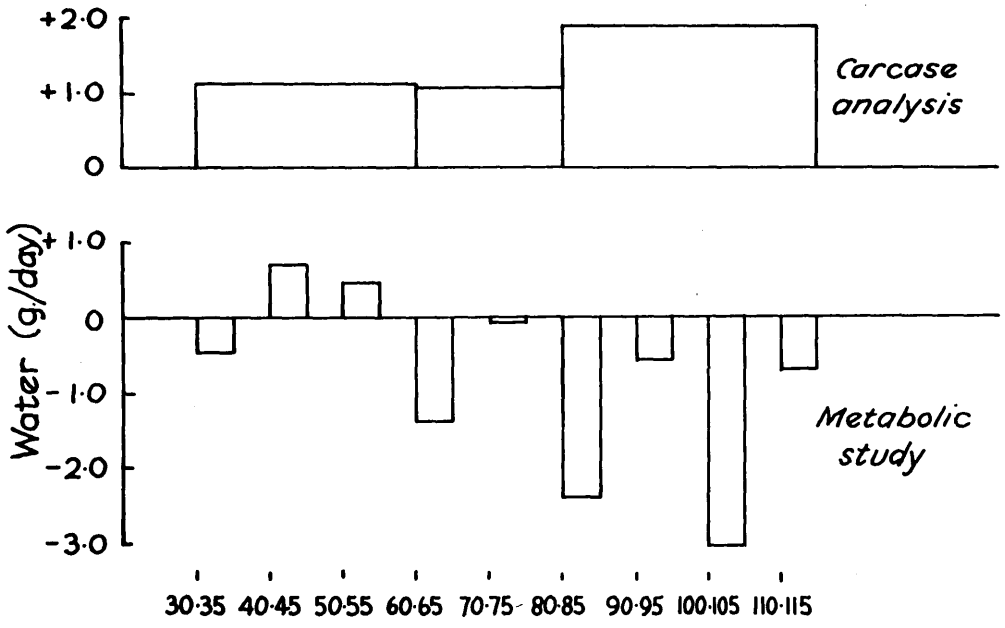


Figure (60)

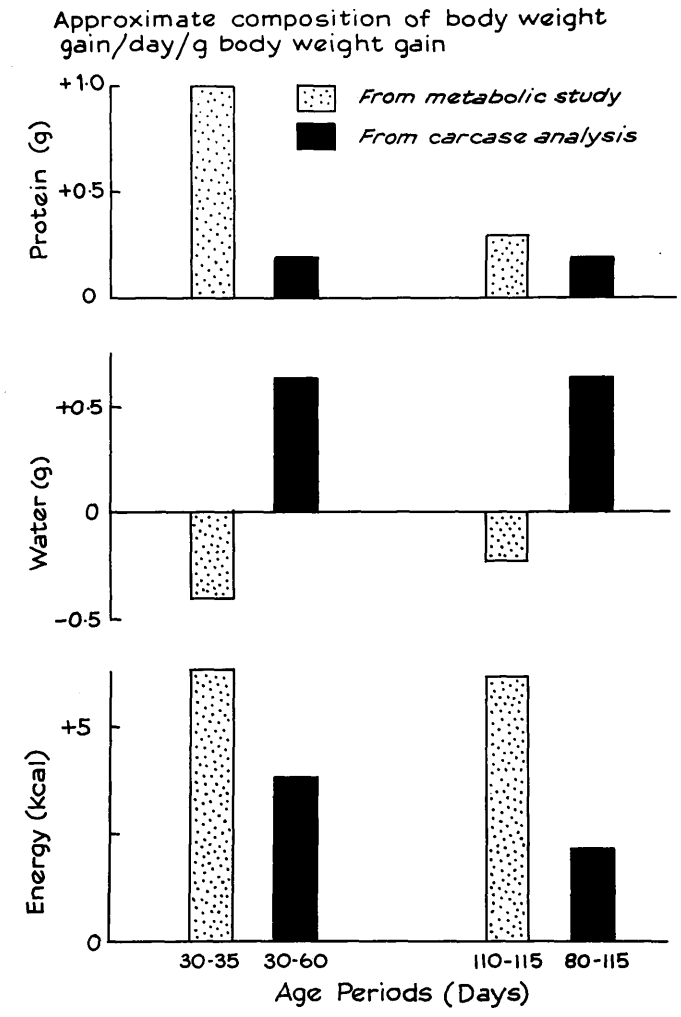
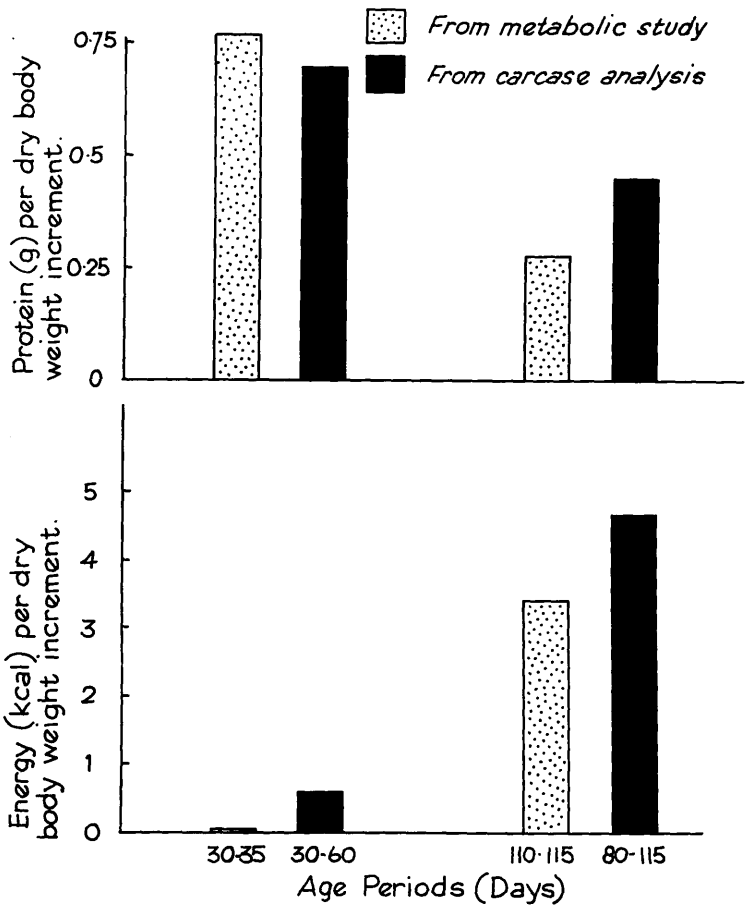

Approximate composition of body weight gain/day/g body weight gain
From metabolic study
From carcase analysis
Protein (g)
+1·0
+0·5
0
Water (g)
+0·5
0
-0·5
Energy (kcal)
+5
0
30-35
30-60
110-115
80-115
Age Periods (Days)

Figure (61)

Composition of gain in weight / dry body weight increment.



(In the metabolic study, energy in kcal is derived from non-protein sources. In the carcase analysis, energy in kcal is derived from fat).

Figure (62)

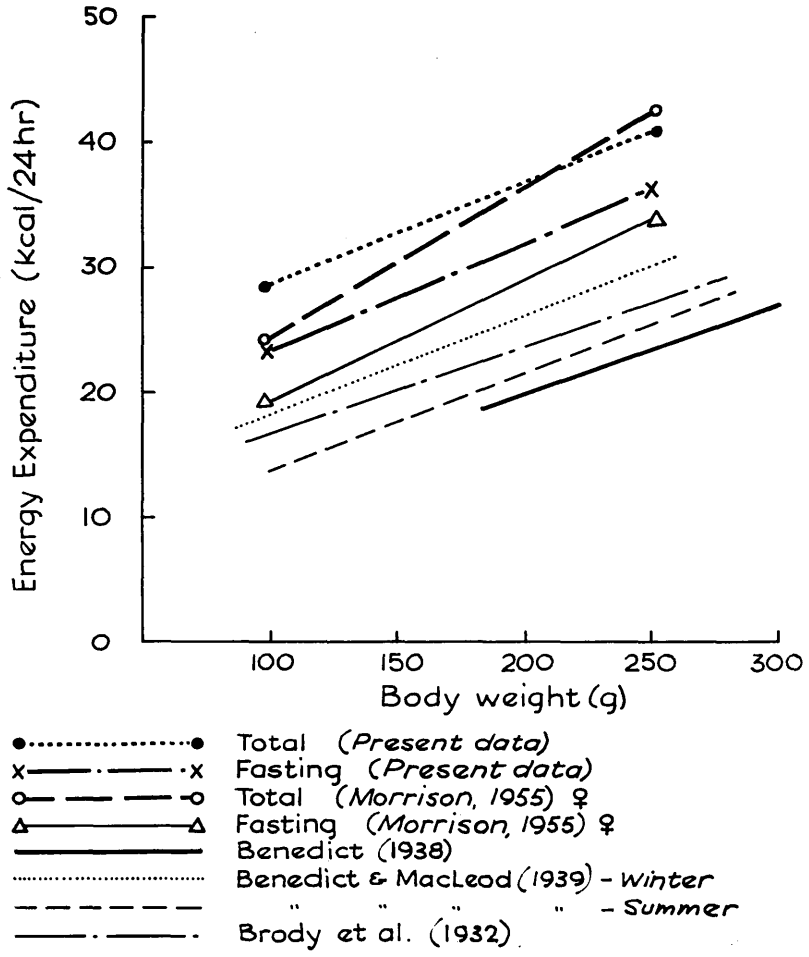

50
40
30
20
10
0
Energy Expenditure (kcal/24hr)
100
150
200
250
300
Body weight (g)
Total (Present data)
Fasting (Present data)
Total (Morrison, 1955) ♀
Fasting (Morrison, 1955) ♀
Benedict (1938)
Benedict & MacLeod (1939) - Winter
" " " " - Summer
Brody et al. (1932)

Figure (63)

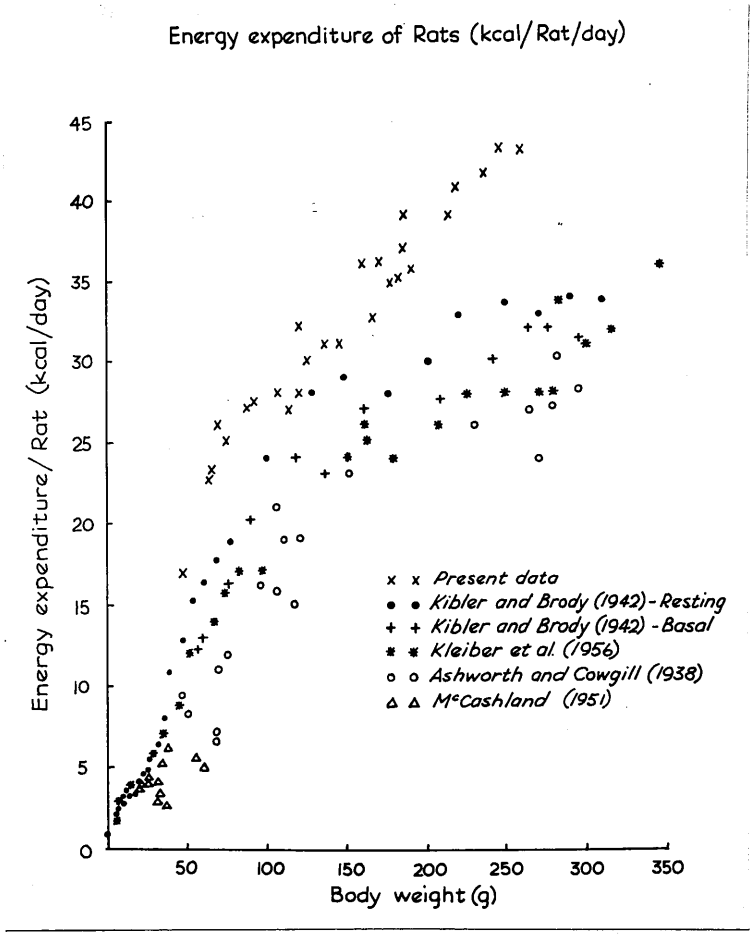

Energy expenditure of Rats (kcal/Rat/day)
Energy expenditure/Rat (kcal/day)
Body weight (g)
0
5
10
15
20
25
30
35
40
45
50
100
150
200
250
300
350
x x Present data
• • Kibler and Brody (1942) - Resting
+ + Kibler and Brody (1942) - Basal
* * Kleiber et al. (1956)
o o Ashworth and Cowgill (1938)
△ △ McCashland (1951)

Figure (64)

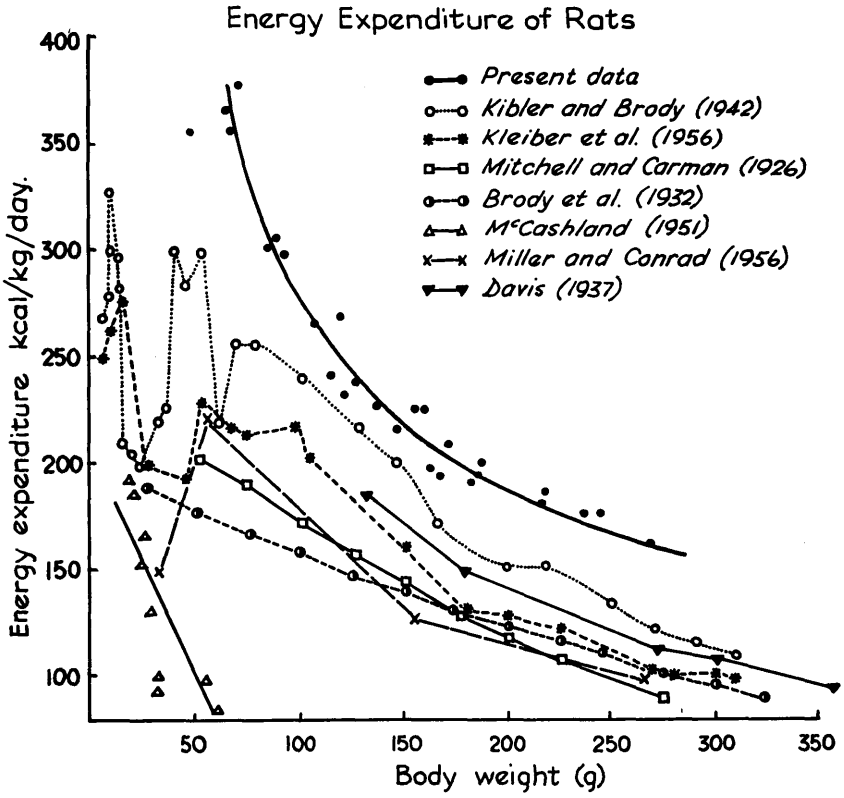

Energy Expenditure of Rats
Present data
Kibler and Brody (1942)
Kleiber et al. (1956)
Mitchell and Carman (1926)
Brody et al. (1932)
McCashland (1951)
Miller and Conrad (1956)
Davis (1937)
Energy expenditure kcal/kg/day.
400
350
300
250
200
150
100
50
100
150
200
250
300
350
Body weight (g)

Figure (65)

Appendix I, A

Procedure for daily change-over used with closed-circuit respirometer

Preparations for change-over

(1) Weigh dry animal frame.

(2) Weigh dry urine funnel.

(3) Weigh dry tin box.

(4) Weigh food box containing food.

(5) Weigh soda asbestos tubes.

(6) Weigh guard anhydrone tube.

(7) Fill and weigh water-bottle.

(8) Weigh water absorbing tubes.

(9) Place about 10 ml 10% H_2SO_4 into urine flask, wash down neck of flask with distilled water, dry neck of flask and weigh urine flask.

Order of events during change-over

(1) Switch off drum for recording oxygen usage. Record time and spirometer reading. Remove drum and trace of oxygen usage. Replace fresh paper on drum and smoke.

(2) Switch off pump and adjust to standard point of phase.

(3) Record time, spirometer reading, barometric pressure and cabinet temperature.

(4) Connect spirometer with water manometer.

(5) Switch off fan. Open door of cabinet, close stopper taps of U-tubes and record chamber temperature.

(6) Place fresh chamber on inside spare rack. Remove used animal chamber to outside rack.

(7) Fill spirometer from oxygen cylinder.

(8) Open used animal chamber. Remove water-bottle. Remove rat and place in tin box. Replace lid of chamber.

(9) Weigh rat in tin box.

(10) Transfer used animal chamber to inside rack and fresh chamber to outside rack.

(11) Insert urine funnel and frame with attached food box in fresh animal chamber, attach urine funnel and transfer rat to animal chamber.

(12) Place fresh water-bottle in animal chamber. Bolt down lid. Record time.

(13) Place fresh animal chamber in position and remove used animal chamber to outside rack.

(14) Remove used absorbing train. Replace with fresh absorbing train.

(15) Attach ducts to animal chamber and to absorbing train.

(16) Record temperature of animal chamber. Open stopper taps in absorbing train.

(17) Switch on pump and close door of cabinet.

(18) Graduate the smoked paper for recording of oxygen usage with lines 1 cm apart. Place smoked drum in position in cabinet and switch on.

(19) If the manometer level shows evidence of reduced pressure in the chamber circuit over 15 mins., connect spirometer to chamber circuit. Record time, spirometer reading, cabinet temperature and barometric pressure.

Order of events after change-over

(1) Remove the frame from the animal chamber and place it on a clean sheet of paper.

(2) Remove the urine funnel. Shake dry food off funnel on to the same sheet of paper. Place urine funnel inverted on paper so that no fluid is lost from it.

(3) Remove urine flask.

(4) Transfer faeces from grid of frame to tin box. Shake dry food from frame on to paper.

(5) Weigh urine flask.

(6) Weigh urine funnel and place in mouth of urine flask.

(7) Weigh animal frame.

(8) Scrape contaminated food from animal frame into urine funnel. Wash frame and funnel residues into urine flask.

(9) Weigh tin box with moist faeces. Place in oven to dry.

(10) Weigh water-bottle.

(11) Weigh water absorbing tubes.

(12) Weigh soda asbestos and anhydrone guard tubes.

(13) Weigh food box.

(14) Brush dry scattered food from chamber on to paper. Weigh all the scattered dry food.

(15) Annotate and varnish trace of oxygen usage.

Appendix I, B

Refilling of the spirometer

(1) Disconnect spirometer from chamber circuit.

(2) Record time and spirometer scale reading.

(3) Fill spirometer from oxygen cylinder.

(4) Leave apparatus for 15 min, noting fall in pressure in water manometer due to oxygen usage in the animal chamber.

(5) Record cabinet temperature and barometric pressure.

(6) Record spirometer scale reading and time.

(7) Reconnect spirometer with chamber circuit, allowing oxygen to enter circuit and manometer to return to resting level.

(8) Observe usage of oxygen for a further 15 min.

Appendix I, C.

Changing of the absorbing tubes

(1) Switch off pump motor.

(2) Connect the oxygen inlet to the manometer.

(3) Adjust the phase of the pump so that the pressure in the chamber circuit is equal to the atmospheric pressure.

(4) Seal the ducts on either side of the tube or tubes to be replaced, using screw-clips on the rubber connections or stopper taps of U-tubes.

(5) Replace the absorbing tube or tubes by a freshly weighed tube or tubes.

(6) Unseal absorbing train and restart the pump.

(7) When the manometer shows a slightly reduced pressure in the chamber circuit, reconnect spirometer with the circuit.

METABOLIC DATA

Rat No. 113 Sex Male. Pregnancy - Oestrus - Diet M.S.I. (9)

	Initial	Final
Date	1. 5.54	2. 5.54
Time	9.55 a.m.	10.50 a.m.
Pump on	10.00 a.m.	
Chamber Temperature	19.2°C	25.5°C

O_2 Consumption	Spirometer Reading cm.	Bar. Press. mm.	Cabinet Temp. °C	Time
Initial	25.01	746.6	23.0	10.15 a.m.
Final	9.22	744.5	24.2	6.20 p.m.
Initial	24.63	744.5	24.2	6.35 p.m.
Final	13.75	743.5	24.2	11.25 p.m.
Initial	25.08	743.5	24.2	11.40 p.m.
Final	1.92	740.5	24.2	10.50 a.m.

H_2O Absorption	Tube Weights	g	241.570	259.732
CO_2 Absorption	Tube Weights	g	233.129	247.533
Chemical H_2O Absorption	Tube Weight	g	104.548	106.188
Spirometer Driers	Tube Weights	g	-	-
Weight Rat + Box		g	376.97	381.83
Final Weight Box		g	-	-
Weight Box + Wet Faeces		g	-	163.582
Weight Box + Dry Faeces		g	-	163.457
Dry Weight of Box		g	162.804	-
Food Box + Food		g	175.671	151.319
Scattered Food - Dry		g	-	6.248
Funnel Weight		g	267.629	267.822
Frame Weight		g	256.709	261.322
Gross Urine Weight		g	53.516	59.663
Water Bottle		g	159.762	139.260

NOTES

Pump Stroke	R.P.M.	Estimated Vent. Rate
12	240	1670 litres/day

Drum off 10.30 a.m. Spirometer reading = 2.70 cm

Appendix I, E

Procedure for Bomb Calorimetry

(1) The silica crucible, used to carry the pelleted material, is weighed with a 6 cm length of fuse wire.

(2) The material to be burnt is pelleted in the press with the fuse wire embedded in it.

(3) The pelleted substance, with the fuse wire, is placed in the crucible and the whole weighed. The difference between the weights found in (1) and (3) gives the weight of substance used.

(4) The crucible with pellet is attached to the spring holder formed by the contacts in the bomb cap. The ends of the fuse wire are bound to the contacts.

(5) A light film of silicone grease is applied to the outside rim of the bomb body.

(6) The cap is screwed onto the body of the bomb and lightly tightened with a large spanner.

(7) The bomb is filled with oxygen to 25 atmospheres.

(8) The calorimeter vessel is filled to the approximate level with tap water at about 14 - 15°C. Water is added or withdrawn by a pipette until the vessel is exactly balanced by the standard weight. The vessel is then placed in the water-jacket of the apparatus.

(9) The leads from the ignition unit are bound to the external contacts on the bomb cap, and the bomb is carefully lowered into the calorimeter vessel, and arranged to sit in the bottom centre of the vessel.

(10) The stirrer is fitted to the driving mechanism and the position of the bomb adjusted so that the stirrer clears the bomb.

(11) The thermometer is carefully passed into the calorimeter vessel, through the spring clip on the stirrer super-structure, until it reaches the standard immersion mark. The thermometer is always the last part of the apparatus to be set in place and the first part to be removed at the end of an estimation.

(12) The stirrer motor is switched on and the stirrer is allowed to run, at about 1 cycle per sec, for about 5 min. This allows the temperature relations of the different parts of the apparatus to become steady.

(13) The thermometer reading is recorded at $\frac{1}{2}$ min. intervals for 3 min, or until the rate of rise or fall of temperature has been substantially constant for 3 min.

(14) The ignition switch is depressed at the end of the 3 min pre-period and the temperature is recorded at 1 min. intervals until the rate of temperature fall

has been steady for 3 min. The stirrer motor is switched off.

(15) The apparatus is dismantled in the reverse order of assembly. On removing the cap from the bomb the inside of the bomb is closely inspected for signs of scattered material other than ash, or any other sign of incomplete combustion.

Calculation Basically the total heat produced is found by multiplying the temperature rise by the water equivalent of the calorimeter. A correction has to be applied for the cooling of the calorimeter; this correction can be derived either graphically or from the Regnault-Pfaundler formula:

$$\text{Correction} = nv + \frac{(v_1 - v)}{(t_1 - t)}\left[\sum_{1}^{n-1}(t) + \tfrac{1}{2}(t_o + t_1) - nt\right] = nv + kP$$

where n is the time in min from firing to first recorded temperature after the maximum; v and v_1 are rates of fall of temperature in pre and cooling periods; t and t_o are average and final pre-ignition temperatures; tn and t_1 are initial and average cooling period temperatures.

Using the above formula, a specimen calculation is given as follows:-

Weight of food sample M.S.I. = 1.844 g.

Temperature readings at ½ min intervals, (°C).

Pre-ignition temperatures	Heating period temperatures	Cooling period temperatures
17.250	18.18	t_n 20.502
17.245	19.82	20.495
17.240	20.215	20.485
17.235	20.378	20.475
17.230	20.470	20.464
17.225	20.503	20.454
t_o 17.219	20.504	20.444
	20.504	20.433
	t_{n-1} 20.504	

$t = 17.235$ $\quad (t) = 181.078$ $\quad t_1 = 20.469$

$v = 0.005$ $\quad \frac{1}{2}(t_o + t_n) = 18.861$ $\quad v_1 = 0.010$

$n = 10$ $\quad nt = 172.35$

$nv = 0.05$

Observed temperature rise = $t_n - t_o = 3.283^{\circ}C$

$$\text{Correction} = 0.05 + \frac{0.005}{3.234}(181.078 + 18.861 - 172.35)$$

$$= 0.05 + (0.00155 \times 25.589)$$

$$= 0.093$$

Corrected temperature rise = 3.376°C

Water equivalent of calorimeter = 2285 g

Total heat produced = 7714.16 cal

Total heat/g food = 4.183 kcal/g

Total heat at constant pressure per g food = 4.180 kcal/g

Appendix I, F

Analysis of oxygen consumption traces

(1) Calculate total time from opening of the tap connecting spirometer to chamber circuit (T_3) to end of trace, (from times marked on trace) and express as decimal parts of an hour.

(2) Measure total length of trace in cm from opening of tap T_3 to end of trace. Ensure that rule is parallel to guide lines.

(3) Take all measurements on the basis of 4-hr intervals, starting at 10 a.m., i.e:- 10 a.m. - 2 p.m.; 2 p.m. - 6 p.m.; 6 p.m. - 10 p.m.; 10 p.m. - 2 a.m.; 2 a.m. - 6 a.m.; 6 a.m. - 10 a.m.

(4) Calculate the time interval from the time of opening the tap T_3 to the first of these periods nearest to a 4-hr interval. From this, calculate the length of trace from the beginning to the end of this first period. e.g.

Total length of trace	130 cm
Total time of trace	24 hr 30 min = 24.5 hr
Time of opening tap T_3	9.45 a.m.
End of next time period	2.00 p.m.
Time interval	4 hr 15 min = 4.25 hr
Calculated length of trace	130(4.25/24.5) cm = 22.55cm

(5) Using guide lines, rule and set-square, measure off this calculated distance along the trace, from the point of opening of the tap T_3, and draw a short horizontal line to include the end point of this measured distance. The horizontal line should be on the same level as the starting level of the sloped trace, not on the starting level of the spirometer. The end point, in this example, should correspond to the time 2 p.m.

(6) Mark the end point precisely on the short horizontal, and, with a set-square, drop a perpendicular from the horizontal to cut the oxygen consumption trace. Draw a short vertical line to cut the trace.

(7) Measure the length of the vertical between the horizontal and the point where the vertical cuts the trace. This distance is the fall of the spirometer, in cm, in the first 4.25 hr. This value is scaled to 4 hr., i.e. multiplied by 4.00/4.25 to give the spirometer fall in the first 4-hr period (10 a.m. - 2 p.m. in the example above).

(8) Calculate the horizontal distance for the simple 4-hr period, i.e. 130(4/24.5) cm, and measure this distance along the trace as before. Draw a short horizontal to include, this time, the 6 p.m. end point. This horizontal should be level with the

ppint on the trace of the 2 p.m. end point. Again drop a vertical to cut the trace at the 6 p.m. end point, and measure the vertical interval. This distance is the fall of the spirometer in the period 2 p.m. - 6 p.m.

(9) Repeat this procedure for the subsequent periods up to 6 a.m.

(10) When a period includes a refilling of the spirometer, set off the horizontal as usual, but draw an additional short horizontal to cut the spirometer refilling line. Then measure the vertical from this additional horizontal to the low point of the spirometer. Then draw a horizontal from the end point of the period, to cut the spirometer refilling line. Draw and measure the vertical from the highest point of the equilibrating spirometer trace to the last horizontal. The sum of the two vertical distances measured in this case, gives the total distance fallen by the spirometer during this time interval.

(11) For the last period, set off the horizontal as usual, but to include the final point of the trace. Drop a vertical to the final point of the trace and measure it. This distance corresponds to the fall

of the spirometer over the whole of the last period (in the example above from 6 a.m. to 10.15 a.m., or 4.25 hr).

(12) Measure the total length of the trace for the final period. Scale the spirometer fall down to a 4-hr interval by multiplying fall by the standard 4-hr horizontal and dividing by the measured horizontal for final period.

(13) As a check, the horizontal distance measured in the final period should be matched against the distance calculated from the time of the final period. The two values will probably differ by 2 or 3 mm. If, however, they differ by more than 5 mm, a mistake has probably been made in laying off and measuring distances, and the entire analysis of this run should be repeated.

(14) Express the graphical records either in the crude distance measurements (arbitrary units) or convert the values to units of oxygen consumption (ml per hr) by multiplying by $\frac{1000}{5.11 \times 4}$, since

$$\frac{\text{final spirometer reading} - \text{initial spirometer reading}}{5.11}$$

= vol of O_2 in litres.

Appendix I, G.

Preparation of diet M.S.I.

10 - 20 kg of diet are usually prepared at one time. Margarine is melted in a large enamel basin and cod liver oil and α-tocopherol are added to it. Sucrose is rapidly stirred in, followed by some starch, till the mixture became of a dry consistency. At this stage to ensure freedom from lumps, the mixture is rubbed through a mesh of 1.5 mm in diameter and 5 holes per cm. Salt mixture and Hepamino are mixed together with some starch and the water-soluble vitamins are dissolved in water (100 - 200 ml) and are ground with some starch, using mortar and pestle. To this vitamin-starch mixture is added the Hepamino-salt mixture and the rest of the starch. Thorough mixing is then carried out before and after the addition of casein. The diet is then stored in large jars in a refrigerator until required.

Mixing was originally carried out on the surface of a large table, but later a large, clean bin was used. Mixing by hand had the disadvantage that a fine, white powder was deposited everywhere nearby. It was, however, encouraging to learn that mixing by hand was

considered more efficient than mechanically driven machines, since these sometimes had a tendency to fractionate the dietary components (Lane-Petter, 1951).

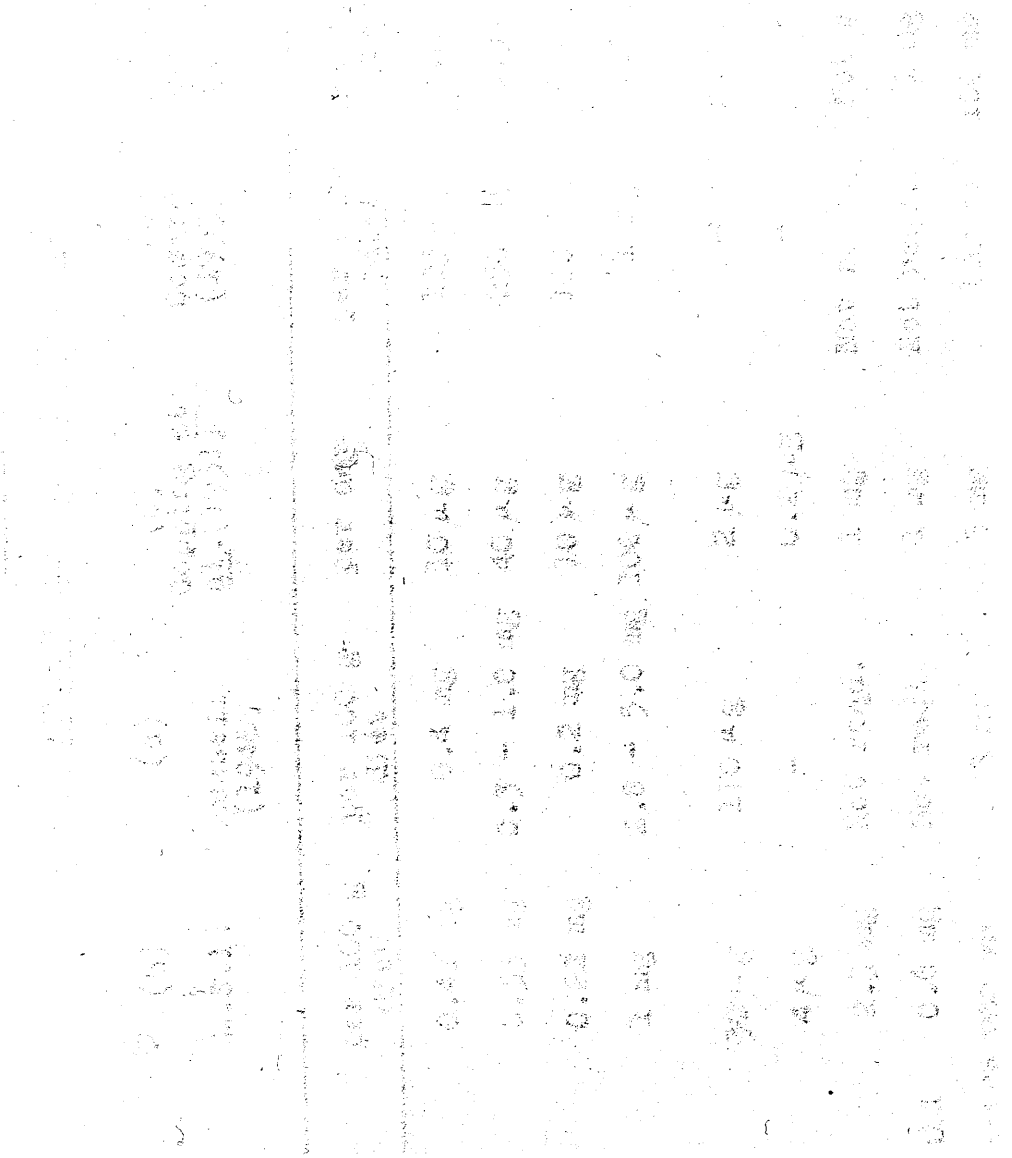


Table (1)

VITAMIN REQUIREMENTS FOR RATS

(a) Reference	(b) M.S.I.	(c) Russell (1948)	(d) Copping et al. (1951)	(e) Coward (1953)	(f) Cuthbertson (1957)	(g) Glaxo quoted by Cuthbertson (1957)	(h. Mayer (19
Requirement	per 100 g diet	per 100 g diet	per day	per 100 g diet	per 100 g diet	per 100 g diet	per 10 diet
Thiamin	0.41 mg	0.4 mg	10 µg.	125 µg	0.2 mg	3 mg	0.5 m
Riboflavin	0.53 mg	0.3 - 1.0 mg	40 µg	250 µg	0.5 mg	3 mg	0.5 m
Pyridoxine	0.22 mg	0.2 mg	10 µg	100 µg	0.2 mg	0.8 mg	0.5 m
Pantothenic acid	1 mg	2.8 - 5.0 mg	100 µg	1 mg	1.2 mg	10 mg	5 mg
Folic acid	30 µg	110 µg	2 µg	-	Not reqd.	0.1 mg	50 µg
Biotin	4 µg	-	0.2 µg	-	-	0.02 mg	50 µg
Inositol	2.5 mg	Not reqd.	1 mg	Not reqd.	Not reqd.	22 mg	10 mg
Nicotinic acid	0.6 mg	Not reqd.	1 mg	Not reqd.	1 mg	10 mg	5 mg
Choline chloride	200 mg	3 mg	3 mg	100 mg	100 mg	100 mg	100 mg
α-tocopherol	5 mg	0.25 - 0.75 mg per day	1 mg/week	3 mg	5 mg	28 mg	10 mg
p. amino-benzoic acid	-	Not reqd.	1 mg	Not reqd.	Not reqd.	7.5 mg	10 mg

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Vitamin A	474 I.U.	7 μg/day	120 I.U. per week	40 I.U.	300 I.U.	400 I.U.	1,200 I.U. every 10 days
Vitamin D	68 I.U.	-	200 I.U. per week	-	100 I.U.	200 I.U.	10 mg of Vitamin D

Table (2)

COMPOSITION OF BATCHES OF DIET M.S.I.

	Nitrogen mg/g	Energy kcal/g	Fat g/100g	Water g/100g
Diet for Series I	32.45	4.257	8.6	7.74
Diet for Series II	31.03	4.274	8.9	7.50
Diet for Series III	30.76	4.397	8.5	5.76
Diet for Weanlings	31.40	4.324	-	6.40

Table (3)

THEORETICAL R.Q. OF DIET M.S.I.

Dietary Component	Amount burned in g per g diet	Oxygen used		CO_2 produced		R.Q.
		g	litres	g	litres	
Protein	0.20	0.286	0.200	0.325	0.164	0.82
Carbohydrate	0.64	0.758	0.530	1.043	0.527	1.00
Fat	0.095	0.269	0.188	0.264	0.134	0.71
Total	0.935	1.313	0.918	1.632	0.825	0.90

Table (4)

FOOD AND MOISTURE ON FUNNEL AND FRAME

(a) Date	(b) Change in Funnel Wt.(g)	(c) Change in Frame Wt.(g)	(d) Change in Funnel and Frame Wt.(g)	(e) Wt. of Dry food on Filter Paper (g)	(f) Wt. of food corrected for moisture (g)	(g) Moistur... on funn... and fra... (g)
29.10.54	0.195	0.522	0.717	0.247	0.266	0.451
30.10.54	0.187	0.388	0.575	0.234	0.252	0.323
2.11.54	0.259	1.908	1.167	0.491	0.528	0.639
4.11.54	0.231	1.274	1.505	0.530	0.570	0.935
5.11.54	0.213	1.391	1.604	0.550	0.591	1.013
7.11.54	0.043	0.077	0.120	0.008	0.009	0.111
8.11.54	0.333	1.449	1.782	0.614	0.660	1.123
9.11.54	0.309	0.868	1.177	0.404	0.434	0.743
30.11.54	0.269	1.685	1.954	0.648	0.697	1.257
1.12.54	0.206	1.196	1.402	0.466	0.501	0.901
3.12.54	0.173	2.325	2.498	0.949	1.020	1.478
4.12.54	0.221	0.745	0.966	0.369	0.397	0.569

(a)	(b)	(c)	(d)	(e)	(f)	(g)
5.12.54	0.177	1.341	1.518	0.456	0.490	1.028
14.12.54	0.215	1.006	1.221	0.362	0.389	0.832
15.12.54	0.328	0.600	0.928	0.207	0.223	0.705
16.12.54	0.140	0.458	0.598	0.112	0.120	0.478
17.12.54	0.219	0.415	0.634	0.143	0.154	0.480
18.12.54	0.343	0.820	1.163	0.204	0.219	0.944
19.12.54	0.240	0.707	0.947	0.173	0.186	0.761
20.12.54	0.216	0.975	1.191	0.286	0.307	0.884
21.12.54	0.235	0.558	0.793	0.177	0.190	0.603
22.12.54	0.352	0.855	1.207	0.338	0.363	0.844
23.12.54	0.352	0.915	1.267	0.262	0.282	0.985

Table (5)

URINE SOLIDS AND URINARY NITROGEN

(a) Date	(b) Wt. of Rat (g)	(c) Wt. of Urine (g)	(d) Total N in Urine (mg)	(e) Wt. of Urine solids (g)
6.12.54	208	10.750	278.5	1.296
14.12.54	152	4.701	172.9	0.937
15.12.54	156	2.254	116.8	0.689
16.12.54	148	4.913	174.8	0.873
17.12.54	150	4.198	140.0	0.810
18.12.54	152	6.782	195.9	0.926
19.12.54	163	6.189	179.6	1.006
20.12.54	165	4.855	174.1	1.023
21.12.54	168	5.084	160.1	0.816
22.12.54	168	4.865	173.7	0.860
23.12.54	170	4.528	180.9	0.968
26.12.54	210	6.670	231.3	1.060

(a)	(b)	(c)	(d)	(e)
27.12.54	214	7.781	262.8	1.208
28.12.54	217	9.127	247.7	1.274
29.12.54	219	8.919	251.2	1.135
20. 1.55	65	1.927	87.0	0.447
24. 1.55	77	5.171	138.0	0.595
25. 1.55	82	6.658	113.6	0.616
26. 1.55	85	8.753	115.8	0.627
27. 1.55	88	7.423	113.9	0.664
28. 1.55	93	9.320	115.1	0.666

Table (6)

RATS USED IN METABOLIC STUDIES

Series I. Litter born 2.2.53.

Rat No.	Sex	Notes
33	M	Metabolic studies; analysed at 115 days.
34	M	Analysed at 30 days.
35	M	Metabolic studies; analysed at 115 days.
36	M	Analysed at 60 days.
29	F	-
30	F	-
31	F	Mated 26. 5.53. 6 young born on 17. 6.53 (3 females, average weight 3.8 g and 3 males, average weight 5.3 g).
32	F	-

Series II. Litter born 2. 9.53

63	M	Analysed at 30 days.
64	M	Metabolic studies; analysed at 115 days.
65	M	Analysed at 80 days.
66	M	Analysed at 60 days.

Series II. Litter born 2. 9.53 (contd.)

Rat. No.	Sex	Notes
67	M	Analysed at 30 days.
68	M	Metabolic studies; died on 19.10.53.
69	M	Analysed at 60 days.
70	M	Metabolic studies; analysed at 115 days.
71	M	Metabolic studies; died on 12.10.53.

Series III. Litter born 30. 1.54

109	M	Analysed at 80 days.
110	M	Analysed at 80 days.
111	M	Analysed at 60 days.
112	M	Metabolic studies; analysed at 115 days.
113	M	Metabolic studies; analysed at 115 days.
114	M	Analysed at 30 days.
115	M	Analysed at 30 days.
116	M	Analysed at 60 days.

Table (7)

RATS USED IN STUDIES OF DIETS M.S.I. AND 41.

Litter born 26. 4.53

Rat No.	Sex	Diet	Notes
51	F	M.S.I.	Fed for 52 days. Killed by coal gas and tissues examined histologically (p. 47, Vol. 1).
54	F		
57	M		
58	M		
52	F	41	
53	F		
55	M		
56	M		

Litter born 19. 9.53

Rat No.	Sex	Diet	Notes
79	F	M.S.I.	Fed for 120 days.
81	F		
72	M		
73	M		
78	F	41	
80	F		
74	M		
77	M		

Litter born 29. 9.53

Rat No.	Sex	Diet	Notes
95	F		
97	F	M.S.I.	Fed for 115 days.
99	M		
100	M		
94	F		
98	F	41	
90	M		
101	M		

Litter born 1. 2.54

Rat. No.	Sex	Diet	Notes
129	F	M.S.I.	Mated at 123 days. On 25. 6.57 litter of 15 born, 8 females, average weight 4.6 g, 7 males, average weight 4.9 g. 11 of litter left for lactation, of which 6 were weaned at 21 days.

Litter born 1. 2.54 (contd.)

Rat. No.	Sex	Diet	Notes
131	F	M.S.I.	Mated at 123 days. On 27. 6.57 litter born ? number; found dead and in process of being eaten by mother. On 28. 6.57 4 of Rat 129's litter were fostered to Rat 131, of which all were weaned at 21 days.
134	M		
136	M		Fed for 160 days.
132	F	41	
133	F		
135	M		
137	M		

Table (8)

METHODS OF CARCASE ANALYSIS

(a) Authors of Methods of Analysis	(b) Type of Rats	(c) Type of Carcase	(d) Method of Killing	(e) Prep. of Carcase	(f) Water and Total solids	(g) Nitrogen	(h) Fat
Addis et al. (1936)	Male albino	-	-	-	In vacuo	Gravimetric	Hot alcohol
Annegers (1954)	-	Clipped	Blow on head	Ground in Waring blender	In vacuum desiccator	-	Soxhlet (Ethyl ether)
Ashworth & Cowgill (1938)	Albino	-	-	Minced	Vacuum oven at 70°C	Kjeldahl	Anhydrous alcohol-ether
Bachmann et al. (1938)	Albino	-	Blow on head	Chopped and into boiling caustic	-	Kjeldahl	Saponif. and Pet. ether extractio
Bates et al. (1955)	-	-	-	Ground in Waring blender	Oven at 70°C	Micro-Kjeldahl (on dry defatted material)	Soxhlet ($CHCl_3$)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Chanutin (1931)	Male and female albino	Empty	Blow on back of neck	Minced	Heating for 48 hr at 100-110°C	Kjeldahl	Soxhlet (ether)
Da Costa & Clayton (1950)	Male Sprague-Dawley	-	-	-	Vacuum oven at 110°C	-	-
Deuel et al. (1944)	Male and female albino	Empty	Sodium amytal	Ground	Vacuum oven at 60°C	Kjeldahl (on fat-free material)	Soxhlet (diethyl ether
Feyder (1935)	Male	-	Blow on head	Into boiling KOH (30%)	-	Kjeldahl	Saponif. and Pet. ether extracti
Hamilton & Dewar (1938)	Male and female	-	Ether	Skin cut in places, cavities opened up	Oven at 100°C to constant weight	-	-
Hamilton (1939)	Albino	Empty	Ether	-	-	Kjeldahl	-

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Hatai (1917)	Albino	Empty	-	Minced	Oven at 95°C	Estimated as organic extractives	Alcohol and ether extract
Horst et al. (1934)	Male	Empty	Coal gas	Minced	Partial vacuum at 105°C	Kjeldahl	Saponif. and extracted by pet. ether
Lee & Schaffer (1934)	-	Empty	Coal gas	Ground	Oven at 60°C	Kjeldahl	Soxhlet (Pet. ether)
Lesser et al. (1952)	Albino	Clipped	Cyclo-propane	Minced	Vacuum desiccation	-	Soxhlet (ether)
Li et al. (1948)	Female	Empty	-	-	Lyophilization	Micro-Kjeldahl (dried tissue)	Soxhlet (Pet. ether)
Light et al. (1954)	-	Empty	-	Ground	Vacuum oven at 60-65°C (CO_2 at 20 mm Hg)	Kjeldahl (dried tissue)	Boiling with anhydrous alcohol-ether (dry tissue)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Lowrey (1913)	Albino	Skin estimated separately	$CHCl_3$	-	Oven at 95°C	-	-
Mitchell & Carman (1926)	-	Minus gastro-intestinal tract	Details of analysis not given				
Nash (1942)	-	-	-	-	Oven at 100°C	Estimated by difference	Ether extracti
Pembrey & Spriggs (1904)	Male	-	$CHCl_3$	Minced and frozen	Water and dry oven at 105°C	Kjeldahl	Saponif.
Pickens et al. (1940)	Male albino	Empty	-	Ground	Oven at 55°C	Kjeldahl (on dry fat-free tissue)	Ether extractio
Rutten et al. (1955)	Wistar	Minus skin, tail, claws and gut	$CHCl_3$	Homog-enised	Oven at 55°C	-	Saponif. and ethe extractic

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Sinclair (1930)	Albino	Whole carcase	Stunned by blow	Minced	-	-	Hot alcohol ether extracti...
Spray & Widdowson (1950)	Hooded	-	Coal gas	Digestion with HCl	Estimated by difference	Kjeldahl	Saponif.
Truszkowski (1926)	Albino	Empty	Strangulation	Minced	At 100°C	Kjeldahl after hydrolysis With 4% H_2SO_4	-
Weeks (1957)	Female Benger	Minus viscera, skin, head tail and claws	-	-	Continuous water extraction	Kjeldahl	Ethyl ar... Pet. eth... extracti...
Williams et al. (1945)	-	Empty	-	Ground	Frozen and dried under vacuum	-	Ethanol-ether extraction

Table (9)

REGRESSION OF FOOD ADHERING TO FUNNEL AND FRAME ON CHANGE IN WEIGHT IN FUNNEL AND FRAME

cf Fig. (12). N = 23

Theoretical linear equation where F is food adhering to funnel and frame in g and C is change in weight in funnel and frame in g:-

$$F = \underline{a} + \underline{b}(C - \bar{C})$$

Computed linear equation:-

$$F = 0.385 + 0.417(C - 1.171)$$

i.e. $$F = 0.417C - 0.104$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	1.009	1	1.009	149.26	12.2	<0.001
Residual	0.142	21	0.0068			
Total	1.151	22	0.0523			

Standard Error of a = 0.0172

Standard Error of b = 0.0342

Standard Error of Intercept on F axis = 0.0436

Table (1c)

REGRESSION OF URINARY SOLIDS ON URINARY NITROGEN

cf Fig. (13). N = 21

Theoretical linear equation where S is urinary solids in g and U is urinary Nitrogen in mg:-

$$S = \underline{a} + \underline{b}(U - \bar{U})$$

Computed linear equation:-

$$S = 0.881 + 0.0041(U - 172.570)$$

$$\text{i.e. } S = 0.174 + 0.0041U$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	1.033	1	1.033	218.038	14.76	<0.001
Residual	0.090	19	0,0047			
Total	1.124	20	0.0562			

Standard Error of a = 0.015

Standard Error of b = 0.0003

Standard Error of Intercept on S axis = 0.0502

Table (11)

REGRESSION OF ENERGY EXPENDITURE ON BODY WEIGHT

cf Fig. (20). N = 26

Theoretical linear equation where E is energy expenditure in kcal and W is body weight in g:-

$$E = \underline{a} + \underline{b}(W - \overline{W})$$

Computed linear equation:-

$$E = 32.95 + 0.0833(W - 151.369)$$

$$\text{i.e. } E = 20.34 + 0.0833W$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	729.627	1	729.627	83.040	9.11	<0.001
Residual	210.875	24	8.786			
Total	940.502	26				

Standard Error of a = 0.581

Standard Error of b = 0.0029

Standard Error of Intercept on E axis = 0.4273

Table (12)

REGRESSION OF ENERGY EXPENDITURE ON ABSORBED FOOD ENERGY

cf Fig. (27). N = 26

Theoretical linear equation where E is energy expenditure in kcal and N is absorbed food energy in kcal:-

$$E = \underline{a} + \underline{b}(N - \bar{N})$$

Computed linear equation:-

$$E = 32.95 + 0.4898(N - 44.372)$$

$$\text{i.e. } E = 11.22 + 0.490N$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	747.802	1	747.802	93.138	9.65	<0.001
Residual	192.700	24	8.029			
Total	940.502	25				

Standard Error of a = 0.55

Standard Error of b = 0.0507

Standard Error of Intercept on E axis = 2.3196

Table (13)

REGRESSION OF NON-PROTEIN R.Q. ON THE RATIO OF INGESTED ENERGY TO ENERGY EXPENDITURE (G/E)

cf Fig. (28). N = 119

Theoretical linear equation where R is daily non-protein R.Q. and B is the ratio G/E:-

$$R = \underline{a} + \underline{b}(B - \bar{B})$$

Computed linear equation:-

$$R = 0.929 + 0.085(B - 1.37)$$

$$\text{i.e. } R = 0.811 + 0.085B$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	0.050	1	0.050	3.877	1.98	0.05
Residual	1.517	117	0.013			
Total	1.568	118				

Standard Error of a = 0.0104

Standard Error of b = 0.0431

Standard Error of Intercept on R axis = 0.0604

Table (14)

REGRESSION OF NON-PROTEIN R.Q. ON THE RATIO OF ABSORBED ENERGY TO ENERGY EXPENDITURE (N/E)

of Fig. (29). N = 119

Theoretical linear equation where R is daily non-protein R.Q. and A is the ratio N/E:-

$$R = \underline{a} + \underline{b}(A - \bar{A})$$

Computed linear equation:-

$$R = 0.929 + 0.110(A - 1.337)$$

$$\text{i.e. } R = 0.781 + 0.110A$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	0.0810	1	0.0810	6.378	2.89	0.01
Residual	1.487	117	0.0127			
Total	1.568	118				

Standard Error of a = 0.0103

Standard Error of b = 0.0436

Standard Error of Intercept on R axis = 0.0592

Table (15)

REGRESSION OF URINARY NITROGEN ON INGESTED ENERGY

cf Fig. (35). N = 26

Theoretical linear equation where N is urinary nitrogen in mg and G is ingested energy in kcal:-

$$N = \underline{a} + \underline{b}(G - \bar{G})$$

Computed linear equation (for joint regression of 3 series):-

$$N = 158.23 + 5.08(G - 45.81)$$

i.e. $N = 5.08G - 74.48$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Joint Regression	62421.35	1	62421.35	61.85	7.87	0.001
Residual	22201.67	22	1009.17			
Total	84623.02	23				

Standard Error of a = 6.2309

Standard Error of b = 0.6462

Standard Error of Intercept on N axis = 30.3518

Table (16)

REGRESSION OF FAECAL ENERGY ON INGESTED ENERGY

cf Fig. (30). N = 26

Theoretical linear equation where D is faecal energy in kcal and G is ingested energy in kcal:-

$$D = \underline{a} + \underline{b}(G - \overline{G})$$

Computed linear equation:-

$$D = 1.466 + 0.0286(G - 45.807)$$

$$\text{i.e. } D = 0.157 + 0.0286G$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	2.698	1	2.698	21.952	4.69	<0.001
Residual	2.949	24	0.123			
Total	5.647	25				

Standard Error of a = 0.0687

Standard Error of b = 0.0061

Standard Error of Intercept on D axis = 0.3821

Table (17)

REGRESSION OF WEIGHT OF DRY FAECES ON WEIGHT OF FOOD

cf Fig. (36). N = 130

Theoretical linear equation where H is weight of dry faeces in g and I is weight of food in g:-

$$H = \underline{a} + \underline{b}(I - \bar{I})$$

Computed linear equation:-

$$H = 0.437 + 0.0415(I - 10.151)$$

i.e. $$H = 0.016 + 0.0415I$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	1.9240	1	1.9240	100.7320	10.04	<0.001
Residual	2.4388	128	0.0191			
Total	4.3628	129				

Standard Error of a = 0.0126

Standard Error of b = 0.0041

Standard Error of Intercept on H axis = 0.0438

Table (18)

REGRESSION OF VAPORIZED WATER ON BODY WEIGHT (ABOVE 120 GRAMS)

cf Fig. (41). N = 17

Theoretical linear equation where V = vaporized water in g and W is body weight in g:-

$$V = \underline{a} + \underline{b}(W - \overline{W})$$

Computed linear equation:-

$$V = 16.23 + 0.0021(W - 184.38)$$

$$\text{i.e. } V = 15.84 + 0.0021W$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	1.233	1	1.233	0.0079	0.0889	Not significant
Residual	425.746	15	28.383			
Total	426.979	16				

Standard Error of a = 1.2921

Standard Error of b = 0.0317

Standard Error of Intercept on V axis = 5.9919

Table (19)

REGRESSION OF VAPORIZED WATER ON BODY WEIGHT (ABOVE 120 GRAMS)

cf Fig. (41). N = 10

Theoretical linear equation where V is vaporized water in g and W is body weight in g:-

$$V = \underline{a} + \underline{b}(W - \overline{W})$$

Computed linear equation:-

$$V = 12.96 + 0.0894(W - 84.81)$$

$$\text{i.e. } V = 5.38 + 0.0894W$$

Analysis of Regression. Difference of coefficient b from zero.

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	t	P
Regression	40.149	1	40.149	19.797	4.46	<0.01
Residual	16.209	8	2.028			
Total	56.358	9				

Standard Error of a = 0.4503

Standard Error of b = 0.0201

Standard Error of Intercept on V axis = 1.7614

Table (20)

ANALYSIS OF VARIANCE OF ENERGY EXPENDITURE

N = 122.(N (planned) = 135; Missing values = 13)

Source of Variance	Crude Squares	D.F.	Mean Squares	Variance Ratio	P
Between 5 day runs	4531.2915	8	566.4114		
Between days within runs	13.8941	4	3.4735		
Between series	313.8650	2	156.9331		
Error	436.88	107	4.0830		
Completed Total	5295.93	121			
Original Total	4707.62	121			
Between 5 day runs (corrected)	4027.8650	8	503.4831	123.3	<0.001
Between days within runs (corrected)	12.3505	4	3.0876	0.756	Not significant
Between series (corrected)	278.9945	2	139.4973	34.165	<0.001

Table (21)

ANALYSIS OF CO-VARIANCE FOR ENERGY EXPENDITURE ON BODY WEIGHT AND FOOD INTAKE (MEAN VALUES)

Source	D.F.	C $(E)^2$	A $(W)^2$	B $(F)^2$	Q (EW)	P (WF)	R (EF)
Total	26	1001.46	87130.50	3248.36	9167.00	14375.27	1613.53
Between Periods	8	901.18	82216.04	2185.65	8591.44	12825.98	1359.20
Residual	18	100.28	4914.46	1062.71	575.56	1549.29	254.33
(Periods + Residual) - Residual	8						

Table (21) (contd.)

Source	$\frac{BQ^2 + AR^2 - 2PQR}{AB - P^2}$	$C - \frac{BQ^2 + AR^2 - 2PQR}{AB - P^2}$	$S^2_{(DF - 2)}$
Total	976.12	25.34	1.056
Between Periods	899.73	1.45	0.24
Residual	76.66	23.62	1.48
(Periods + Residual) - Residual		1.72	0.29

$$b_1 = (BQ - PR)/(AB - P^2) = 0.0862$$

$$b_2 = (AR - PQ)/(AB - P^2) = 0.115$$

Table (22)

ANALYSIS OF CO-VARIANCE FOR ENERGY EXPENDITURE ON BODY WEIGHT AND FOOD INTAKE (VALUES FOR INDIVIDUAL DAYS)

Source	D.F.	C $(\underline{E})^2$	A $(\underline{W})^2$	B $(\underline{F})^2$	Q $(\underline{EW})$	P $(\underline{WF})$	R $(\underline{EF})$	$\frac{BQ^2 + AR^2 - 2PQR}{AB - P^2}$
Total	121	5,295.93	434,016.80	23,128.15	45,956.26	73,057.08	8,904.00	4,992.14
Between days (within periods)	4	13.8941	1,245.69	378.88	99.16	477.74	22.39	9.1434
Between periods	8	4,531.2915	407,476.42	11,366.29	42,765.04	64,568.96	6,917.72	4,505.78
Residual	109	750.7444	25,294.69	11,382.98	3,092.06	8,010.38	1,963.89	487.58
Periods + Residual	117	5,282.0359	432,771.11	22,749.27	45,875.10	72,579.34	8,881.61	4,996.3
Days + Residual	113	764.6385	26,540.38	11,761.86	3,191.22	8,488.12	1,986.28	486.78

Table (22) (contd.)

Source	$C - \frac{(BQ^2 + AR^2 - 2PQR)}{AB - P^2}$	S^2 (DF - 2)	Variance Ratio	b_1	b_2
Total	303.79				
Between days (within periods)	4.7507				
Between periods	25.5017				
Residual	263.1590	2.5			
Periods + Residual	285.704			0.087	0.112
Days + Residual	277.8537			0.086	0.107
(Periods + Residual) - Residual	22.545	3.76	1.5		
(Days + Residual) - Residual	14.695	7.35	2.9		

Table (23)

WATER AND HEAT LOSS FROM SKIN AND LUNGS

(a) Series	(b) Age (days)	(c) Pulmonary Ventil. litres/day	(d) Water loss from lungs (g)	(e) % of total vaporiz. water from lungs	(f) Heat loss by vaporiz. (kcal)	(g) Heat loss via lungs (kcal)	(h) Heat loss via skin (kcal)	(i) % of total heat lost by vaporiz.	(j) % of total heat lost via lungs	(k) % of total heat lost via skin
I	30-35	106.5	3.1	26.5	6.8	1.8	5.0	29.1	7.7	21.4
	40-45	115.2	3.3	23.7	8.1	1.9	6.2	31.9	7.5	24.4
	50-55	129.7	3.8	23.3	9.5	2.2	7.3	33.3	7.7	25.6
	60-65	137.3	4.0	26.9	8.6	2.3	6.3	28.7	7.7	21.0
	70-75	163.0	4.7	29.9	9.1	2.7	6.4	25.4	7.6	17.8
	80-85	161.1	4.7	32.6	8.3	2.7	5.6	23.5	7.7	15.8
	90-95	147.5	4.3	24.0	10.4	2.5	7.9	31.7	7.6	24.1
	100-105	158.8	4.6	26.4	10.4	2.7	7.8	29.7	7.6	22.1
	110-115	196.2	5.7	32.8	10.1	3.3	6.8	23.2	7.6	15.6

Table (23) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
II	30-35	107.0	3.1	26.9	6.7	1.8	4.9	28.4	7.7	20.7
	40-45	125.7	3.6	28.2	7.4	2.1	5.3	27.3	7.7	19.6
	50-55	121.3	3.5	27.1	7.5	2.0	5.5	27.5	7.4	20.1
	60-65	126.8	3.7	30.8	7.0	2.1	4.8	24.7	7.6	17.1
	70-75	144.4	4.2	26.8	9.1	2.4	6.7	28.8	7.7	21.1
	80-85	157.9	4.6	29.3	9.1	2.7	6.4	25.9	7.6	18.3
	90-95	169.6	4.9	26.6	10.6	2.8	7.8	28.9	7.7	21.2
	100-105	-	-	-	-	-	-	-	-	-
	110-115	179.1	5.2	28.0	10.8	3.0	7.8	27.4	7.7	19.7
III	30-35	117.4	3.4	26.2	7.6	2.0	5.6	28.8	7.5	21.3
	40-45	124.4	3.6	27.1	7.7	2.1	5.6	28.0	7.6	20.4
	50-55	144.6	4.2	25.5	9.5	2.4	7.1	29.7	7.6	22.1
	60-65	141.6	4.1	26.0	9.2	2.4	6.8	29.5	7.7	21.8

Table (23) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
	70-75	161.0	4.7	29.6	9.2	2.7	6.5	25.7	7.5	18.1
	80-85	176.2	5.1	32.1	9.0	3.0	6.0	23.3	7.6	15.7
III	90-95	184.4	5.3	31.7	9.7	3.1	6.6	23.7	7.5	16.2
	100-105	189.0	5.5	33.1	9.6	3.2	6.4	23.0	7.6	15.4
	110-115	198.3	5.7	34.1	9.7	3.3	6.4	22.1	7.5	14.6
2 weanlings	21-26	145.7	4.2	27.7	9.0	2.4	7.6	26.8	7.1	19.7

Table (24)

RETENTION OF INGESTED NITROGEN AND ENERGY

(a) Series	(b) Age (Days)	(c) % Ingested N Absorbed	(d) % Ingested NRetained	(e) N (mg) per g gain in weight	(f) Gross N efficiency	(g) % Ingested Energy Absorbed	(h) % Ingested Energy Retained	(i) Energy (kcal) per g gain in weight	(j) Gross energetic efficiency
I	30-35	93.2	47.9	43	51.3	96.5	18.2	2.3	19.4
	40-45	96.1	63.9	123	66.4	96.2	19.0	5.3	20.1
	50-55	95.4	47.8	212	50.2	96.8	12.7	7.5	13.5
	60-65	94.8	48.9	-	52.4	96.8	12.3	-	13.1
	70-75	97.1	34.2	68	35.2	96.2	14.7	4.0	16.0
	80-85	97.1	30.1	102	31.0	96.2	9.3	4.3	10.0
	90-95	96.9	53.4	36	55.1	97.4	27.5	2.5	29.1
	100-105	96.7	55.2	-	57.1	96.7	17.2	-	18.2
	110-115	97.0	32.0	27	33.0	96.5	7.2	-	7.8

Table (24) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
II	30-35	96.9	56.7	119	58.5	97.8	18.8	5.1	19.7
	40-45	96.2	40.2	123	41.8	97.2	11.9	4.8	12.7
	50-55	95.5	40.2	25	42.1	95.6	24.8	2.1	26.9
	60-65	95.9	41.2	515	43.0	97.1	2.1	3.4	2.3
	70-75	94.8	36.9	38	38.9	96.4	20.1	2.7	21.7
	80-85	93.2	46.4	65	49.8	95.1	25.8	4.8	28.0
	90-95	93.7	30.1	37	32.1	96.1	21.8	3.5	23.7
	100-105	-	-	-	-	-	-	-	-
	110-115	93.9	31.2	41	33.3	96.9	17.6	3.1	19.0
III	30-35	97.7	80.7	175	82.6	98.7	20.3	6.3	20.8
	40-45	95.5	51.0	61	53.5	95.8	17.6	3.0	19.1
	50-55	96.4	74.7	73	77.5	97.8	31.3	4.4	32.4
	60-65	95.9	59.5	79	62.1	97.2	30.5	5.8	32.1

Table (24) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
III	70-75	94.0	60.0	77	63.8	97.4	32.3	5.9	34.1
	80-85	94.5	49.8	149	52.7	97.4	30.9	13.3	32.7
	90-95	93.9	51.1	76	54.5	97.1	27.2	5.8	28.8
	100-105	94.8	50.1	126	52.8	97.5	39.3	14.0	41.3
	110-115	93.5	37.5	56	40.2	96.6	29.2	6.2	31.4
Mean of 3 Series		95.4				96.8			
Weanlings	21-26	95.4	65.7			97.2	27.5	2.3	

Table (25)

ACTUAL COMPOSITION OF RAT CARCASES

(a) Rat No.	(b) Age (days)	(c) Weight (g)	(d) Water (g)	(e) Fat (g)	(f) Nitrogen (g)	(g) Protein (N x 6.25) (g)	(h) Energy (measured) (kcal)
34	30	57	44.0	1.45	1.66	10.38	67.47
36	60	153	102.8	5.47	5.26	32.88	290.77
33	115	201	136.7	8.67	6.56	41.00	351.04
35	115	250	163.4	12.27	8.40	52.50	491.95
63	30	58	43.9	2.03	1.53	9.56	68.41
67	30	58	44.5	1.97	1.48	9.25	73.00
66	60	96	68.4	3.29	3.02	18.88	150.18
69	60	97	70.0	3.76	3.03	18.94	140.92
65	80	131	87.5	7.53	4.05	25.31	242.79
70	115	211	137.5	18.91	6.44	40.25	473.94
64	115	211	140.9	19.23	5.63	35.19	421.03
115	30	61	44.6	2.07	1.55	9.69	85.46
114	30	59	43.0	2.53	1.64	10.25	84.86

Table (25) (Contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
111	60	123	83.2	8.43	3.87	24.19	215.74
116	60	104	71.4	6.99	3.26	20.38	179.64
110	80	171	111.3	17.08	5.59	34.94	352.13
109	80	131	86.4	12.05	4.05	25.31	251.33
113	115	271	170.4	32.99	8.90	55.63	590.99
112	115	254	164.9	22.09	8.24	51.50	497.81
-	Newborn	4.8	4.1	0.04	0.08	0.49	3.04
-	1	4.9	4.1	0.07	0.08	0.50	3.89
-	21	26	19.2	0.98	0.77	4.79	34.96
-	20	35	24.4	2.21	0.99	6.16	60.08
72	143	276	171.6	34.33	7.87	49.19	675.34
73	143	278	166.5	37.86	9.43	58.94	730.03
7	194	329	201.5	39.00	10.67	66.56	735.46
-	242	307	184.3	44.15	9.06	56.63	743.88
-	247	319	193.1	46.87	9.65	60.31	787.24

Table (26)

PERCENTAGE COMPOSITION OF RAT CARCASES

(a) Rat No. or Age (days)	(b) % Water	(c) % Solids	(d) % Fat	(e) % Nitrogen	(f) % Protein	(g) Total %
34	77.0	23.0	4.3	2.9	18.2	99.5
36	67.0	33.0	6.7	3.4	21.4	95.1
33	68.0	32.0	6.3	3.3	20.4	94.7
35	65.4	34.6	8.4	3.4	21.0	94.8
63	74.9	25.1	3.0	2.6	16.4	94.3
67	76.2	23.8	3.4	2.5	15.8	95.4
66	70.9	29.1	3.4	3.1	19.6	93.9
69	72.3	27.7	3.9	3.1	19.5	95.7
65	66.5	33.5	5.7	3.1	19.2	91.4
70	65.3	34.7	8.9	3.1	19.1	93.3
64	66.6	33.4	9.1	2.7	16.6	92.3
115	72.8	27.2	3.4	2.5	15.8	92.0

Table (26) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
114	72.3	27.7	4.3	2.8	17.3	93.9
111	68.0	32.2	6.9	3.2	19.7	94.6
116	68.4	31.6	6.7	3.1	19.5	94.6
110	64.9	35.1	10.0	3.3	20.4	95.3
109	65.8	34.2	9.2	3.1	19.3	94.3
113	62.9	37.1	12.2	3.3	20.5	95.6
112	65.0	35.0	8.7	3.2	20.3	94.0
Newborn	85.7	14.3	0.9	1.6	10.2	96.8
1 day	84.7	15.3	1.5	1.6	10.2	96.4
20 days	69.9	30.1	6.3	2.8	17.7	93.9
21 days	73.8	26.2	3.8	2.9	18.4	96.0
72	62.1	37.9	12.4	2.9	17.8	92.3
73	60.0	40.0	13.6	3.4	21.2	94.8
194 days	61.2	38.8	11.9	3.2	20.3	93.4
242 days	60.0	40.0	14.4	2.9	18.4	92.8
247 days	60.5	39.5	14.7	3.0	18.9	94.1

Table (26) (contd.)

Mean Values

Age (days)	Weight (g)	% Water	% Solids	% Fat	% Protein	Total %
115	233	65.5	34.5	8.9	19.7	94.1
80	144	62.9	37.1	8.3	19.6	90.8
60	115	69.3	30.7	5.5	19.6	94.4
30	59	74.7	25.3	3.6	16.7	95.0
20-21	30	71.8	28.2	5.1	18.0	94.9
Newborn	4.9	85.2	14.8	1.2	10.2	96.6
143	277	61.0	39.0	13.0	19.5	93.5
228	237	60.3	39.7	13.6	19.2	93.1

Table (27)

FAT-FREE AND CALORIC COMPOSITION OF RAT CARCASES

(a) Rat No. or Age (days)	(b) kcal from Fat	(c) kcal from Protein	(d) Total kcal (computed)	(e) kcal (computed) per 100 g body weight	(f) % Water in Fat-free Rat	(g) % N in Fat-Free Rat
34	13.49	59.69	73.18	144.2	80.5	3.0
36	50.87	189.06	239.93	185.3	71.8	3.7
33	80.63	235.75	316.38	176.0	72.6	3.5
35	114.11	301.88	415.99	198.8	71.4	3.7
63	18.88	54.97	73.85	121.5	77.6	2.7
67	18.32	62.44	80.76	122.4	78.9	2.6
66	30.60	108.56	139.16	137.6	73.5	3.3
69	34.94	108.91	143.85	144.4	75.2	3.3
65	70.03	145.53	213.56	163.9	70.6	3.3
70	175.86	231.44	407.30	192.7	71.8	3.4
64	178.84	202.34	381.18	180.2	73.3	2.9
115	19.25	55.72	74.97	122.2	75.3	2.6
114	23.53	58.94	82.47	139.0	75.6	2.9

Table (27) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
111	78.40	139.09	217.49	177.2	73.0	3.4
116	65.01	117.19	182.20	174.5	73.3	3.3
110	158.84	200.91	359.75	209.8	72.1	3.6
109	112.07	145.53	255.60	196.3	72.5	3.4
113	306.81	319.87	626.68	231.3	71.6	3.7
112	205.44	296.13	501.57	197.6	75.3	3.6
Newborn	0.39	2.81	3.20	67.0	86.5	2.0
1 day	0.68	2.88	3.56	72.6	84.9	1.7
20 days	9.17	27.56	36.74	141.1	74.6	3.0
21 days	20.55	35.39	55.94	168.0	76.8	3.1
72	319.27	282.84	602.11	218.0	70.9	3.3
73	352.10	338.91	691.01	248.6	69.4	3.9
194 days	362.70	382.72	745.42	226.7	69.5	3.7
242 days	410.59	325.62	736.21	239.5	70.0	3.4
247 days	435.89	346.78	782.67	245.0	70.8	3.5

Table (27) (Contd.)

Mean Values

Age (days)	No. of Rats	% Water in Fat-free Rat	% N in Fat-free Rat	% Protein in Fat-free Rat
115	6	72.7	3.5	21.6
80	3	71.7	3.4	21.4
60	5	73.3	3.4	21.1
30	5	77.6	2.8	17.4
20-21	2 groups	75.7	3.0	18.9
Newborn	2 groups	86.2	1.6	10.3
143	2	70.2	3.5	22.1
228	3	70.1	3.6	22.2

Table (28)

COMPONENTS OF BODY WEIGHT GAINED FROM CARCASE ANALYSIS

(a) Series	(b) Age of weight gain (days)	(c) Weight gained (g)	(d) Fat gained (g)	(e) Protein gained (g)	(f) Water gained (g)	(g) Fat/g weight increase (g)	(h) Protein/g weight increase (g)	(i) Water/g weight increase (g)
I	30-60	96.4	4.0	22.5	88.8	0.04	0.23	0.61
	60-115	72.1	5.0	13.9	47.3	0.06	0.19	0.66
	115-143	51.3	25.7	7.3	19.0	0.50	0.14	0.37
II	20-30	28.1	0.4	3.9	22.4	0.01	0.14	0.80
	30-60	38.1	1.4	9.5	25.0	0.04	0.25	0.66
	60-80	34.9	4.1	6.4	18.3	0.12	0.18	0.52
	80-115	79.5	11.6	12.4	51.7	0.15	0.16	0.65
	115-143	65.9	17.1	16.4	29.9	0.26	0.25	0.45

Table (28) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	0-20	25.5	1.6	5.0	17.7	0.06	0.20	0.69
	0-30	55.5	2.3	9.4	39.8	0.04	0.17	0.71
	20-30	30.0	0.7	4.4	22.1	0.02	0.15	0.74
III	30-60	53.2	5.4	12.4	33.4	0.10	0.23	0.63
	60-80	37.8	6.9	7.8	21.6	0.18	0.21	0.57
	80-115	110.9	12.9	23.5	68.8	0.12	0.21	0.62
	115-228	56.3	15.9	7.6	25.2	0.28	0.14	0.45

Table (28) (contd.)

(a) Series	(b) Age of weight gain (days)	(c) Energy gained (kcal)	(d) Energy/g weight increase (kcal)	(e) Dry body weight increment (D.B.W.I.) (g)	(f) Protein/ D.B.W.I. (g)	(g) Fat/ D.B.W.I. (g)	(h) Energy/ D.B.W.I. (kcal)	(i) Energy from fat per D.B.W.I. (kcal)
	30-60	223.3	2.31	37.6	0.60	0.11	5.94	1.02
I	60-115	131.2	1.82	24.8	0.56	0.20	5.30	1.86
	115-143	255.2	3.03	32.7	0.22	0.79	7.80	7.35
	20-30	23.2	0.83	5.7	0.70	0.07	4.10	0.65
	30-60	74.9	1.97	13.1	0.73	0.11	5.71	1.02
	60-80	97.2	2.78	16.6	0.39	0.25	5.85	2.33
II	80-115	204.7	2.57	27.8	0.45	0.42	7.36	3.91
	115-143	255.2	3.87	36.0	0.46	0.47	7.10	4.37

Table (28) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	0-20	44.0	1.73	7.8	0.64	0.20	5.64	1.86
	0-30	81.7	1.47	15.7	0.60	0.14	5.20	1.30
	20-30	37.7	1.26	7.9	0.56	0.09	4.77	0. 84
III	30-60	112.5	2.11	19.8	0.63	0.27	5.68	2.51
	60-80	104.0	2.75	16.2	0.48	0.43	6.42	4.00
	80-115	242.7	2.19	42.1	0.56	0.31	5.72	2.88
	115-228	178.2	3.16	31.1	0.24	0.51	5.73	4.74

Table (29)

COMPONENTS OF BODY WEIGHT GAINED IN METABOLIC SERIES III

Age of weight gain (days)	Weight gain per day (g)	Water balance per day (g)	Dry Body Weight Increment (D.B.W.I.) (g)	Nitrogen gained/day (mg)	Nitrogen/g D.B.W.I. (mg)	Protein/g D.B.W.I. (mg)
30-35	+ 1.093	- 0.44	1.533	190.74	124.44	0.77
40-45	+ 2.163	- 0.70	1.463	131.09	89.60	0.56
50-55	+ 3.556	+ 0.48	3.076	258.48	84.03	0.52
60-65	+ 2.534	- 1.34	3.874	199.98	51.62	0.32
70-75	+ 3.131	- 0.02	3.151	240.51	76.32	0.48
80-85	+ 1.418	- 2.42	3.838	211.75	55.17	0.34
90-95	+ 2.866	- 0.53	3.393	217.57	64.07	0.40
100-105	+ 2.009	- 3.06	5.069	252.55	49.82	0.31
110-115	+ 3.085	- 0.71	3.795	172.31	45.40	0.28

Table (29) (contd.)

(a) Age of weight gain (days)	(b) Energy gained/day (kcal)	(c) Energy/g D.B.W.I. (kcal)	(d) Energy from Protein/ D.B.W.I. (kcal)	(e) Non-protein Energy/ D.B.W.I. (kcal)	(f) % Energy from Protein/ D.B.W.I.	(g) % Energy from non-protein sources/ D.B.W.I.
30-35	6.86	4.47	4.46	0.01	99.8	0.2
40-45	6.47	4.42	3.22	1.20	72.8	27.2
50-55	15.47	5.03	3.02	2.01	60.0	40.0
60-65	14.64	3.78	1.85	1.93	48.9	51.1
70-75	18.54	5.88	2.74	3.14	46.6	53.4
80-85	18.82	4.90	1.98	2.92	40.4	59.6
90-95	16.57	4.88	2.30	2.58	47.1	52.9
100-105	28.25	5.57	1.79	3.78	32.1	67.9
110-115	19.04	5.01	1.63	3.38	32.5	67.5

Table (30)

SEQUENCE AND DATES OF STUDIES

(a) Serial No.	(b) Rat No.	(c) Date	(d) Age of Rat (Days)	(e) Mean Body Weight (g)	(f) Notes
1	33 & 36	4-5.3.53	30	117.8	$CaCl_2$ and soda asbestos tubes changed.
2	33	5-6		61.7	
3		6-7		64.6	
4		7-8		66.8	
5		8-9		68.8	
6	33	14-15.3.53	40	83.8	$CaCl_2$ tube changed.
7		15-16		81.1	
8		16-17		81.2	
9		17-18		85.3	
10		18-19		89.6	Soda asbestos tubes changed.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
11	33	24-25.3.53.	50	105.2	
12		25-26		104.2	
13		26-27		106.6	$CaCl_2$ tubes broken on 27.3.56.
14		27-28		107.9	$CaCl_2$ tube changed.
15		28-29		109.3	$CaCl_2$ and soda asbestos tubes changed.
16	33	3-4.4.53	60	126.3	$CaCl_2$ and soda asbestos tubes changed.
17		4-5		126.0	
18		5-6		127.3	
19		6-7		123.2	
20		7-8		117.9	? Initial leak. Condensation in animal chamber. Weight balance discrepancy. Data discarded.
21	35	13-14.4.53	70	162.3	
22		14-15		164.6	$CaCl_2$ tube changed.
23		15-16		174.3	

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
24	35	16-17.4.53	70	176.9	
25		17-18		177.8	$CaCl_2$ tube changed.
26	35	23-24.4.53	80	190.2	
27		24-25		192.1	
28		25-26		193.7	
29		26-27		190.8	
30		27-28		191.7	
31	33	3-4.5.53	90	166.6	Pump stroke increased from 8 to 10 m
32		4-5		161.8	Weight balance discrepancy. ? cause.
33		5-6		162.2	$CaCl_2$ tube changed.
34		6-7		169.2	$CaCl_2$ and anhydrone tubes changed.
35		7-8		174.6	$CaCl_2$ and anhydrone tubes changed.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
36	33	13-14.5.53	100	181.4	
37		14-15		179.8	
38		15-16		180.0	$CaCl_2$ and soda asbestos tubes changed. Weight balance discrepancy.
39		16-17		182.5	$CaCl_2$ tube changed. Water bottle almost empty.
40		17-18		183.5	$CaCl_2$ tube changed.
41	35	23-24.5.53	110	241.0	$CaCl_2$ and soda asbestos tubes changed.
42		24-25		239.4	
43		25-26		245.6	$CaCl_2$ tube changed.
44		27-28		246.9	$CaCl_2$ tube changed.
45		28-29		249.4	
46	68	28-29.9.53	40	60.9	Initial leak: corrected.
47		29-30		60.5	

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
48	68	30.9 -1.10.53	30	63.4	
49		1-2.10.53		65.7	
50		2-3.10.53		67.7	Soda asbestos tube changed.
51	71	8-9.10.53	40	87.1	
52		9-10		87.0	Breakage of chamber thermometer. Scattered Hg removed. Soda asbestos and $CaCl_2$ tubes changed. Rat suffered from Hg poisoning and died on 12.10.53.
53	70	10-11	42	87.2	
54		11-12		87.5	
55		12-13		89.0	
	68	18-19	50	-	No data on 19.10.53 because of death of rat. Little O_2 used overnight. ? leak.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
56	64	19-20.10.53	51	105.7	
57		20.		105.3	Discontinued at 8.30 p.m. because O_2 usage seemed less than expected. Leak suspected but weight balance unsatisfactory.
58		21-22		110.8	
59		22-23		114.6	
60		23-24		113.8	
61	70	28-29	60	120.2	$CaCl_2$ tube changed.
62		29-30		120.0	
63		30-31		119.8	
64		31.10-1.11.53		120.3	
65		1-2.11.53		121.0	
66	64	7-8.11.53	70	140.6	Pump stroke changed from 10 to 12m
67		8-9		141.3	$CaCl_2$ tube changed.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
68	64	9-10.11.53	70	144.9	
69		10-11		150.4	
70		11-12		155.2	$CaCl_2$ tube changed.
71	70	17-18.11.53	80	148.8	
72		18-19		153.1	
73		19-20		155.3	
74		20-21		156.8	Soda asbestos tube changed.
75		21-22		158.3	
76	64	27-28	90	178.1	
77		28-29		181.8	
78		29-30		184.4	
79		30.11-1.12.53		188.5	
80		1-2.12.53		191.6	$CaCl_2$ tube changed.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
81	70	7.12.53	100	-	Inadequate O_2 usage. ? cause. Run abandoned.
82		8.12.53		-	? leak. Run stopped. No leak found when testing with barometer *in situ*.
83		10-11.12.53		193.4	Soda asbestos tube changed. Cabinet temperature fell overnight because lamps burned out.
84		11-12		197.4	
85		12-13		198.7	
86	64	17-18	110	210.8	
87		18-19		215.6	Soda asbestos tube changed.
88		19-20		219.2	Soda asbestos tube changed.
89		20-21		220.4	
90		21.12.53		-	Run stopped because of low O_2 usage.

Table (30)(contd.)

(a)	(b)	(c)	(d)	(e)	(f)
91	113	1-2.3.54	30	64.9	
92		2-3		67.3	
93		3-4		70.0	Asbestos tubes broke but contents collected and weighed.
94		4-5		70.1	
95		5-6		72.6	
96	112	11-12.3.54	40	90.0	Low intake of water from water-bottle.
97		12-13		87.7	
98		13-14		88.7	
99		14-15		95.9	Soda asbestos tube changed.
100		15-16		97.8	
101	113	21-22	50	111.8	
102		22-23		113.2	Soda asbestos tube changed.

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
103	113	23-24.3.54	50	119.8	
104		24-25		121.8	
105		25-26		123.3	
106	112	31.3-1.4.54	60	132.9	Pump stroke changed from 10 to 12 mm.
107		1-2.4.54		134.6	Soda asbestos tube changed.
108		2-3.		134.6	
109		3-4		137.3	
110		4-5		142.3	
111	113	10-11.4.54	70	156.2	
112		11-12		153.3	Soda asbestos tube changed.
113		12-13		155.4	
114		13-14		164.9	$CaCl_2$ tube changed.
115		14-15		167.6	

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
116	112	20-21.4.54	80	183.9	
117		21-22		183.3	
118		22-23		184.2	
119		23-24		188.0	$CaCl_2$ tube changed.
120		24-25		190.6	
121	113	30.4 -1.5.54	90	212.4	
122		1-2.5.54		216.6	
123		2-3		219.5	
124		3-4		221.0	
125		4-5		223.5	
126	112	10-11.5.54	100	230.3	
127		11-12		233.9	
128		12-13		237.4	

Table (30) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)
129	112	13-14.5.54	100	238.0	
130		14-15		238.7	
131	113	20-21.5.54	110	262.8	
132		21-22		268.7	
133		22-23		271.2	
134		23-24		273.0	
135		24-25		274.5	Discrepancy in weight balance. ? cause.
136		10-11.1.55	21	39.4	2 weanlings were together in animal chamber. Data are the mean values.
137		11-12		43.1	
138		12-13		47.0	
139		13-14		50.8	
140		14-15		54.2	

Table (31)

SPIROMETER SCALE READINGS - ORIGINAL AND REDUCED TO S.T.P.

(a) Serial No.	(b) Initial Spir. Reading (cm)	(c) Temp. (°C)	(d) Press. (mm Hg)	(e) p	(f) Final Spir. Reading	(g) Temp. (°C)	(h) Press. (mm Hg)	(i) q	(j) px_1	(k) qx_2
1	24.63	21.0	774.3	0.924	2.45	24.0	775.2	0.912	22.76	2.22
	22.93	24.0	775.2	0.912	20.42	23.5	775.5	0.914	20.91	18.66
	24.77	23.5	775.5	0.914	2.18	23.5	776.5	0.915	22.64	1.95
2	24.31	23.0	776.5	0.918	18.92	24.0	774.5	0.911	22.32	17.24
	24.22	24.0	774.5	0.911	3.87	22.6	772.0	0.914	22.06	3.54
3	23.82	21.2	771.5	0.919	17.10	23.3	770.3	0.908	21.89	15.53
	24.22	23.3	770.3	0.908	4.65	23.2	774.2	0.913	21.99	4.25
4	25.05	23.5	774.5	0.913	18.80	24.5	774.5	0.914	22.87	17.07
	24.60	24.5	774.5	0.914	6.60	23.6	776.0	0.914	22.34	6.03
5	24.22	22.5	776.0	0.919	14.53	23.5	776.5	0.916	22.26	13.31
	24.15	23.5	776.5	0.916	7.55	23.2	779.0	0.919	22.12	6.94
6	24.08	21.3	775.0	0.906	12.08	23.0	773.0	0.901	22.20	11.03
	24.63	23.0	773.0	0.901	6.75	22.6	769.0	0.909	22.49	6.14

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
7	24.52 24.58	22.0 23.5	768.5 765.3	0.922 0.913	13.53 8.18	23.5 22.5	765.3 764.0	0.913 0.910	22.36 22.15	12.19 7.39
8	24.62 24.49	22.0 23.5	764.0 765.3	0.912 0.901	14.25 7.62	23.5 22.5	765.3 768.5	0.901 0.904	22.31 22.07	12.84 6.93
9	24.28 24.50	22.0 23.5	768.5 769.0	0.912 0.906	13.43 6.96	23.5 22.5	769.0 769.5	0.906 0.910	22.14 22.20	12.17 6.33
10	25.45 24.10	21.8 23.5	769.2 769.0	0.914 0.906	13.78 7.28	23.5 23.0	769.0 769.2	0.906 0.908	23.26 21.83	12.48 6.61
11	24.33 24.32	22.0 24.0	774.0 774.0	0.918 0.910	11.25 6.80	24.0 22.8	774.0 771.3	0.910 0.912	22.33 22.13	10.64 6.20
12	24.63 24.22	22.8 24.2	770.8 766.0	0.912 0.899	12.68 6.12	24.2 24.0	766.0 760.8	0.899 0.894	22.46 21.77	11.40 5.47
13	-	-	-	-	-	-	-	-	-	-
14	25.78 24.79	21.5 22.5	761.5 755.0	0.905 0.894	11.96 5.82	22.5 22.2	755.0 745.0	0.894 0.882	23.33 21.16	10.69 5.13

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
15	24.58 24.68	21.6 23.0	745.0 744.8	0.884 0.878	7.92 6.77	23.0 23.0	744.8 745.0	0.878 0.878	21.73 21.67	6.95 5.94
16	24.70 24.77	21.8 24.0	745.5 749.5	0.884 0.880	7.69 7.05	24.0 23.2	749.5 749.8	0.880 0.882	21.83 21.80	6.77 6.22
17	24.52 24.17	22.7 23.3	748.8 751.8	0.885 0.884	5.38 7.40	23.3 22.6	751.8 749.5	0.884 0.885	21.70 21.37	4.76 6.55
18	24.60 24.22	21.0 23.0	749.5 748.5	0.892 0.883	9.30 5.68	23.0 22.8	748.5 749.2	0.883 0.884	21.94 21.38	8.21 5.02
19	24.22 24.13	23.0 23.5	749.5 753.2	0.884 0.886	8.92 6.08	23.5 23.0	753.2 757.0	0.886 0.893	21.43 21.38	7.90 5.43
20	-	-	-	-	-	-	-	-	-	-
21	24.20 24.03	22.0 24.2	754.7 756.6	0.895 0.887	5.43 5.50	24.2 24.0	756.6 763.5	0.887 0.897	21.66 21.31	4.82 4.93
22	24.48 24.69	24.0 24.0	764.0 767.0	0.891 0.901	4.58 3.58	24.0 22.5	767.0 763.0	0.901 0.902	21.81 22.25	4.13 3.23

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
23	24.78 24.75	22.0 22.7	762.5 762.0	0.904 0.900	6.12 2.16	22.7 22.8	762.0 755.3	0.900 0.892	22.40 22.28	5.51 1.97
24	24.79 24.78	22.5 23.5	754.8 754.5	0.892 0.888	4.38 2.42	23.5 24.2	754.5 761.5	0.888 0.894	22.11 22.00	3.89 2.16
25	24.68 24.69	23.8 23.0	762.0 767.5	0.897 0.906	4.20 2.20	23.0 25.0	767.5 768.5	0.897 0.898	22.14 22.37	3.77 1.98
26	24.68 24.92	22.8 24.2	761.2 760.1	0.899 0.892	5.22 4.18	24.2 24.5	760.1 761.2	0.892 0.891	22.19 22.23	4.66 3.72
27	24.73 24.70	25.0 24.0	761.0 760.0	0.888 0.892	5.18 2.73	24.0 23.5	760.0 760.5	0.892 0.895	21.96 22.03	4.62 2.44
28	24.88 25.00	24.0 23.2	760.5 759.0	0.893 0.895	3.79 3.96	23.2 24.2	759.0 756.5	0.895 0.889	22.22 22.38	3.39 3.52
29	24.68 24.93	24.0 24.2	756.0 753.3	0.888 0.884	6.28 4.75	24.2 23.8	753.3 750.0	0.884 0.882	21.92 22.04	5.55 4.19
30	24.59 24.72	23.3 24.8	749.8 745.5	0.883 0.871	6.36 2.62	24.8 25.2	745.5 740.0	0.871 0.862	21.71 21.53	5.54 2.26

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
31	24.70 24.80	23.2 24.5	772.0 771.5	0.911 0.904	7.18 5.59	24.5 24.5	771.5 771.5	0.904 0.904	22.50 22.42	6.49 5.05
32	-	-	-	-	-	-	-	-	-	-
33	24.18 24.92	24.8 24.5	770.0 768.0	0.900 0.900	6.22 6.90	24.5 24.2	768.0 766.0	0.900 0.899	21.76 22.43	5.60 6.20
34	24.62 24.68	24.3 23.5	766.0 765.0	0.899 0.901	7.68 4.18	23.5 24.2	765.0 765.0	0.901 0.899	22.13 22.24	6.92 3.76
35	24.68 24.78	24.2 24.3	764.0 764.5	0.897 0.897	7.18 3.78	24.3 24.8	764.5 765.5	0.897 0.895	22.14 22.23	6.44 3.88
36	24.34 24.88	21.0 25.0	755.8 753.0	0.900 0.879	6.03 3.78	25.0 24.2	753.0 750.5	0.879 0.880	21.91 21.87	5.30 3.33
37	24.67 24.75	23.8 23.8	750.5 746.3	0.882 0.877	7.19 5.19	23.8 23.5	746.3 745.0	0.877 0.876	21.76 21.71	6.31 4.55
38	-	-	-	-	-	-	-	-	-	-

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
39	25.20	23.0	743.5	0.876	4.17	24.0	746.5	0.876	22.08	3.65
	24.95	24.0	746.5	0.876	2.46	24.0	750.0	0.880	21.86	2.16
40	24.66	23.5	750.0	0.882	6.12	24.0	757.0	0.889	21.75	5.14
	25.09	24.0	757.0	0.889	2.63	24.0	761.5	0.895	22.31	2.35
41	-	-	-	-	-	-	-	-	-	-
42	25.09	23.5	764.8	0.900	3.79	24.2	765.0	0.898	22.58	3.40
	25.35	24.2	765.0	0.898	3.63	24.3	762.5	0.894	22.76	3.25
	10.40	24.3	762.5	0.894	6.82	24.0	762.0	0.895	9.30	6.10
43	25.22	23.5	762.0	0.897	2.68	23.0	765.0	0.903	22.62	2.42
	9.15	23.0	765.0	0.903	7.52	23.0	765.5	0.903	8.26	6.79
	25.29	23.0	765.5	0.903	3.88	23.6	766.5	0.902	22.84	3.45
	12.08	23.6	766.5	0.902	7.60	23.5	766.0	0.902	10.90	6.86
44	25.25	23.5	766.0	0.902	2.52	23.5	762.5	0.898	22.78	2.26
	25.26	23.5	762.5	0.898	2.59	23.8	762.5	0.897	22.68	2.32
	11.12	23.8	762.5	0.897	7.08	23.2	762.3	0.899	9.97	6.36
45	25.23	23.2	762.0	0.898	2.58	23.2	766.0	0.903	22.66	2.33
	7.08	23.2	766.0	0.903	4.78	23.6	766.8	0.902	6.39	4.31
	25.38	23.6	766.8	0.902	3.79	24.2	770.0	0.904	22.89	3.43
	11.21	24.2	770.0	0.904	8.22	22.8	770.0	0.910	10.18	7.48

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
46	23.15 23.45	22.0 22.8	755.6 758.0	0.896 0.896	10.72 11.70	22.8 23.0	758.0 754.5	0.896 0.889	20.74 21.01	9.61 10.40
47	23.84 23.85	23.1 22.8	754.5 755.5	0.889 0.892	11.92 8.58	22.8 22.8	755.5 752.0	0.892 0.898	21.19 21.27	10.63 7.70
48	23.64 24.18	23.0 23.2	752.0 755.5	0.887 0.890	12.62 8.24	23.2 22.8	755.5 758.5	0.890 0.896	20.97 21.52	11.23 7.38
49	22.93 23.56	22.8 23.2	759.0 762.0	0.897 0.898	11.08 8.12	23.2 23.2	762.0 763.0	0.898 0.899	20.57 21.16	9.95 7.30
50	23.82 23.85 23.78	23.0 22.0 23.0	763.0 762.0 762.0	0.900 0.903 0.899	12.12 23.85 7.58	23.0 23.0 21.8	762.0 762.0 763.2	0.903 0.899 0.906	21.44 21.54 21.38	10.94 21.44 6.87
51	23.90 24.18	23.2 23.2	768.5 767.2	0.906 0.905	10.70 5.65	23.2 23.6	767.2 764.5	0.905 0.901	21.65 21.88	9.68 5.09
52	-	-	-	-	-	-	-	-	-	-
53	23.97 23.93	22.8 24.2	758.5 757.5	0.896 0.889	5.45 9.14	24.2 23.5	757.5 757.0	0.889 0.891	21.47 21.27	4.84 8.14

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
54	23.63 24.22	23.5 23.8	757.0 755.0	0.891 0.888	10.34 6.89	23.8 23.5	755.0 753.0	0.888 0.886	21.05 21.51	9.18 6.10
55	24.12 24.29	23.8 24.0	750.0 753.3	0.883 0.885	9.89 8.30	24.0 24.0	753.3 755.5	0.885 0.887	21.30 21.50	8.75 7.36
56	23.88 24.42	23.8 24.5	770.5 769.0	0.907 0.901	11.05 11.38	24.5 23.2	769.0 766.0	0.901 0.903	21.66 22.00	9.96 10.28
57	-	-	-	-	-	-	-	-	-	-
58	24.60 24.70	22.5 24.2	764.0 762.0	0.904 0.894	13.88 8.78	24.2 23.8	762.0 761.0	0.894 0.895	22.24 22.08	12.41 7.86
59	25.26 24.62	23.3 24.0	760.5 757.0	0.896 0.891	11.90 7.47	24.0 23.8	757.0 751.5	0.891 0.884	22.63 21.94	10.60 6.60
60	24.70 25.00	23.5 24.0	751.0 753.0	0.884 0.884	9.18 8.12	24.0 23.6	753.0 753.2	0.884 0.886	21.83 22.10	8.12 7.19
61	24.28 25.42	22.0 23.6	750.0 755.0	0.889 0.889	5.28 9.08	23.6 23.5	755.0 757.2	0.889 0.892	21.58 22.60	4.69 8.10

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
62	24.62 25.15	23.2 24.0	757.0 753.5	0.893 0.885	9.07 8.72	24.0 23.2	753.5 749.0	0.885 0.882	21.99 22.26	8.03 7.69
63	25.62 24.85	22.2 23.5	749.0 750.5	0.887 0.883	9.02 9.28	23.5 23.2	750.5 748.0	0.883 0.881	21.84 21.94	7.96 8.18
64	25.32 25.00	22.2 23.8	747.5 739.2	0.885 0.868	9.82 11.13	23.8 23.5	739.2 735.5	0.870 0.864	22.41 21.70	8.54 9.62
65	24.58 24.98	22.8 23.5	735.0 729.0	0.867 0.856	11.62 7.62	23.5 23.5	729.0 733.0	0.856 0.861	21.31 21.38	9.95 6.56
66	24.20 24.99	21.0 23.8	748.5 753.0	0.892 0.885	5.35 6.89	23.8 23.2	753.0 755.5	0.885 0.890	21.59 22.12	4.73 6.13
67	24.35 25.02	22.3 23.8	755.5 754.0	0.894 0.897	6.75 6.22	23.8 23.5	754.0 755.0	0.897 0.888	21.77 22.44	6.05 5.52
68	25.42 25.08	22.5 23.8	755.0 758.0	0.892 0.892	8.97 6.62	23.8 23.5	758.0 758.5	0.892 0.893	22.67 22.37	8.00 5.91
69	24.92 24.72	23.0 22.0	758.5 759.0	0.896 0.900	8.72 5.95	22.0 23.5	759.0 758.5	0.900 0.891	22.33 22.25	7.85 5.30

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
70	24.82 24.85	23.2 24.2	756.5 755.0	0.892 0.885	7.38 4.85	24.2 23.8	755.0 754.2	0.885 0.887	22.14 21.99	6.53 4.30
71	24.60 25.22	22.2 24.0	771.0 769.0	0.912 0.904	3.58 7.52	24.0 23.5	769.0 766.5	0.904 0.903	22.44 22.80	3.24 6.79
72	24.95 24.98	23.0 24.0	765.2 765.0	0.904 0.899	4.65 5.98	24.0 24.0	765.0 764.5	0.899 0.898	22.55 22.46	4.18 5.37
73	25.08 25.28	23.2 24.2	764.5 766.0	0.901 0.898	4.38 6.18	24.2 24.0	766.0 766.5	0.898 0.900	22.60 22.70	3.93 5.56
74	24.83 24.98	23.5 24.0	767.0 767.0	0.903 0.903	6.52 6.35	24.0 23.8	767.0 765.0	0.903 0.900	22.42 22.56	5.89 5.72
75	25.00 25.18	22.8 24.2	765.0 764.5	0.904 0.898	2.28 6.52	24.2 24.2	764.5 763.5	0.898 0.896	22.60 22.59	2.05 5.84
76	24.78 25.22	21.2 24.2	749.0 753.2	0.891 0.905	1.78 3.12	24.2 23.8	753.2 757.0	0.905 0.891	22.47 22.82	1.61 2.78
77	24.93 25.15	23.0 24.0	757.0 755.2	0.894 0.888	4.48 3.58	24.0 23.8	755.2 755.0	0.888 0.888	22.29 22.24	3.98 3.18

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
78	25.22	22.8	755.0	0.891	6.78	24.2	750.5	0.880	22.47	5.97
	25.08	24.2	750.5	0.880	2.02	24.0	753.0	0.884	22.07	1.79
79	24.85	23.2	753.5	0.888	5.18	24.2	759.0	0.890	22.07	4.61
	24.80	24.2	759.0	0.890	2.80	24.0	759.0	0.891	22.07	2.49
80	25.10	23.2	759.0	0.895	4.22	24.0	757.0	0.889	22.46	3.75
	25.08	24.0	757.0	0.889	2.38	24.0	754.0	0.886	22.30	2.11
81	-	-	-	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-	-	-	-
83	24.55	23.5	760.5	0.898	4.48	23.8	763.0	0.898	22.04	4.02
	25.15	23.8	763.0	0.898	1.82	20.8	765.0	0.914	22.58	1.66
	23.58	20.5	765.0	0.914	20.72	22.2	765.0	0.906	21.55	18.77
84	24.92	22.0	765.0	0.907	3.20	24.2	763.0	0.896	22.60	2.87
	24.98	24.2	763.0	0.896	2.22	24.2	760.0	0.892	22.38	1.98
85	25.18	23.8	760.0	0.894	2.18	24.5	760.8	0.891	22.51	1.94
	25.20	24.5	760.8	0.891	3.62	24.2	759.0	0.890	22.45	3.22

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
86	24.82 25.10	21.5 24.5	765.8 763.0	0.910 0.895	2.68 3.22	24.5 24.0	763.0 760.0	0.895 0.893	22.59 22.46	2.40 2.88
87	24.82 24.85	22.8 24.0	760.0 759.0	0.898 0.892	2.82 2.23	24.0 24.0	759.0 764.5	0.892 0.898	22.29 22.17	2.52 2.00
88	25.15 25.02	23.0 24.2	764.5 766.0	0.902 0.899	3.78 1.98	24.2 24.0	766.0 765.2	0.899 0.899	22.69 22.49	3.40 1.78
89	24.78 24.72	23.5 24.2	765.2 762.2	0.901 0.895	2.90 2.02	24.2 23.8	762.2 758.0	0.895 0.891	22.33 22.12	2.59 1.80
90	-	-	-	-	-	-	-	-	-	-
91	24.60 25.05	21.2 24.0	749.0 749.5	0.891 0.880	11.60 10.92	24.0 22.5	749.5 743.8	0.880 0.878	21.92 22.04	10.21 9.59
92	24.82 24.62	22.3 22.8	743.5 730.8	0.878 0.862	9.97 9.98	22.8 22.2	730.8 726.5	0.862 0.859	21.79 21.22	8.59 8.57
93	24.80 24.52	22.2 24.2	726.5 727.2	0.858 0.851	10.58 6.80	24.2 23.2	727.2 734.5	0.851 0.864	21.28 20.87	9.00 5.88

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
94	24.07 24.85	21.8 24.2	735.0 740.2	0.872 0.867	8.63 7.88	24.2 23.5	740.2 745.5	0.867 0.877	20.99 21.54	7.48 6.91
95	24.25 24.72	23.2 24.5	746.0 746.8	0.878 0.873	11.88 8.42	24.5 23.8	746.8 741.2	0.873 0.871	21.29 21.58	10.37 7.33
96	24.50 25.12	22.2 24.2	756.0 756.0	0.895 0.886	10.68 5.78	24.2 23.8	756.0 759.5	0.886 0.892	21.93 22.26	9.46 5.16
97	24.78 25.02	23.5 24.2	759.5 761.8	0.894 0.893	11.02 11.55	23.8 23.5	761.8 764.8	0.895 0.900	22.15 22.34	9.86 10.39
98	24.90 24.61	23.0 23.9	765.0 765.3	0.902 0.899	11.45 7.02	23.8 23.0	765.3 764.3	0.899 0.902	22.46 22.12	10.29 6.33
99	25.00 24.72	22.2 23.8	764.3 763.8	0.905 0.898	12.28 6.68	23.2 22.8	763.8 765.0	0.900 0.903	22.63 22.20	11.05 6.03
100	24.65 24.88	22.2 23.5	765.0 765.8	0.906 0.901	10.68 7.52	23.2 22.8	765.8 766.0	0.902 0.905	22.33 22.42	9.63 6.81
101	24.78 25.18	21.2 23.5	754.0 750.0	0.897 0.882	8.45 5.78	23.5 23.5	750.2 745.6	0.882 0.876	22.23 22.21	7.45 5.06

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
102	25.32	23.0	745.5	0.878	4.98	23.5	742.2	0.872	22.23	4.34
	25.22	24.2	742.0	0.870	5.88	23.5	741.3	0.872	21.94	5.13
103	24.92	23.2	741.3	0.872	2.58	23.5	752.5	0.886	21.73	2.29
	25.05	23.5	752.5	0.886	8.73	23.2	760.8	0.896	22.19	7.82
104	25.32	23.5	760.8	0.896	8.62	24.2	759.5	0.890	22.69	7.67
	25.38	24.5	759.5	0.889	8.15	23.5	753.8	0.887	22.56	7.23
105	25.15	23.2	753.8	0.888	8.78	24.2	753.8	0.884	22.33	7.76
	25.22	24.2	753.8	0.884	6.95	24.2	757.5	0.888	22.29	6.17
106	24.28	21.2	747.0	0.888	4.65	24.2	745.2	0.873	21.56	4.06
	24.78	24.2	745.2	0.873	7.30	24.0	749.5	0.880	21.63	6.40
107	25.48	23.5	749.8	0.882	4.55	24.3	751.0	0.880	22.47	4.00
	24.68	24.5	751.0	0.879	8.01	24.0	750.7	0.881	21.69	7.06
108	24.60	23.5	750.7	0.883	8.52	24.8	753.5	0.880	21.72	7.50
	24.53	23.9	753.5	0.886	8.02	23.8	746.0	0.877	21.76	7.03
109	25.02	23.8	746.0	0.876	4.50	24.0	749.9	0.880	21.92	3.96
	24.90	24.0	749.0	0.880	7.82	23.8	756.2	0.890	21.91	6.96

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
110	25.29	23.5	756.5	0.890	9.15	24.0	758.0	0.890	22.51	8.14
	25.62	24.0	758.0	0.890	5.33	24.2	761.0	0.892	22.80	4.75
111	25.25	22.5	767.8	0.908	12.67	24.0	766.7	0.901	22.93	11.42
	24.69	23.8	766.7	0.902	11.25	24.0	766.2	0.900	22.27	10.13
	25.25	24.0	766.0	0.900	7.73	23.8	765.2	0.900	22.73	6.96
112	24.62	23.3	765.2	0.901	5.48	24.2	765.0	0.897	22.18	4.92
	25.00	24.2	765.0	0.897	5.67	23.8	765.8	0.901	22.43	5.11
113	25.28	23.5	766.1	0.902	6.95	24.5	765.6	0.897	22.80	6.23
	25.50	24.5	765.5	0.897	5.29	23.5	764.8	0.900	22.87	4.76
114	25.36	23.2	765.1	0.901	5.75	24.5	767.5	0.899	22.85	5.17
	25.32	24.5	767.5	0.899	5.02	23.8	764.8	0.900	22.76	4.52
115	25.12	23.5	764.7	0.900	2.68	24.5	765.8	0.898	22.61	2.41
	24.85	24.5	766.0	0.898	5.60	24.2	769.2	0.903	22.32	5.06
116	24.87	21.8	765.3	0.908	12.63	24.3	765.2	0.897	22.58	11.33
	24.62	24.3	765.2	0.897	12.25	24.2	766.8	0.900	22.08	11.03
	25.13	24.2	767.0	0.900	4.16	23.2	768.0	0.905	22.62	3.76

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
117	24.78	22.8	768.0	0.908	2.52	24.2	767.2	0.900	22.50	2.27
	25.23	24.2	767.2	0.900	4.02	23.5	767.8	0.904	22.71	3.63
118	25.15	23.2	767.6	0.905	3.98	24.2	767.0	0.900	22.76	3.58
	25.10	24.2	767.0	0.900	5.52	23.2	767.2	0.904	22.59	4.99
119	25.29	22.8	767.2	0.906	11.28	24.0	766.0	0.900	22.91	10.15
	24.38	24.0	766.0	0.900	15.22	23.8	767.2	0.902	21.94	13.73
	25.45	23.8	767.0	0.902	2.22	23.0	767.8	0.906	22.96	2.01
120	25.02	22.8	768.0	0.908	8.82	23.5	767.0	0.903	22.72	7.96
	24.75	23.5	767.0	0.903	17.55	23.8	767.0	0.901	22.35	15.81
	25.15	24.0	767.0	0.901	4.75	23.5	767.2	0.903	22.66	4.29
121	24.88	22.2	752.2	0.891	10.92	24.2	749.6	0.877	22.17	9.57
	24.82	24.5	749.8	0.878	14.02	24.2	749.0	0.878	21.79	12.31
	25.38	24.2	748.8	0.878	2.68	23.5	746.8	0.878	22.28	2.35
122	25.61	23.0	746.6	0.880	9.22	24.2	744.5	0.872	22.01	8.04
	24.63	24.2	744.5	0.872	13.75	24.2	743.5	0.871	21.48	11.98
	25.08	24.2	743.5	0.871	1.92	24.2	740.5	0.868	21.84	1.67
123	25.52	23.2	746.5	0.872	1.87	23.8	743.0	0.872	22.25	1.62
	25.28	23.8	743.2	0.873	2.25	23.8	746.6	0.877	22.07	1.97

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
124	25.12	23.2	746.8	0.879	11.64	24.4	749.6	0.878	22.08	10.22
	25.02	24.4	749.6	0.878	13.95	24.3	752.4	0.882	21.97	2.30
	24.93	24.2	752.4	0.882	2.83	23.8	756.2	0.889	21.99	2.52
125	24.99	23.5	756.2	0.890	10.95	25.0	756.5	0.883	22.24	9.67
	25.00	25.0	756.5	0.883	13.72	24.3	757.0	0.886	22.08	12.16
	24.78	24.5	757.0	0.886	3.32	24.2	753.8	0.884	21.96	2.93
126	24.32	22.3	761.3	0.900	9.48	24.5	760.2	0.891	21.89	8.45
	25.30	24.5	760.2	0.891	14.17	24.5	761.2	0.892	22.54	12.64
	25.58	24.5	761.2	0.892	3.82	24.0	762.2	0.896	22.82	3.42
127	24.77	23.8	762.3	0.897	10.31	24.2	761.2	0.894	22.22	9.22
	25.08	24.2	761.2	0.894	13.82	24.6	761.8	0.892	22.42	12.34
	25.39	24.5	762.0	0.892	2.32	24.2	763.2	0.895	22.65	2.08
128	25.17	23.8	763.2	0.898	11.22	24.2	763.2	0.896	22.60	10.05
	25.30	24.2	763.2	0.896	12.73	25.0	763.8	0.892	22.67	11.36
	25.20	25.0	763.8	0.892	4.72	24.8	765.0	0.894	22.48	4.22
129	25.42	24.2	765.2	0.898	11.43	25.0	765.2	0.894	22.83	10.22
	25.17	25.0	765.2	0.894	15.25	25.0	765.5	0.894	22.50	13.63
	25.42	25.0	765.5	0.894	3.52	24.5	765.8	0.897	22.73	3.16

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
130	25.02	23.8	765.9	0.901	9.72	24.2	765.8	0.898	22.54	8.73
	25.00	24.2	765.8	0.898	13.35	24.2	766.2	0.899	22.45	12.00
	24.90	24.2	766.2	0.899	3.30	24.2	765.1	0.898	22.39	2.96
131	24.73	23.2	764.8	0.901	10.62	24.2	763.0	0.895	22.28	9.50
	24.99	24.2	763.0	0.895	13.02	24.5	762.3	0.893	22.37	11.63
	25.30	24.5	762.3	0.893	3.98	24.0	763.2	0.897	22.59	3.57
132	24.92	24.0	763.2	0.897	8.33	24.5	761.8	0.894	22.35	7.45
	24.95	24.5	761.5	0.894	13.22	24.7	762.2	0.892	22.31	11.79
	24.78	24.4	762.2	0.893	3.80	23.8	759.8	0.894	22.13	3.40
133	25.25	23.2	759.8	0.895	6.95	24.5	758.2	0.888	22.60	6.71
	24.99	24.5	758.2	0.888	13.67	24.5	757.5	0.887	22.19	12.13
	25.60	24.5	757.5	0.887	2.08	24.0	754.6	0.886	22.71	1.84
134	24.92	23.5	754.5	0.888	10.78	24.0	752.5	0.884	22.13	9.58
	24.95	24.0	752.5	0.884	13.00	24.0	752.2	0.884	22.06	11.49
	25.35	24.0	752.2	0.884	3.58	23.2	750.2	0.884	22.41	3.16
	7.58	23.0	750.2	0.885	6.12	23.0	750.2	0.885	6.71	5.41
135	24.82	22.8	750.0	0.886	9.02	24.5	748.5	0.876	21.99	7.96
	24.88	24.5	748.5	0.876	13.35	24.2	749.8	0.879	21.79	11.73
	24.98	24.2	749.8	0.879	2.68	24.2	750.2	0.880	21.90	2.36
	11.30	24.2	750.2	0.880	9.70	24.2	750.7	0.880	9.86	8.71

Table (31) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
136	24.49	24.0	737.0	0.865	9,68	25.8	740.2	0.860	21.18	8.32
	24.82	25.2	740.2	0.862	5.55	25.0	744.2	0.869	21.39	4.82
137	24.80	24.8	744.2	0.869	4.60	25.5	745.0	0.867	21.55	3.99
	24.70	25.2	745.0	0.868	7.50	25.2	739.2	0.861	21.44	6.46
138	24.70	24.8	739.0	0.863	5.80	24.5	746.0	0.873	21.32	5.06
	24.97	24.8	746.0	0.872	3.90	25.3	747.0	0.871	21.77	3.40
139	24.68	24.8	747.7	0.874	6.40	24.8	743.0	0.868	21.57	5.56
	24.65	24.5	743.0	0.870	2.75	24.8	747.5	0.874	21.45	2.40
140	24.75	24.0	747.8	0.878	7.82	25.0	752.2	0.878	21.73	6.87
	25.10	25.0	752.2	0.878	2.20	25.0	748.5	0.874	22.04	1.92

Table (32)

RESPIRATORY EXCHANGE

(a) Serial No.	(b) (px_1-qx_2)	(c) $1/5.11\ (px_1-qx_2)$	(d) $0.454\ (p-q)$	(e) $0.0214\ (T_2-T_1)$	(f) 0.015	(g) Total Vol. of O_2 (litres)	(h) Weight of O_2 (g)	(i) Weight of CO_2 (g)	(j) Vol. of CO_2 (litres)	(k) R.Q.
1	43.48	8.509	+0.004	0.171	0.015	8.699	12.431	15.083	7.629	0.877
2	23.60	4.618	+0.002	0.156	0.015	4.791	6.846	8.696	4.399	0.918
3	24.10	4.716	+0.003	0.118	0.015	4.852	6.933	8.153	4.124	0.850
4	22.11	4.327	-0.0005	0.128	0.015	4.470	6.388	7.903	3.997	0.894
5	24.13	4.722	0	0.124	0.015	4.861	6.946	8.099	4.096	0.843
6	24.61	4.816	-0.001	0.152	0.015	4.982	7.105	10.290	5.205	1.045
7	27.52	5.386	+0.005	0.171	0.015	5.578	7.971	7.594	3.841	0.681
8	24.93	4.879	+0.004	0.079	0.015	4.976	7.111	8.874	4.488	0.902
9	25.80	5.049	+0.001	0.122	0.015	5.187	7.412	8.095	4.095	0.789
10	26.00	5.088	+0.003	0.101	0.015	5.206	7.432	10.254	5.186	0.996
11	27.98	5.476	+0.003	0.137	0.015	5.630	8.045	9.320	4.714	0.837
12	27.36	5.354	+0.008	0.156	0.015	5.534	7.908	9.059	4.582	0.828

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
13	-	-	-	-	-	-	-	-	-	-
14	29.67	5.806	+0.010	0.128	0.015	5.960	8.517	10.426	5.273	0.885
15	30.51	5.971	+0.003	0.171	0.015	6.159	8.801	10.986	5.557	0.902
16	30.63	5.996	+0.001	0.158	0.015	6.170	8.817	10.787	5.457	0.884
17	31.76	6.215	0	0.128	0.015	6.358	9.086	11.306	5.719	0.899
18	30.09	5.888	+0.004	0.158	0.015	6.065	8.667	10.491	5.307	0.875
19	29.48	5.769	-0.004	0.184	0.015	5.964	8.522	9.296	4.702	0.788
20	-	-	-	-	-	-	-	-	-	-
21	33.22	6.501	-0.001	0.139	0.015	6.654	9.509	10.564	5.343	0.803
22	36.70	7.182	-0.005	0.071	0.015	7.263	10.379	12.983	6.567	0.904
23	37.14	7.268	+0.005	0.186	0.015	7.475	10.682	13.823	6.994	0.936
24	38.06	7.448	-0.001	0.150	0.015	7.612	10.878	14.299	7.233	0.950
25	38.76	7.585	-0.0005	0.150	0.015	7.749	11.073	12.836	6.493	0.838

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
26	36.04	7.053	+0.004	0.139	0.015	7.211	10.305	13.541	6.849	0.950
27	36.93	7.227	-0.003	0.086	0.015	7.324	10.466	12.995	6.573	0.897
28	37.69	7.376	+0.002	0.077	0.015	7.470	10.675	13.188	6.671	0.893
29	34.22	6.697	+0.003	0.122	0.015	6.837	9.770	12.080	6.110	0.894
30	35.44	6.935	+0.009	0.171	0.015	7.131	10.190	13.394	6.752	0.947
31	33.38	6.532	+0.003	0.107	0.015	6.657	9.513	11.609	5.872	0.882
32	-	-	-	-	-	-	-	-	-	-
33	32.39	6.338	+0.0005	0.032	0.015	6.386	9.125	11.828	5.983	0.937
34	33.69	6.593	0	0.071	0.015	6.679	9.544	12.317	6.230	0.933
35	34.55	6.761	+0.001	0.126	0.015	6.903	9.865	13.038	6.595	0.955
36	35.15	6.879	+0.009	0.150	0.015	7.053	10.079	13.018	6.585	0.934
37	32.61	6.381	+0.003	0.143	0.015	6.542	9.349	11.256	5.693	0.870
38	-	-	-	-	-	-	-	-	-	-

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
39	38.13	7.462	-0.002	0.111	0.015	7.587	10.842	13.687	6.923	0.912
40	36.27	7.098	-0.006	0.111	0.015	7.218	10.315	12.594	6.370	0.883
41	-	-	-	-	-	-	-	-	-	-
42	41.89	8.197	+0.002	0.101	0.015	8.315	11.882	14.648	7.409	0.891
43	45.10	8.826	-0.002	0.086	0.015	8.924	12.753	16.181	8.185	0.917
44	44.49	8.706	+0.001	0.101	0.015	8.823	12.608	16.106	8.147	0.923
45	44.52	8.712	-0.005	0.098	0.015	8.820	12.604	15.710	7.946	0.901
46	21.74	4.254	+0.003	0.026	0.015	4.298	6.142	7.560	3.823	0.889
47	24.13	4.722	+0.004	0.096	0.015	4.829	6.901	8.779	4.441	0.920
48	23.88	4.673	+0.004	0.092	0.015	4.776	6.825	8.448	4.273	0.895
49	24.48	4.790	-0.001	0.092	0.015	4.896	6.996	8.793	4.448	0.908
50	25.11	4.914	-0.003	0.054	0.015	4.979	7.115	7.109	3.596	0.722

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
51	28.76	5.628	+0.0005	0.107	0.015	5.750	8.217	10.483	5.302	0.922
52	-	-	-	-	-	-	-	-	-	-
53	29.76	5.824	+0.002	0.128	0.015	5.969	8.530	10.413	5.267	0.882
54	27.28	5.338	+0.002	0.150	0.015	5.505	7.867	9.541	4.826	0.877
55	26.69	5.223	-0.002	0.143	0.015	5.379	7.687	8.138	4.116	0.765
56	23.42	4.583	+0.002	0.143	0.015	4.759	6.801	8.564	4.332	0.910
57	-	-	+0.001	-	-	-	-	-	-	-
58	24.05	4.706	+0.004	0.128	0.015	4.853	6.935	9.199	4.653	0.959
59	27.37	5.356	+0.005	0.107	0.015	5.483	7.835	10.907	5.517	1.006
60	28.62	5.601	+0.001	0.146	0.015	5.761	8.232	11.688	5.912	1.026
61	31.39	6.143	-0.001	0.146	0.015	6.303	9.007	11.110	5.620	0.892
62	28.53	5.583	-0.005	0.098	0.015	5.691	8.132	11.759	5.948	1.045
63	27.64	5.604	+0.001	0.154	0.015	5.786	8.268	9.687	4.900	0.847

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
64	25.95	5.078	+0.009	0.165	0.015	5.268	7.528	10.209	5.164	0.980
65	26.18	5.123	+0.003	0.214	0.015	5.355	7.652	9.515	4.813	0.899
66	32.85	6.428	+0.001	0.176	0.015	6.620	9.460	11.724	5.930	0.896
67	32.64	6.387	+0.003	0.171	0.015	6.576	9.397	11.610	5.873	0.893
68	31.13	6.092	-0.0005	0.128	0.015	6.235	8.910	10.676	5.400	0.866
69	31.43	6.150	+0.002	0.143	0.015	6.310	9.017	11.399	5.766	0.914
70	33.30	6.516	+0.002	0.128	0.015	6.661	9.519	10.907	5.517	0.828
71	35.21	6.890	+0.004	0.161	0.015	7.069	10.102	13.105	6.629	0.938
72	35.46	6.939	+0.003	0.128	0.015	7.085	10.124	13.053	6.602	0.932
73	35.81	7.008	+0.0005	0.131	0.015	7.154	10.223	13.100	6.626	0.926
74	33.37	6.530	+0.001	0.118	0.015	6.664	9.523	12.978	6.564	0.985
75	37.30	7.299	+0.004	0.124	0.015	7.442	10.635	13.906	7.034	0.945

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
76	40.90	8.004	0	0.182	0.015	8.201	11.719	14.183	7.174	0.875
77	37.37	7.313	+0.003	0.124	0.015	7.455	10.653	13.401	6.778	0.909
78	36.78	7.197	+0.003	0.150	0.015	7.365	10.525	11.980	6.060	0.823
79	37.04	7.248	-0.001	0.124	0.015	7.386	10.555	12.201	6.171	0.835
80	38.90	7.612	+0.005	0.113	0.015	7.745	11.068	12.563	6.355	0.821
81	-	-	-	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-	-	-	-
83	41.72	8.164	+0.004	+0.078	0.015	8.254	11.795	16.652	8.423	1.020
84	40.13	7.853	+0.007	+0.092	0.015	7.967	11.385	14.926	7.550	0.948
85	39.80	7.788	+0.002	+0.122	0.015	7.927	11.328	15.761	7.972	1.006
86	39.77	7.783	+0.008	0.178	0.015	7.982	11.406	14.238	7.201	0.902
87	39.94	7.816	0	0.128	0.015	7.959	11.373	13.703	6.931	0.871
88	40.00	7.828	+0.001	0.128	0.015	7.972	11.392	13.621	6.890	0.864
89	40.06	7.829	+0.005	0.150	0.015	8.009	11.445	14.191	7.178	0.896
90	-	-	-	-	-	-	-	-	-	-

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
91	24.16	4.728	+0.006	0.073	0.015	4.822	6.891	8.356	4.226	0.876
92	25.85	5.056	+0.009	0.107	0.015	5.187	7.412	9.791	4.953	0.955
93	27.27	5.336	-0.003	0.154	0.015	5.502	7.862	9.879	4.997	0.908
94	28.14	5.507	-0.002	0.084	0.015	5.604	8.008	9.967	5.041	0.899
95	25.17	4.926	+0.003	0.081	0.015	5.025	7.181	9.183	4.645	0.924
96	29.57	5.786	+0.001	0.096	0.015	5.897	8.427	10.769	5.447	0.924
97	24.24	4.744	-0.003	0.064	0.015	4.820	6.888	7.937	4.014	0.833
98	27.96	5.471	0	0.111	0.015	5.597	7.998	10.379	5.250	0.938
99	27.75	5.430	+0.001	0.103	0.015	5.549	7.929	10.389	5.255	0.947
100	28.31	5.540	+0.0005	0.111	0.015	5.666	8.097	9.999	5.057	0.893
101	31.93	6.248	+0.0005	0.111	0.015	6.374	9.108	10.764	5.444	0.854
102	34.70	6.790	+0.003	0.075	0.015	6.883	9.836	14.873	7.523	1.093
103	33.81	6.616	-0.01	0.107	0.015	6.727	9.613	12.063	6.101	0.907
104	30.35	5.939	-0.004	0.086	0.015	6.044	8.637	10.403	5.262	0.871
105	30.69	6.006	0	0.121	0.015	6.143	8.778	11.250	5.765	0.939

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
106	32.71	6.401	+0.004	0.133	0.015	6.553	9.364	9.724	4.918	0.750
107	33.10	6.477	+0.0005	0.069	0.015	6.560	9.374	11.894	6.016	0.917
108	28.95	5.665	+0.003	0.086	0.015	5.769	8.244	8.084	4.089	0.709
109	32.91	6.440	+0.006	0.101	0.015	6.562	9.377	11.599	5.867	0.894
110	32.42	6.344	+0.001	0.096	0.015	6.456	9.226	12.766	6.457	1.000
111	39.42	7.714	+0.004	0.124	0.015	7.857	11.228	15.177	7.677	0.977
112	34.58	6.767	0	0.071	0.015	6.853	9.793	11.692	5.914	0.863
113	34.68	6.786	+0.001	0.094	0.015	6.896	9.854	13.214	6.684	0.969
114	35.92	7.029	+0.0005	0.094	0.015	7.138	10.200	14.067	7.115	0.997
115	37.46	7.331	-0.0014	0.107	0.015	7.454	10.652	13.975	7.069	0.948
116	41.16	8.055	+0.001	0.135	0.015	8.206	11.726	15.895	8.040	0.980
117	39.31	7.693	+0.002	0.113	0.015	7.823	11.179	14.299	7.232	0.924
118	36.78	7.197	+0.0005	0.092	0.015	7.304	10.437	12.441	6.293	0.862

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
119	41.92	8.203	0	0.098	0.015	8.316	11.884	14.927	7.550	0.908
120	39.67	7.763	+0.002	0.103	0.015	7.883	11.265	12.120	6.130	0.778
121	42.01	8.221	+0.006	0.124	0.015	8.366	11.955	15.665	7.923	0.918
122	43.64	8.540	+0.005	0.135	0.015	8.694	12.424	16.137	8.162	0.939
123	40.72	7.968	-0.002	0.101	0.015	8.082	11.549	14.427	7.297	0.903
124	41.00	8.023	-0.005	0.090	0.015	8.123	11.608	14.415	7.291	0.898
125	41.52	8.125	+0.003	0.113	0.015	8.256	11.798	15.061	7.618	0.923
126	42.74	8.364	+0.002	0.122	0.015	8.503	12.151	16.261	8.225	0.967
127	43.65	8.542	+0.001	0.124	0.015	8.682	12.407	16.128	8.158	0.940
128	42.12	8.242	+0.002	0.081	0.015	8.340	11.918	15.229	7.703	0.924
129	41.05	8.033	+0.0005	0.107	0.015	8.155	11.653	14.842	7.507	0.921
130	43.69	8.550	+0.001	0.092	0.015	8.658	12.372	15.954	8.069	0.932

Table (32) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
131	42.54	8.325	+0,002	0.113	0.015	8.455	12.082	15.889	8.037	0.951
132	44.15	8.640	+0.0014	0.086	0.015	8.742	12.492	16.079	8.133	0.930
133	46.82	9.162	+0.004	0.122	0.015	9.303	13.294	17.331	8.766	0.942
134	43.72	8.556	+0.001	0.096	0.015	8.668	12.387	15.707	7.945	0.917
135	-	-	-	-	-	-	-	-	-	-
136	29.43	5.759	-0.0009	0.124	0.015	5.897	8.427	10.870	5.545	0.940
137	32.44	6.348	+0.004	0.086	0.015	6.453	9.221	12.111	6.173	0.957
138	34.63	6.777	-0.004	0.086	0.015	6.875	9.824	12.418	6.328	0.920
139	35.06	6.861	+0.0009	0.092	0.015	6.969	9.959	12.927	6.586	0.945
140	34.98	6.845	+0.002	0.124	0.015	6.986	9.983	12.737	6.490	0.921

Table (33)

FOOD CONSUMPTION

(a) Serial No.	(b) Food Box Weight Diff. (g)	(c) Dry Scattered Food (g)	(d) Frame Wt. Incr. Measured (g)	(e) Funnel Wt. Incr. Measured (g)	(f) Frame and Funnel Wt. Incr. Measured as Food (g)	(g) Total Wt. Food Consumed (g)
1	12.611	0.884	0.884	0.356	0.415	11.312
2	7.727	0.054	0.408	0.139	0.125	7.548
3	6.862	0.044	0.237	0.113	0.035	6.783
4	6.561	0.123	0.333	0.155	0.100	6.338
5	8.367	0.314	0.379	0.177	0.125	7.928
6	10.534	2.264	0.929	0.191	0.365	7.905
7	7.612	2.270	0.555	0.261	0.240	5.102
8	17.289	9.048	0.877	0.381	0.425	7.816
9	18.115	8.262	1.005	0.514	0.535	9.318
10	16.174	6.378	1.089	0.405	0.530	9.266

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
11	15.798	9.912	1.058	0.196	0.420	5.466
12	18.666	8.948	1.431	0.390	0.660	7.058
13	20.100	9.917	1.165	0.496	0.595	9.588
14	16.287	5.656	1.502	0.431	0.703	9.928
15	17.315	6.362	1.410	0.375	0.647	10.306
16	16.134	6.198	1.642	0.439	0.765	9.171
17	18.755	7.546	1.852	0.466	0.864	10.345
18	17.626	7.191	1.451	0.496	0.709	9.726
19	12.363	6.826	0.604	0.291	0.270	5.267
20	8.190	3.986	2.112	0.357	0.927	3.280
21	7.861	1.672	0.415	0.182	0.145	6.044
22	11.989	0.958	0.559	0.208	0.215	10.816
23	14.218	0.527	0.452	0.188	0.165	12.526

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
24	13.215	0.926	0.429	0.168	0.145	12.144
25	12.227	0.343	0.322	0.141	0.090	11.794
26	12.124	0.343	0.538	0.101	0.165	11.616
27	9.814	0.538	0.440	0.172	0.155	9.121
28	10.172	0.705	0.594	0.195	0.220	9.247
29	9.998	1.521	0.661	0.285	0.295	8.182
30	12.796	1.010	0.733	0.187	0.285	11.501
31	15.309	6.115	0.864	0.604	0.515	8.679
32	10.167	3.570	3.069	0.385	1.338	5.259
33	18.917	7.340	1.392	0.678	0.760	10.817
34	19.743	5.967	2.266	0.500	1.051	12.725
35	22.122	7.673	2.289	0.593	1.100	13.349

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
36	16.580	3.698	2.577	0.534	1.195	11.687
37	12.090	4.375	1.213	0.444	0.595	7.120
38	17.665	5.067	2.931	0.672	1.401	11.197
39	17.748	2.297	3.774	0.470	1.668	13.785
40	16.156	5.600	1.098	0.341	0.500	10.056
41	10.390	0.382	0.454	0.174	0.160	9.848
42	10.743	0.812	0.643	0.167	0.235	9.696
43	13.630	0.569	0.460	0.265	0.200	12.861
44	13.440	0.486	0.364	0.158	0.110	12.844
45	12.971	0.386	0.544	0.284	0.245	12.340
46	6.257	0.077	0.282	0.105	0.057	6.123
47	8.035	0.028	0.269	0.096	0.040	7.967
48	7.124	0.028	0.452	0.111	0.130	6.966

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
49	7.638	0.012	0.434	0.179	0.150	7.476
50	7.761	0.022	0.306	0.177	0.095	7.554
51	7.548	0.154	0.233	0.106	0.035	7.359
52	0.478	0.002	0.171	0.082	0	0.476
53	8.580	0.176	0.452	0.187	0.165	8.239
54	7.546	0.040	0.258	0.172	0.030	7.476
55	7.898	0.174	0.316	0.144	0.085	7.639
56	6.133	0.096	0.171	0.073	0	6.037
57	-	-	-	-	-	-
58	9.616	0.079	0.176	0.100	0.005	9.532
59	10.047	0.046	0.176	0.139	0.020	9.981
60	9.139	0.020	0.351	0.121	0.090	9.029

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
61	9.767	0.981	0.437	0.168	0.150	8.630
62	7.903	1.525	0.302	0.128	0.075	6.303
63	8.440	1.148	0.389	0.250	0.165	7.127
64	7.850	0.648	0.468	0.211	0.180	7.022
65	8.152	0.950	0.330	0.254	0.140	7.062
66	9.379	0.040	0.299	0.159	0.085	9.254
67	10.198	0.029	0.373	0.092	0.090	10.079
68	10.096	0.038	0.295	0.171	0.090	9.968
69	10.423	0.068	0.259	0.175	0.075	10.280
70	12.117	0.237	0.449	0.193	0.165	11.715
71	17.365	3.500	0.909	0.248	0.385	13.480
72	13.669	2.052	0.608	0.246	0.255	11.362
73	14.387	1.967	0.698	0.236	0.290	12.130

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
74	19.522	6.813	0.908	0.273	0.390	12.319
75	20.596	7.312	0.961	0.232	0.400	12.884
76	13.031	0.202	0.427	0.134	0.130	12.699
77	11.891	0.084	0.483	0.131	0.150	11.657
78	12.697	0.528	0.605	0.172	0.222	11.947
79	13.111	0.962	0.634	0.247	0.265	11.884
80	16.500	2.580	0.730	0.196	0.280	13.640
81	-	-	-	-	-	-
82	-	-	-	-	-	-
83	30.432	12.135	2.120	0.392	0.945	16.009
84	22.541	9.153	1.730	0.335	0.758	11.652
85	26.098	10.750	1.315	0.263	0.560	13.643

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
86	14.490	1.148	0.580	0.159	0.205	12.120
87	15.253	4.002	0.918	0.189	0.356	10.052
88	17.050	3.677	0.796	0.205	0.320	12.043
89	15.163	3.042	0.574	0.181	0.210	10.989
90	-	-	-	-	-	-
91	8.393	3.096	0.607	0.136	0.205	5.092
92	20.204	11.336	0.587	0.256	0.245	8.623
93	21.599	12.620	1.126	0.235	0.040	8.939
94	23.592	15.288	0.742	0.268	0.360	7.944
95	23.045	14.792	1.066	0.225	0.440	7.813
96	10.092	0.142	0.331	0.168	0.105	9.845
97	4.653	0.121	0.275	0.143	0.075	4.457
98	9.366	0.156	0.290	0.188	0.097	9.113

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Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
99	9.704	0.111	0.424	0.157	0.136	9.457
100	9.280	0.289	0.385	0.155	0.120	8.871
101	32.087	18.074	1.935	0.382	0.864	13.149
102	29.981	16.850	2.477	0.304	1.057	12.074
103	28.524	17.079	1.206	0.412	0.580	10.865
104	28.236	16.840	1.462	0.197	0.595	10.801
105	27.579	17.774	1.180	0.217	0.485	9.320
106	20.599	9.837	0.840	0.292	0.370	10.392
107	24.409	13.557	1.721	0.220	0.707	10.145
108	20.272	12.625	0.838	0.267	0.360	10.287
109	28.344	15.987	1.249	0.427	0.600	11.757
110	29.809	17.367	0.901	0.307	0.402	12.032

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
111	19.248	2.608	3.021	0.291	1.279	15.361
112	12.110	5.032	1.112	0.160	0.430	6.648
113	26.813	10.207	3.320	0.243	1.384	15.222
114	28.747	12.503	4.591	0.243	1.915	14.327
115	30.298	14.840	4.320	0.275	1.815	13.643
116	18.287	3.255	2.581	0.311	1.104	13.978
117	27.722	8.549	8.307	0.208	3.452	15.721
118	27.973	13.674	4.349	0.239	1.812	12.487
119	32.420	14.437	5.459	0.243	2.277	15.706
120	32.136	19.320	3.795	0.214	1.570	11.246
121	21.432	4.911	3.836	0.318	1. 631	14.890
122	24.352	6.248	4.613	0.193	1.903	16.201
123	17.820	5.095	2.339	0.257	0.980	11.745

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
124	19.355	5.159	3.488	0.231	1.449	12.747
125	22.492	7.632	2.957	0.376	1.288	13.572
126	37.943	13.812	8.221	0.337	3.470	20.661
127	27.132	7.280	6.994	0.243	2.918	16.934
128	25.080	7.209	6.499	0.203	2.695	15.176
129	25.434	10.631	4.104	0.268	1.722	13.081
130	37.014	18.737	5.183	0.149	2.123	16.154
131	20.074	3.060	1.728	0.315	0.749	16.265
132	19.737	2.750	2.509	0.175	1.017	15.970
133	17.637	2.446	1.543	0.234	0.645	14.546
134	17.871	3.851	2.793	0.216	1.152	12.868
135	19.240	3.546	2.888	0.328	1.239	14.455

Table (33) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)
136	5.438	0.580	0.253	0.084	0.139	4.791
137	6.177	0.206	0.206	0.122	0.086	5.885
138	6.545	0.514	0.290	0.107	0.083	5.948
139	6.300	0.288	0.320	0.150	0.125	5.887
140	6.550	0.472	0.340	0.178	0.116	5.962

Table (34)

ENERGY BALANCE

(a) Serial No.	(b) Gross Food Energy (kcal)	(c) Faecal Energy (kcal)	(d) Urinary Energy (kcal)	(e) 4.077 x litres O_2 (kcal)	(f) 0.956 x litres CO_2 (kcal)	(g) 1.841 x g urinary N (kcal)	(h) Total Energy Expen. (kcal)	(i) Total Energy Expen./ 24 hr. (kcal)	(j) Energy Balance (kcal)
1	48.347	1.303	0,869	35.466	7.293	0.186	42.578	41.849	+4.326
2	32.260	1.035	0.456	19.533	4.205	0.097	23.641	24.492	+6.277
3	28.990	0.595	0.576	19.782	3.943	0.124	23.601	23.168	+4.651
4	27.089	1.102	0.705	18.224	3.821	0.150	21.895	21.742	+3.540
5	33.884	1.581	0.817	19.818	3.916	0.174	23.560	23.725	+7.761
6	33.786	1.641	0.860	20.312	4.976	0.184	25.104	24.854	+6.431
7	21.806	1.503	0.876	22.742	3.638	0.124	26.256	26.440	-7.013
8	33.406	0.919	0.516	20.287	4.291	0.111	24.467	24.810	+7.161
9	39.825	1.165	0.876	21.147	3.915	0.123	24.939	25.213	+12.571
10	39.603	1.113	0.860	21.225	4.958	0.184	25.999	25.453	+ 12.177

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
11	23.362	1.190	0.688	22.954	4.507	0.148	27.313	27.122	-5.638
12	30.166	1.113	0.877	22.562	4.380	0.187	26.760	26.947	+1.229
13	40.979	-	0.989	-	-	0.212	-	-	-
14	42.432	1.334	1.178	24.299	5.041	0.253	29.087	29.494	+10.426
15	44.048	0.901	1.256	25.110	5.312	0.268	30.154	30.154	+11.737
16	39.197	0.928	1.135	25.155	5.217	0.243	30.129	30.219	+6.915
17	44.215	1.888	1.144	25.922	5.467	0.244	31.145	31.363	+9.820
18	41.569	0.983	1.187	24.727	5.073	0.255	29.545	30.165	+9.234
19	22.511	0.973	0.757	24.315	4.495	0.162	28.648	28.562	-7.781
20	14.019	-	1.290	-	-	0.276	-	-	-
21	25.832	0.972	1.582	27.128	5.108	0.338	31.898	31.898	-8.620
22	46.228	1.761	2.004	29.611	6.278	0.428	35.461	35.461	+7.002
23	57.810	2.112	1.840	30.476	6.686	0.395	36.767	37.833	+16.025

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
24	51.903	2.212	1.969	31.034	6.915	0.422	37.564	37.564	+10.158
25	50.408	1.878	1.849	31.593	6.207	0.396	37.404	37.030	+9.651
26	49.647	1.243	1.729	29.399	6.548	0.371	35.576	36.074	+10.601
27	38.983	1.733	1.634	29.860	6.284	0.350	35.794	36.402	-0.786
28	39.522	2.027	1.780	30.455	6.377	0.381	36.451	36.852	-1.137
29	34.970	1.240	1.488	27.874	5.841	0.319	33.396	33.396	-1.154
30	49.155	1.730	1.772	29.073	6.455	0.379	35.139	35.139	+10.514
31	37.094	1.563	0.989	27.141	5.614	0.212	32.543	32.543	+1.999
32	22.477	-	0.903	-	-	0.193	-	-	-
33	46.232	1.143	1.436	26.036	5.720	0.308	31.448	31.888	+11.765
34	54.386	2.489	1.385	27.230	5.956	0.297	32.889	32.889	+17.623
35	57.054	1.136	1.479	28.144	6.305	0.316	34.133	33.416	+21.023

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
36	49.950	1.113	1.238	28.755	6.295	0.265	34.785	34.542	+8.057
37	30.431	1.642	0.886	26.672	5.443	0.190	31.925	32.851	-4.948
38	47.856	-	1.772	-	-	0.379	-	-	-
39	58.917	1.794	1.075	30.932	6.618	0.231	37.319	37.319	+18.729
40	42.979	1.382	1.522	29.428	6.090	0.325	35.193	35.580	+4.495
41	42.090	-	2.202	-	-	0.471	-	-	-
42	41.441	0.818	2.279	33.900	7.083	0.487	40.496	41.508	-3.164
43	54.968	2.434	2.055	36.383	7.825	0.440	43.768	43.768	+6.721
44	54.895	2.389	2.073	35.971	7.789	0.444	43.316	44.226	+6.207
45	52.741	1.495	1.858	35.959	7.596	0.398	43.157	44.409	-
46	26.066	0.405	0.662	17.523	3.655	0.143	21.035	21.182	+3.817
47	33.916	0.743	0.765	19.688	4.246	0.164	23.770	23.841	+8.567
48	29.654	0.883	0.757	19.472	4.085	0.162	23.395	23.723	+4.091

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
49	31.825	0.533	0.869	19.961	4.252	0.185	24.028	24.196	+6.227
50	32.157	0.865	0.998	20.300	3.438	0.213	23.525	24.372	+5.922
51	31.327	1.431	1.247	23.443	5.069	0.267	28.245	28.443	+0.206
52	2.026	0.916	0.602	-	-	-	-	-	-
53	35.073	1.008	1.264	24.336	5.035	0.270	29.101	29.014	+3.787
54	31.825	1.021	1.170	22.444	4.614	0.251	24.807	25.601	+4.033
55	32.519	0.758	1.213	21.930	3.935	0.260	25.605	26.527	+4.021
56	25.699	1.514	1.195	19.402	4.141	0.256	23.287	23.869	-0.879
57	-	-	-	-	-	-	-	-	-
58	40.578	1.971	1.307	19.786	4.448	0.280	23.954	25.056	+12.244
59	42.489	1.342	1.582	22.354	5.274	0.339	27.289	27.862	+1.703
60	38.436	1.979	1.514	23.488	5.652	0.323	28.817	28.817	+6.126

Cyc.

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
61	36.738	0.661	1.316	25.697	5.373	0.281	30.789	30.789	+3.972
62	26.832	1.241	1.066	23.202	5.686	0.228	28.660	28.860	-4.335
63	30.340	0.679	1.041	23.589	4.684	0.223	28.050	28.050	+0.570
64	29.893	0.475	1.075	21.478	4.937	0.231	26.184	26.184	-2.159
65	30.063	1.453	0.955	21.832	4.601	0.204	26.229	26.780	+0.875
66	39.394	1.841	1.823	26.980	5.669	0.390	32.269	32.269	+3.461
67	42.906	1.484	1.780	26.810	5.615	0.381	32.044	31.820	+7.822
68	42.434	1.385	1.574	25.420	5.162	0.336	30.246	30.881	+8.594
69	43.762	1.215	1.565	25.726	5.512	0.335	30.903	31.119	+9.863
70	49.871	1.965	1.557	27.157	5.274	0.334	32.097	32.097	+14.252
71	57.384	2.032	1.746	28.820	6.337	0.374	34.783	34.887	+18.719
72	48.368	3.535	1.686	28.886	6.312	0.361	34.837	34.837	+8.310
73	51.637	2.363	1.625	29.167	6.334	0.349	35.152	35.539	+11.110

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
74	52.442	1.905	1.514	27.169	6.275	0.323	33.121	33.353	+15.670
75	54.847	3.144	1.531	30.341	6.725	0.329	36.737	36.737	+13.438
76	54.060	2.529	2.417	33.435	6.858	0.517	39.776	38.821	+10.293
77	49.624	2.211	1.969	30.394	6.480	0.422	36.452	36.087	+9.357
78	50.858	1.655	2.176	30.027	5.793	0.467	35.353	35.247	+11.780
79	50.590	1.860	2.073	30.113	5.899	0.443	35.569	36.458	+10.199
80	58.065	2.105	2.331	31.576	6.075	0.499	37.152	37.932	+15.697
81	-	-	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-	-	-
83	73.867	3.029	1.789	-	-	-	-	-	-
84	53.766	2.000	1.746	32.481	7.218	0.374	39.325	39.876	+10.144
85	62.953	2.244	1.720	32.316	7.621	0.368	39.571	40.402	+18.587

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
86	55.924	0.945	2.245	32.543	6.884	0.481	38.946	39.374	13.360
87	46.380	1.874	1.668	32.449	6.626	0.357	38.718	38.718	4.120
88	55.567	1.902	2.219	32.502	6.587	0.476	38.613	38.613	12.833
89	50.705	1.784	2.296	32.653	6.862	0.491	39.024	40.273	6.352
90	-	-	-	-	-	-	-	-	-
91	22.389	0.659	0.456	19.659	4.040	0.097	23.602	24.098	-2.824
92	37.915	0.610	0.404	21.147	4.735	0.087	25.795	26.234	+10.667
93	39.305	0.201	0.335	22.432	4.777	0.072	27.137	27.327	+11.442
94	34.930	0.359	0.258	22.848	4.819	0.056	27.611	27.694	+6.619
95	34.354	0.434	0.301	20.487	4.441	0.064	24.864	25.212	+8.407
96	43.288	3.517	1.204	23.961	5.207	0.257	28.911	29.113	+9.454
97	19.597	0.943	0.894	19.651	3.837	0.192	23.296	23.459	-5.699
98	40.070	0.654	1.471	22.819	5.019	0.315	27.529	27.908	+10.037

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
99	41.582	1.797	1.305	22.623	5.024	0.277	27.370	28.246	+10.234
100	39.006	0.876	1.367	23.100	4.834	0.293	27.641	28.443	+8.320
101	57.816	1.199	0.894	25.987	5.204	0.191	31.000	32.333	+23.390
102	53.089	1.149	0.507	28.062	7.192	0.108	35.146	35.533	+15.900
103	47.773	0.874	0.593	27.426	5.833	0.128	33.131	33.131	+13.175
104	47.492	1.417	0.611	24.641	5.030	0.131	29.540	29.747	+15.717
105	40.980	0.835	0.619	25.045	5.454	0.132	30.367	30.367	+9.159
106	45.694	1.976	1.204	26.717	4.702	0.258	31.161	31.067	+11.447
107	44.608	1.273	1.195	26.745	5.751	0.255	32.241	31.564	+10.576
108	45.232	1.069	0.722	23.520	3.909	0.154	27.275	27.193	+16.248
109	51.696	1.055	1.049	26.753	5.609	0.224	32.138	32.234	+17.358
110	52.905	1.431	1.092	26.321	6.173	0.234	32.360	32.937	+17.445

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
111	67.542	1.718	1.866	32.033	7.339	0.400	38.972	38.309	+25.651
112	29.231	1.282	1.445	27.940	5.654	0.309	33.285	34.483	-2.525
113	66.931	1.100	1.686	28.115	6.390	0.361	34.144	34.622	+29.523
114	62.996	1.894	1.195	29.102	6.802	0.257	35.647	34.791	+25.116
115	59.988	1.582	1.066	30.390	6.758	0.229	36.919	36.919	+20.151
116	61.461	2.141	2.305	33.456	7.686	0.493	40.649	40.771	+16.244
117	69.125	1.870	1.230	31.894	6.914	0.264	38.544	39.199	+26.826
118	54.905	1.117	1.660	29.778	6.016	0.356	35.438	36.856	+15.272
119	69.059	1.689	1.591	33.904	7.218	0.341	40.781	39.027	+26.752
120	49.449	1.051	1.410	32.139	5.860	0.302	37.697	37.961	+9.027
121	65.471	2.020	1.634	34.108	7.574	0.350	41.332	40.753	+21.064
122	71.236	2.054	1.737	35.445	7.803	0.372	42.876	41.289	+26.156
123	51.643	1.384	1.505	32.950	6.976	0.322	39.604	41.624	+6.228

Table (34) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
124	56.049	1.224	1.531	33.117	6.970	0.328	39.759	40.037	+13.257
125	59.676	2.271	1.496	33.660	7.283	0.320	40.623	40.623	+15.286
126	90.846	2.627	2.296	34.667	7.863	0.491	42.039	41.913	+44.010
127	74.459	1.938	1.720	35.397	7.799	0.368	42.828	42.699	+28.102
128	66.729	1.733	1.866	34.002	7.364	0.400	40.966	41.539	+21.591
129	57.517	11.391	1.599	33.249	7.177	0.342	40.084	41.367	+13.160
130	71.029	1.311	2.219	35.299	7.714	0.476	42.537	42.112	+25.387
131	71.517	2.196	2.141	34.471	7.683	0.458	41.696	43.489	+23.691
132	70.220	2.141	2.193	35.641	7.775	0.469	42.947	44.021	+21.865
133	63.959	2.655	2.649	37.928	8.380	0.568	45.740	43.636	+15.019
134	56.581	1.880	1.840	35.339	7.595	0.395	42.539	44.538	+8.323
135	-	-	-	-	-	-	-	-	-

Table(34) (contd.

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
136	20.717	1.347	0.412	12.021	2.651	0.088	14.584	14.948	4.009
137	25.447	0.590	0,492	13.155	2.951	0.106	15.999	16.112	8.253
138	25.719	0.508	0.445	14.015	3.025	0.095	16.945	16.775	7.992
139	25.453	0.408	0.453	14.207	3.148	0.097	17.258	17.620	6.973
140	25.780	0.655	0.485	14.241	3.102	0.104	17.239	17.981	6.659

Table (35)

NON-PROTEIN R.Q. AND TIMES OF RUNS

(a) Serial No.	(b) O_2 for Prot. Metab. (litres)	(c) CO_2 for Prot. Metab. (litres)	(d) Non-Prot. O_2 (litres)	(e) Non-Prot. CO_2 (litres)	(f) Non-Prot. R.Q.	(g) Time of Run Hr.	Min.	(h) Correction Factor to per 24 hr.
1	0.674	0.553	7.877	6.946	0.882	24	25	0.983
2	0.352	0.289	4.611	4.268	0.926	23.	10	1.036
3	0.449	0.368	4.437	3.785	0.853	23	50	1.007
4	0.544	0.446	3.895	3.523	0.904	24	10	0.993
5	0.631	0.518	4.264	3.607	0.846	23	50	1.007
6	0.666	0.547	4.266	4.606	1.080	24	15	0.990
7	0.449	0.368	5.168	3.460	0.670	23	50	1.007
8	0.402	0.330	4.644	4.221	0.909	23	40	1.014
9	0.445	0.365	4.799	3.775	0.787	23	45	1.011
10	0.667	0.547	4.430	4.530	1.022	24	30	0.979

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
11	0.535	0.439	5.055	4.242	0.839	24	10	0.993
12	0.678	0.556	4.895	4.058	0.829	23	50	1.007
13	-	-	-	-	-	23	45	1.011
14	0.916	0.751	5.127	4.596	0.896	23	40	1.014
15	0.972	0.797	5.187	4.760	0.918	24	00	1.000
16	0.880	0.722	5.308	4.751	0.895	23	55	1.003
17	0.886	0.726	5.517	5.033	0.912	23	50	1.007
18	0.923	0.757	5.269	4.661	0.885	23	30	1.021
19	0.588	0.482	5.358	4.206	0.785	24	05	0.997
20	-	-	-	-	-	24	45	0.970
21	1.225	1.005	5.429	4.338	0.799	24	00	1.000
22	1.552	1.273	5.711	5.294	0.927	24	00	1.000
23	1.430	1.172	6.262	6.007	0.959	23	20	1.029

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
24	1.528	1.253	6.061	5.987	0.988	23	45	1.001
25	1.435	1.177	6.082	5.251	0.863	24	15	0.990
26	1.342	1.101	5.970	5.844	0.979	23	40	1.014
27	1.267	1.039	6.182	5.646	0.913	23	35	1.017
28	1.381	1.132	6.171	5.612	0.909	23	45	1.011
29	1.156	0.948	5.681	5.162	0.909	24	00	1.000
30	1.373	1.126	5.758	5.626	0.977	24	00	1.000
31	0.768	0.629	5.889	5.243	0.890	24	00	1.000
32	-	-	-	-	-	23	45	1.011
33	1.116	0.915	5.359	5.152	0.961	23	40	1.014
34	1.075	0.882	5.604	5.348	0.954	24	00	1.000
35	1.144	0.938	5.614	5.519	0.983	24	30	0.979

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
36	0.961	0.788	6.043	5.751	0.952	24	10	0.993
37	0.689	0.565	6.043	5.293	0.876	23	20	1.029
38	-	-	-	-	-	23	50	1.007
39	0.836	0.686	6.751	6.237	0.924	24	00	1.000
40	1.179	0.967	6.118	5.473	0.895	23	45	1.011
41	-	-	-	-	-	24	00	1.000
42	1.765	1.448	6.758	6.146	0.909	23	25	1.025
43	1.596	1.309	7.328	6.876	0.938	24	00	1.000
44	1.609	1.320	7.214	6.998	0.970	23	30	1.021
45	1.444	1.184	7.632	6.992	0.916	23	20	1.029
46	0.516	0.423	3.812	3.427	0.899	23	50	1.007
47	0.593	0.487	4.250	3.967	0.933	23	55	1.003
48	0.508	0.483	4.255	3.850	0.905	23	40	1.014

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
49	0.671	0.550	4.259	3.929	0.923	23	50	1.007
50	0.770	0.632	4.388	3.093	0.705	23	10	1.036
51	0.966	0.792	4.824	4.547	0.943	23	50	1.007
52	-	-	-	-	-	22	15	1.079
53	0.977	0.802	4.974	4.449	0.894	24	05	0.997
54	0.910	0.746	4.578	4.234	0.925	23	15	1.032
55	0.941	0.772	4.610	3.496	0.758	23	10	1.036
56	0.929	0.762	3.949	3.678	0.931	23	25	1.025
57	-	-	-	-	-	9	45	-
58	1.014	0.831	4.013	3.990	0.994	23	10	1.036
59	1.228	1.007	4.370	4.626	1.059	23	30	1.021
60	1.172	0.961	4.589	4.951	1.079	24	00	1.000
61	1.020	0.836	5.283	4.784	0.906	24	00	1.000

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
62	0.825	0.677	4.906	5.313	1.083	23	50	1.007
63	0.809	0.663	4.977	4.237	0.851	24	00	1.000
64	0.836	0.686	4.432	4.478	1.010	24	00	1.000
65	0.738	0.605	4.729	4.309	0.911	23	30	1.021
66	1.411	1.157	5.209	4.773	0.916	24	00	1.000
67	1.381	1.133	5.149	4.699	0.913	24	10	0.993
68	1.219	1.000	5.147	4.513	0.877	23	30	1.021
69	1.215	0.997	5.139	4.809	0.936	23	50	1.007
70	1.210	0.993	5.451	4.524	0.830	24	00	1.000
71	1.356	1.112	5.734	5.537	0.966	23	55	1.003
72	1.309	1.073	5.776	5.529	0.957	24	00	1.000
73	1.263	1.036	5.970	5.663	0.949	23	45	1.011
74	1.172	0.961	6.250	5.649	0.904	23	50	1.007

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
75	1.192	0.977	6.250	6.057	0.969	24	00	1.000
76	1.874	1.537	6.130	5.465	0.892	24	35	0.976
77	1.529	1.254	5.851	5.456	0.932	24	15	0.990
78	1.690	1.386	5.653	4.656	0.824	24	05	0.997
79	1.606	1.317	5.965	5.008	0.840	23	25	1.025
80	1.810	1.484	6.098	5.004	0.821	23	30	1.021
81	-	-	-	-	-	-		-
82	-	-	-	-	-	9	15	-
83	1.385	1.136	7.042	-	-	23	30	1.021
84	1.356	1.112	6.723	6.544	0.973	23	40	1.014
85	1.334	1.094	6.759	7.045	1.042	23	30	1.021
86	1.741	1.428	6.319	5.852	0.925	23	45	1.011

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
87	1.293	1.060	6.666	5.871	0.881	24	00	1.000
88	1.724	1.414	6.248	5.476	0.876	24	00	1.000
89	1.779	1.459	6.486	5.949	0.917	23	15	1.032
90	-	-	-	-	-	11	10	-
91	0.350	0.287	4.573	4.028	0.881	23	30	1.021
92	0.314	0.258	4.961	4.779	0.963	23	35	1.017
93	0.262	0.215	5.279	4.817	0.912	23	50	1.007
94	0.202	0.166	5.419	4.890	0.902	23	55	1.003
95	0.232	0.190	4.863	4.520	0.929	23	40	1.014
96	0.931	0.764	5.007	4.721	0.943	23	50	1.007
97	0.694	0.569	4.160	3.473	0.835	23	50	1.007
98	1.142	0.936	4.533	4.388	0.968	24	40	1.014
99	1.004	0.823	4.723	4.600	0.974	23	15	1.032
100	1.061	0.870	4.769	4.334	0.909	23	20	1.029

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
101	0.692	0.567	5.956	5.111	0.858	23	00	1.043
102	0.393	0.322	6.566	7.284	1.109	23	45	1.011
103	0.464	0.380	6.263	5.721	0.913	24	00	1.000
104	0.476	0.391	5.610	4.908	0.875	23	50	1.007
105	0.477	0.392	5.666	5.313	0.938	24	00	1.000
106	0.935	0.767	5.598	4.136	0.739	24	05	0.997
107	0.925	0.759	5.497	5.138	0.935	24	30	0.979
108	0.557	0.457	5.195	3.620	0.697	24	05	0.997
109	0.813	0.666	5.769	5.219	0.905	23	55	1.003
110	0.846	0.694	5.746	5.899	1.027	23	30	1.021
111	1.449	1.188	6.274	6.358	1.013	24	25	0.983
112	1.118	0.917	5.982	5.210	0.871	23	10	1.036

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
113	1.309	1.073	5.684	5.705	1.004	23	40	1.014
114	0.931	0.764	6.036	6.180	1.024	24	35	0.976
115	0.829	0.680	6.625	6.389	0.964	24	00	1.000
116	1.785	1.464	6.446	6.600	1.024	23	55	1.003
117	0.956	0.784	7.000	6.571	0.939	23	35	1.017
118	1.290	1.058	6.306	5.487	0.870	23	05	1.040
119	1.234	1.012	6.724	6.213	0.924	25	05	0.957
120	1.093	0.897	6.845	5.273	0.771	23	50	1.007
121	1.266	1.039	6.983	6.773	0.970	24	20	0.986
122	1.349	1.106	7.023	6.754	0.962	24	55	0.963
123	1.166	0.956	7.328	6.713	0.916	22	50	1.051
124	1.187	0.973	6.993	6.369	0.911	23	50	1.007
125	1.159	0.951	7.097	6.667	0.939	24	00	1.000

Table (35) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)		(h)
126	1.779	1.459	6.698	6.741	1.006	24	05	0.997
127	1.334	1.094	7.322	7.040	0.961	24	05	0.997
128	1.450	1.189	7.007	6.622	0.945	23	40	1.014
129	1.238	1.015	7.178	6.732	0.938	23	15	1.032
130	1.723	1.413	6.848	6.575	0.960	24	15	0.990
131	1.660	1.362	7.159	7.021	0.981	23	00	1.043
132	1.698	1.392	7.263	6.944	0.956	23	25	1.025
133	2.057	1.687	6.818	6.676	0.979	25	10	0.954
134	1.430	1.173	7.645	7.145	0.935	22	55	1.047
135	1.614	1.324	-	-	-	24	00	1.000
136	0.320	0.262	2.703	2.580	0.955	23	25	1.025
137	0.382	0.313	2.868	2.795	0.975	23	50	1.007
138	0.345	0.283	3.058	2.850	0.932	24	15	0.990
139	0.351	0.288	3.207	3.074	0.959	23	3[illegible]	1.021
140	0.376	0.309	3.269	3.076	0.941	23	[illegible]0	1.043

Table (36)

NITROGEN BALANCE

(a) Serial No.	(b) Total Urine N (mg)	(c) Weight of Dry Faeces (g)	(d) N/g Faeces (mg)	(e) Total Faeces N (mg)	(f) Food Weight (g)	(g) N/g Food (mg)	(h) Total Food N (mg)	(i) N Balance (mg)
1	101	0.370	48.5	13	11.312	31.03	351	237
2	53	0.294	28.3	10	7.548	31.03	234	171
3	67	0.169	45.0	27	6.783	31.03	210	116
4	82	0.313	46.5	15	6.338	31.03	197	100
5	95	0.449	40.6	9	7.928	31.03	246	142
6	100	0.466	48.3	10	7.905	31.03	245	135
7	67	0.427	37.3	9	5.102	31.03	158	82
8	60	0.261	27.5	11	7.816	31.03	243	172
9	67	0.331	22.1	7	9.318	31.03	289	215
10	100	0.316	35.0	11	9.266	31.03	288	177

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
11	80	0.338	46.6	14	5.466	31.03	170	76
12	102	0.322	30.9	10	7.058	31.03	219	107
13	115	0.320	38.9	12	9.588	31.03	297	170
14	137	0.379	41.3	11	9.928	31.03	308	160
15	146	0.256	37.4	15	10.306	31.03	320	159
16	132	0.271	45.9	17	9.171	31.03	285	136
17	133	0.551	42.3	8	10.343	31.03	321	180
18	138	0.287	44.1	15	9.726	31.03	302	149
19	88	0.284	44.6	16	5.269	31.03	163	59
20	150	0.335	44.8	13	3.280	31.03	102	-61
21	184	0.291	49.3	17	6.044	31.03	188	-13
22	233	0.527	53.1	10	10.816	31.03	336	93
23	214	0.632	45.6	7	13.526	31.03	420	199
24	229	0.662	49.4	7	12.144	31.03	377	141
25	215	0.562	46.6	7	11.794	31.03	366	144

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
26	201	0.360	44.8	12	11.616	31.03	360	147
27	190	0.502	40.7	8	9.121	31.03	283	85
28	207	0.589	38.8	7	9.247	31.03	287	73
29	173	0.359	36.8	10	8.182	31.03	254	71
30	206	0.501	40.3	8	11.501	31.03	357	143
31	115	0.432	47.9	11	8.679	31.03	269	143
32	105	0.414	42.9	10	5.259	31.03	163	48
33	167	0.316	45.7	14	10.817	31.03	336	155
34	161	0.688	40.1	6	12.725	31.03	395	228
35	172	0.314	41.1	13	13.349	31.03	414	229
36	144	0.322	49.6	15	11.687	31.03	363	204
37	103	0.475	48.4	10	7.120	31.03	221	108
38	206	0.289	45.4	16	11.197	31.03	347	125

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
39	125	0.519	39.5	8	13.785	31.03	428	295
40	177	0.400	41.3	10	10.056	31.03	312	125
41	256	0.826	44.8	5	9.848	31.03	306	45
42	265	0.237	49.8	21	9.696	31.03	301	15
43	239	0.705	48.1	7	12.861	31.03	399	153
44	241	0.692	45.7	7	12.844	31.03	399	151
45	216	0.433	46.3	10	12.340	31.03	383	157
46	77	0.110	44.0	5	6.123	32.45	199	117
47	89	0.202	41.0	8	7.967	32.45	259	162
48	88	0.240	38.5	9	6.966	32.45	226	129
49	101	0.145	35.5	5	7.476	32.45	243	137
50	116	0.235	39.2	9	7.554	32.45	245	120

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
51	145	0.389	47.0	18	7.359	32.45	239	76
52	70	0.249	42.0	10	0.476	32.45	15	-65
53	147	0.274	37.0	10	8.239	32.45	267	110
54	136	0.271	38.0	10	7.476	32.45	243	97
55	141	0.206	42.0	9	7.639	32.45	248	98
56	139	0.371	24.0	9	6.037	32.45	196	48
57	-	-	-	-	-	-	-	-
58	152	0.483	23.0	11	9.532	32.45	309	146
59	184	0.329	36.0	12	9.981	32.45	324	128
60	176	0.485	40.0	19	9.029	32.45	293	98
61	153	0.181	35.7	6	8.630	32.45	280	121
62	124	0.340	37.4	13	6.303	32.45	205	68
63	121	0.186	38.6	7	7.127	32.45	231	103

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
64	125	0.130	44.5	6	7.022	32.45	228	97
65	111	0.398	41.8	17	7.062	32.45	229	101
66	212	0.520	38.0	20	9.254	32.45	300	68
67	207	0.419	37.2	16	10.079	32.45	327	104
68	183	0.391	41.2	16	9.968	32.45	323	124
69	182	0.343	40.7	14	10.280	32.45	334	138
70	181	0.555	37.5	21	11.715	32.45	380	178
71	203	0.515	33.5	17	13.480	32.45	437	217
72	196	0.896	43.0	39	11.362	32.45	369	134
73	189	0.599	44.0	26	12.130	32.45	394	179
74	176	0.483	43.4	21	12.319	32.45	400	203
75	178	0.797	43.3	35	12.884	32.45	418	205

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
76	281	0.715	44.6	32	12.699	32.45	412	99
77	229	0.625	40.0	25	11.657	32.45	378	124
78	253	0.468	42.9	20	11.947	32.45	388	115
79	241	0.526	45.9	24	11.884	32.45	386	121
80	271	0.595	42.9	26	13.640	32.45	443	146
81	-	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-	-
83	208	0.842	37.2	31	16.009	32.45	563	324
84	203	0.556	48.0	44	11.652	32.45	410	163
85	200	0.624	49.7	31	13.643	32.45	480	249
86	261	0.304	38.7	12	12.120	32.45	426	153
87	194	0.603	57.1	34	10.052	32.45	354	126

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
88	258	0.612	44.0	27	12.043	32.45	424	139
89	267	0.574	41.7	24	10.989	32.45	387	96
90	-	-	-	-	-	-	-	-
91	53	0.187	46.0	9	5.092	30.76	157	95
92	47	0.173	42.2	7	8.623	30.76	265	211
93	39	0.057	41.6	2	8.939	30.76	275	234
94	30	0.102	37.9	4	7.944	30.76	244	210
95	35	0.123	38.8	5	7.813	30.76	240	200
96	140	0.247	45.9	11	9.845	30.76	303	152
97	104	0.268	55.2	15	4.457	30.76	137	18
98	171	0.186	47.9	9	9.113	30.76	280	100
99	150	0.511	44.4	23	9.457	30.76	291	118
100	159	0.249	41.6	10	8.871	30.76	273	104

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
101	104	0.340	38.9	13	13.149	30.76	405	288
102	59	0.326	40.6	13	12.074	30.76	371	299
103	69	0.248	37.7	9	10.865	30.76	334	256
104	71	0.402	40.9	16	10.801	30.76	332	245
105	72	0.237	39.2	9	9.320	30.76	287	206
106	140	0.562	27.4	15	10.392	30.76	320	165
107	139	0.362	42.2	15	10.145	30.76	312	158
108	84	0.304	37.2	11	10.287	30.76	316	221
109	122	0.300	39.4	12	11.757	30.76	362	228
110	127	0.407	37.1	15	12.032	30.76	370	228
111	217	0.584	41.9	24	15.361	30.76	473	232
112	168	0.436	43.8	19	6.648	30.76	205	18
113	196	0.374	53.9	20	15.222	30.76	468	259

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
114	139	0.644	49.6	32	14.327	30.76	441	270
115	124	0.538	44.6	24	13.643	30.76	420	272
116	268	0.719	44.4	31	13.978	30.76	430	131
117	143	0.628	45.3	28	15.721	30.76	484	313
118	193	0.375	44.3	17	12.487	30.76	384	174
119	185	0.567	43.9	25	15.706	30.76	483	273
120	164	0.353	42.0	15	11.246	30.76	346	167
121	190	0.660	42.4	28	14.890	30.76	458	240
122	202	0.671	46.2	31	16.201	30.76	498	265
123	175	0.452	43.1	19	11.745	30.76	361	167
124	178	0.400	44.3	18	12.747	30.76	392	196
125	174	0.742	46.3	35	13.572	30.76	418	209

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
126	267	0.884	45.1	40	20.661	30.76	636	329
127	200	0.652	40.4	26	16.934	30.76	521	295
128	217	0.583	46.7	27	15.176	30.76	467	223
129	186	0.468	43.8	21	13.081	30.76	402	195
130	258	0.441	40.5	18	16.154	30.76	497	221
131	249	0.680	41.4	28	16.265	30.76	500	223
132	255	0.663	46.4	31	15.970	30.76	491	205
133	308	0.822	43.6	36	14.546	30.76	447	103
134	214	0.582	42.1	25	12.868	30.76	396	157
135	-	-	48.7	-	-	30.76	-	-
136	48	0.385	42.5	16	4.791	31.40	150	86
137	57	0.169	38.9	6	5.885	31.40	185	122
138	52	0.145	39.4	7	5.948	31.40	187	128

Table (36) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
139	53	0.117	40.7	5	5.887	31.40	185	127
140	56	0.187	41.5	8	5.962	31.40	187	123

Table (37)

COMPONENTS OF WATER INTAKE

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
			Metabolic Water				
Serial No.	Fluid Water Intake (g)	Food Moisture (g)	0.205 x litres O_2 (g)	0.464 x litres CO_2 (g)	1.334 x g urinary N (g)	Total Metabolic Water/24hr (g)	Total Water Intake (g)
1	21.360	0.745	1.753	3.480	0.135	5.098	27.203
2	14.281	0.497	1.017	2.114	0.070	3.061	17.839
3	10.818	0.447	1.002	1.927	0.090	2.839	14.104
4	11.357	0.418	0.910	1.842	0.109	2.643	14.418
5	12.787	0.522	1.003	1.914	0.126	2.791	16.100
6	10.566	0.521	1.011	2.391	0.133	3.269	14.356
7	9.102	0.336	1.151	1.776	0.090	2.837	12.275
8	13.354	0.515	1.034	2.112	0.080	3.066	16.935
9	15.348	0.614	1.075	1.921	0.089	2.907	19.869
10	16.560	0.611	1.045	2.356	0.133	3.268	20.439

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
11	9.975	0.360	1.146	2.172	0.107	3.211	13.546
12	18.519	0.465	1.142	2.141	0.136	3.147	22.131
13	17.554	0.632	-	-	0.154	-	-
14	33.590	0.654	1.219	2.481	0.183	3.517	37.761
15	36.770	0.679	1.073	2.576	0.194	3.457	40.913
16	31.746	0.604	1.269	2.539	0.176	3.632	35.982
17	25.463	0.682	1.313	2.672	0.177	3.808	29.953
18	21.969	0.641	1.269	2.514	0.185	3.598	26.208
19	1.339	0.347	1.219	2.175	0.118	3.276	4.962
20	9.263	0.216	-	-	0.200	-	-
21	1.065	0.398	1.364	2.479	0.245	3.598	5.161
22	32.312	0.713	1.489	3.047	0.310	4.226	37.251
23	19.295	0.891	1.577	3.339	0.286	4.630	24.816

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
24	20.499	0.800	1.556	3.359	0.306	4.609	25.908
25	15.704	0.777	1.541	2.983	0.287	4.237	20.718
26	16.855	0.765	1.499	3.222	0.268	4.453	22.073
27	18.562	0.601	1.527	3.102	0.253	4.376	23.539
28	16.983	0.609	1.548	3.129	0.276	4.401	21.993
29	8.698	0.539	1.402	2.835	0.231	4.006	12.243
30	30.812	0.758	1.462	3.133	0.275	4.320	35.890
31	13.664	0.572	1.365	2.725	0.154	3.936	18.172
32	2.457	0.347	-	-	0.140	-	-
33	39.354	0.713	1.327	2.815	0.223	3.919	43.986
34	59.161	0.839	1.369	2.891	0.215	4.045	64.045
35	45.912	0.880	1.385	2.996	0.229	4.152	50.944

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
36	34.251	0.770	1.436	3.034	0.192	4.278	39.299
37	11.187	0.469	1.380	2.718	0.138	3.960	15.616
38	44.121	0.738	-	-	-	-	-
39	53.338	0.908	1.555	3.212	0.167	4.600	58.846
40	30.453	0.663	1.496	2.988	0.236	4.248	35.364
41	4.766	0.649	-	-	-	-	-
42	29.633	0.639	1.747	3.524	0.353	4.918	35.190
43	19.415	0.848	1.829	3.798	0.319	5.308	25.571
44	26.951	0.846	1.809	3.860	0.322	5.347	33.144
45	22.668	0.813	1.861	3.794	0.289	5.366	28.847
46	8.213	0.474	0.887	1.786	0.103	2.570	11.257
47	16.184	0.617	0.993	2.067	0.119	2.941	19.742
48	15.407	0.539	0.993	2.010	0.118	2.885	1 .831

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
49	15.603	0.579	1.011	2.078	0.134	2.955	19.137
50	15.665	0.585	1.057	1.728	0.154	2.631	18.881
51	19.412	0.569	1.187	2.477	0.193	3.471	23.452
52	10.239	-	-	-	-	-	-
53	15.257	0.638	1.220	2.436	0.195	3.461	19.356
54	13.201	0.578	1.125	2.311	0.182	3.254	17.033
55	13.699	0.591	1.138	1.980	0.188	2.930	17.220
56	12.858	0.467	1.000	2.060	0.186	2.874	16.199
57	-	-	-	-	-	-	-
58	23.164	0.738	1.031	2.237	0.203	3.065	26.967
59	26.068	0.773	1.148	2.614	0.246	3.516	30.357
60	24.881	0.699	1.181	2.743	0.234	3.690	29.270

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
61	13.623	0.668	1.292	2.608	0.204	3.696	17.987
62	12.062	0.488	1.175	2.779	0.165	3.789	16.312
63	12.230	0.552	1.186	2.274	0.162	3.298	16.080
64	15.197	0.544	1.080	2.396	0.167	3.309	19.050
65	15.629	0.547	1.121	2.280	0.148	3.253	20.457
66	25.845	0.716	1.357	2.752	0.282	3.827	30.388
67	26.762	0.780	1.339	2.706	0.276	3.769	31.339
68	23.177	0.772	1.305	2.558	0.244	3.619	27.489
69	25.516	0.796	1.303	2.694	0.243	3.754	30.038
70	24.931	0.907	1.366	2.560	0.242	3.684	29.522
71	21.676	1.043	1.453	3.085	0.375	4.163	26.869
72	19.956	0.879	1.452	3.063	0.262	4.253	25.088
73	19.654	0.939	1.483	3.108	0.253	4.338	24.880

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
74	15.972	0.953	1.376	3.067	0.234	4.209	21.103
75	23.131	0.997	1.526	3.264	0.238	4.552	28.670
76	31.946	0.983	1.641	3.249	0.375	4.515	37.564
77	30.112	0.902	1.513	3.113	0.306	4.320	34.479
78	29.815	0.925	1.505	2.803	0.338	3.970	34.724
79	33.263	0.920	1.552	2.935	0.321	4.166	38.239
80	37.158	1.056	1.621	3.010	0.362	4.269	42.389
81	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-
83	21.697	1.343	1.728	-	0.277	-	-
84	16.205	0.978	1.656	3.552	0.271	4.937	22.120
85	19.585	1.145	1.659	3.776	0.267	5.168	25.898

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
86	26.732	1.017	1.654	3.378	0.348	4.684	32.433
87	21.579	0.843	1.632	3.216	0.258	4.590	26.169
88	25.477	1.010	1.634	3.197	0.345	4.486	30.973
89	31.701	0.922	1.694	3.437	0.356	4.775	37.398
90	-	-	-	-	-	-	-
91	8.219	0.293	1.009	2.002	0.070	2.941	11.453
92	14.008	0.497	1.081	2.337	0.063	3.355	17.860
93	12.078	0.515	1.136	2.335	0.052	3.419	16.012
94	11.545	0.458	1.152	2.350	0.040	3.462	15.465
95	11.408	0.450	1.044	2.185	0.046	3.183	15.041
96	19.957	0.567	1.217	2.545	0.186	3.576	24.100
97	1.284	0.257	0.995	1.875	0.139	2.731	4.272
98	28.627	0.525	1.163	2.470	0.228	3.405	32.557

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
99	20.361	0.545	1.174	2.516	0.201	3.489	24.395
100	18.690	0.511	1.195	2.415	0.212	3.398	22.599
101	22.856	0.757	1.363	2.635	0.138	3.860	27.473
102	14.804	0.695	1.427	3.529	0.079	4.877	20.376
103	14.792	0.626	1.379	2.831	0.093	4.177	19.595
104	13.759	0.622	1.248	2.459	0.095	3.612	17.993
105	12.513	0.537	1.259	2.647	0.095	3.811	16.861
106	15.876	0.599	1.339	2.275	0.187	3.429	19.904
107	14.283	0.584	1.317	2.736	0.185	3.868	18.735
108	9.906	0.593	1.179	1.892	0.111	2.960	13.459
109	21.142	0.677	1.349	2.731	0.163	3.917	25.736
110	19.480	0.693	1.351	3.059	0.169	4.241	24.414

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
111	20.921	0.885	1.583	3.501	0.290	4.794	26.600
112	2.011	0.383	1.456	2.843	0.224	4.075	6.469
113	26.747	0.877	1.434	3.145	0.262	4.327	31.951
114	15.896	0.825	1.428	3.222	0.186	4.464	21.185
115	15.390	0.786	1.528	3.280	0.166	4.642	20.818
116	16.962	0.805	1.687	3.742	0.357	5.072	22.839
117	12.235	0.906	1.631	3.413	0.191	4.853	17.994
118	14.638	0.719	1.557	3.637	0.258	4.336	19.693
119	16.464	0.905	1.631	3.352	0.247	4.736	22.104
120	14.234	0.648	1.627	2.864	0.219	4.272	19.154
121	18.475	0.858	1.691	3.625	0.253	5.063	24.396
122	20.502	0.933	1.716	3.647	0.270	5.093	26.528

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
123	15.384	0.677	1.741	3.558	0.233	5.066	21.127
124	16.383	0.734	1.677	3.407	0.237	4.847	21.964
125	17.806	0.782	1.692	3.535	0.232	4.995	23.583
126	16.966	1.190	1.738	3.805	0.356	5.187	23.343
127	18.335	0.975	1.774	3.774	0.267	5.281	24.591
128	15.055	0.874	1.734	3.624	0.290	5.068	20.997
129	13.656	0.753	1.725	3.594	0.248	5.072	19.481
130	15.571	0.930	1.757	3.706	0.345	5.118	21.619
131	24.867	0.936	1.808	3.890	0.332	5.366	31.169
132	19.169	0.920	1.837	3.868	0.340	5.365	25.454
133	20.377	0.838	1.819	3.880	0.411	5.288	26.503
134	17.407	0.741	1.860	3.860	0.286	5.434	23.582
135	19.988	0.833	1.840	4.561	0.323	6.078	26.899

Table (37) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
136	10.246	0.335	0.620	1.319	0.064	1.874	12.455
137	10.652	0.412	0.666	1.442	0.077	2.032	13.096
138	11.373	0.416	0.698	1.454	0.069	2.082	13.871
139	10.643	0.412	0.730	1.560	0.070	2.220	13.275
140	10.916	0.417	0.749	1.570	0.075	2.243	13.576

Table (38)

COMPONENTS OF WATER LOSS

Serial No.	Weight of Urine (g)	Urinary Water (g)	Vaporized Water (g)	Weight Balance (g)	Vap. Water per 24 hr (g)	Water on Funnel and Frame (g)	Faecal Water (g)	Total Water Loss (g)	Water Balance (Direct $W_v + I$ (see p. 60)
1	4.918	4.338	19.742	-0.463	19.406	0.825	0.286	24.855	+2.35
2	2.754	2.364	12.482	-0.569	12.931	0.422	0.055	15.772	+2.[illegible]7
3	2.529	2.079	11.063	-0.618	11.140	0.315	0.037	13.571	+0.39
4	2.897	2.387	10.151	-0.368	10.080	0.388	0.075	12.930	+1.[illegible]
5	4.298	3.733	12.491	-0.214	12.578	0.431	0.093	16.835	-0.74
6	3.042	2.457	14.130	-0.425	13.989	0.755	0.095	17.296	-2.[illegible]4
7	2.125	1.675	13.067	-0.346	13.158	0.576	0.135	15.544	-3.27
8	1.294	0.874	13.381	-0.615	13.568	0.833	0.071	15.346	+1.5[illegible]
9	1.992	1.937	14.834	-0.746	14.997	0.984	0.070	17.588	+2.[illegible]
10	3.938	3.353	14.309	-0.091	14.009	0.964	0.069	18.395	+2.[illegible]4

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
11	3.623	3.123	14.009	-0.185	13.911	0.834	0.090	17.958	-4.41
12	5.961	5.381	15.847	-0.625	15.598	1.161	0.069	17.588	+4.54
13	5.382	4.737	-	-	-	1.066	0.073	-	-
14	22.423	21.688	18.440	-0.476	18.698	1.230	0.222	41.838	-4.08
15	23.366	22.591	17.186	-0.509	17.186	1.138	0.066	40.981	-0.07
16	21.502	20.787	15.587	-0.629	15.634	1.316	0.065	37.802	-1.82
17	14.724	14.002	16.721	-0.391	16.838	1.454	0.131	32.427	-2.47
18	10.076	9.331	14.611	-0.576	14.918	0.238	0.060	24.547	+1.66
19	2.593	2.058	12.169	-0.589	12.132	0.625	0.067	14.882	-9.92
20	3.206	2.416	-	-	-	1.542	0.144	-	-
21	4.332	3.402	13.269	-0.719	13.269	0.452	0.045	17.168	-12.11
22	6.260	5.130	15.626	-0.392	15.626	0.552	0.101	21.406	+15.85
23	9.512	8.457	16.643	-0.229	17.126	0.475	0.150	26.208	- 1.39

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
24	8.319	7.204	16.729	-0.512	16.746	0.452	0.140	24.542	+1.37
25	9.372	8.312	16.125	-0.553	15.964	0.373	0.167	24.816	-4.10
26	9.276	8.276	15.509	-0.177	15.726	0.474	0.073	24.549	-2.48
27	7.505	6.550	11.947	-0.878	12.150	0.457	0.101	19.258	+4.28
28	8.619	7.594	13.828	-0.658	13.980	0.569	0.169	22.312	-0.32
29	6.431	5.546	11.896	-0.532	11.896	0.651	0.064	18.157	-5.91
30	12.297	11.277	18.411	-0.197	18.411	0.635	0.181	30.504	+5.39
31	2.287	1.267	15.794	-0.364	15.794	0.953	0.066	18.080	+0.09
32	3.499	2.894	-	-	-	2.116	0.347	-	-
33	18.284	17.420	15.954	-0.859	16.177	1.310	0.069	34.976	+9.01
34	41.537	40.702	20.415	-0.603	20.415	1.715	0.181	63.013	+1.03
35	26.947	26.067	19.474	-0.465	19.065	1.782	0.168	47.082	+3.86

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
36	21.027	20.262	17.473	-0.979	17.351	1.916	0.123	39.652	-0.35
37	3.461	2.861	15.771	-0.292	16.228	1.062	0.094	20.245	-4.63
38	30.671	29.656	-	-	-	2.202	0.090	-	-
39	39.727	39.042	20.942	-0.473	20.942	2.576	0.223	62.783	-3.94
40	16.572	15.672	17.308	-0.810	17.498	0.939	0.058	34.167	+1.20
41	10.932	9.707	-	-	-	0.468	0.115	-	-
42	7.520	6.260	16.341	-0.109	16.749	0.575	0.072	23.656	+11.53
43	9.530	8.375	17.131	-0.389	17.131	0.525	0.185	26.216	-0.65
44	14.781	13.616	17.818	-0.637	18.192	0.412	0.217	32.437	+0.71
45	10.622	9.562	16.958	-0.512	17.450	0.583	0.107	27.702	+1.15
46	6.014	5.523	10.327	-0.446	10.399	0.330	0.022	16.274	-5.02
47	7.123	6.583	11.366	-0.068	11.400	0.325	0.024	18.332	+1.41
48	5.485	4.950	11.245	-0.960	11.402	0.433	0.049	16.834	+2.00

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
49	5.695	5.090	12.631	-0.120	12.719	0.463	0.091	18.363	+0.77
50	7.751	7.106	11.208	-0.237	11.611	0.388	0.030	19.135	-0.25
51	10.044	9.274	14.383	+0.164	14.484	0.304	0.530	24.592	-1.11
52	9.091	8.348	-	-	-	0.253	0.067	-	-
53	7.814	7.039	13.340	-0.414	13.300	0.474	0.314	21.127	-1.77
54	5.156	4.426	11.937	-0.270	12.319	0.300	0.131	17.176	-0.14
55	5.946	5.196	12.153	-0.341	12.591	0.375	0.073	18.235	-1.02
56	9.729	8.984	11.340	-0.107	11.624	0.244	0.085	20.937	-4.74
57	6.104	-	-	-0.211	-	-	-	-	-
58	10.858	10.061	11.190	-0.095	11.593	0.271	0.201	22.126	+4.84
59	18.374	17.444	13.658	-0.542	13.945	0.295	0.071	31.755	-1.46
60	18.190	17.295	13.182	-0.299	13.182	0.382	0.095	30.954	-1.68
61	6.421	5.621	12.786	-0.764	12.786	0.455	0.008	18.870	-0.88

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
62	3.784	3.099	10.392	-0.344	10.465	0.355	0.033	13.952	+2.36
63	4.943	4.273	12.029	-0.455	12.029	0.474	0.018	16.794	-0.71
64	5.804	5.119	11.633	-0.236	11.633	0.499	0.089	17.340	+1.71
65	6.901	6.271	12.734	-0.277	13.001	0.444	0.045	19.761	+0.69
66	16.330	15.285	15.824	-0.500	15.824	0.373	0.131	31.613	-1.23
67	14.773	13.748	16.480	-0.463	16.365	0.373	0.083	30.569	+0.77
68	10.716	9.791	14.583	-0.309	14.889	0.376	0.106	25.162	+2.33
69	11.928	11.003	14.509	-0.276	14.611	0.359	0.033	26.006	+4.03
70	13.471	12.556	16.804	-0.276	16.804	0.477	0.143	29.980	-0.46
71	8.814	7.809	15.507	-0.065	15.453	0.772	0.079	24.113	+2.76
72	9.550	8.570	15.062	-0.025	15.062	0.599	0.170	24.401	+0.69
73	10.157	9.207	14.711	-0.256	14.873	0.644	0.175	24.899	-0.02
74	7.362	6.467	15.555	+0.037	15.664	0.791	0.151	23.073	-1.97
75	10.773	9.763	17.385	-0.398	17.385	0.707	0.260	30.442	-1.36

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
76	16.990	15.660	18.224	-0.405	17.787	0.431	0.394	34.272	+3.29
77	18.238	17.123	16.873	-0.593	16.707	0.464	0.164	34.458	+0.02
78	17.517	16.302	18.191	-0.567	18.136	0.555	0.108	35.101	-0.38
79	18.126	16.966	18.164	-0.729	18.618	0.616	0.154	36.354	+1.88
80	26.424	25.139	20.307	-0.419	20.733	0.646	0.198	46.290	-3.90
81	-	-	-	-	-	-	-	-	-
82	-	-	-	-0.510	-	-	-	-	-
83	7.848	6.823	16.323	+0.672	16.666	1.567	0.315	35.371	-
84	6.712	5.707	16.473	-0.313	16.704	1.307	0.173	23.891	-1.77
85	8.310	7.315	17.101	-0.261	17.460	1.018	0.137	25.930	-0.03
86	12.997	11.572	17.398	-0.117	17.589	0.534	0.116	29.811	+2.62
87	6.537	5.567	17.651	-0.440	17.651	0.751	0.257	24.226	+1.94
88	12.214	10.979	19.282	-0.297	19.282	0.681	0.239	31.161	-0.21
89	20.727	19.457	19.211	-0.235	19.826	0.545	0.324	40.152	-2.75

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Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
91	1.744	1.354	11.659	-0.482	11.904	0.538	0.028	13.824	-2.[illegible]7
92	2.984	2.619	12.344	-0.040	12.554	0.598	0.063	15.834	+2.[illegible]
93	2.026	1.691	13.561	-0.619	13.656	0.321	0.028	15.696	+0.[illegible]
94	2.002	1.702	13.119	-0.675	13.158	0.750	0.032	15.642	-0.[illegible]
95	1.541	1.226	13.439	-0.088	13.627	0.851	0.030	15.734	-0.[illegible]
96	7.572	6.827	14.150	-0.511	14.249	0.394	0.039	21.5[illegible]9	+2.[illegible]
97	2.924	2.324	10.374	-0.359	10.447	0.343	0.014	13.128	-8.[illegible]
98	9.841	8.966	13.393	-0.138	13.581	0.381	0.038	22.966	+9.[illegible]
99	10.435	9.640	12.614	-0.340	13.018	0.445	0.320	23.423	+0.[illegible]7
100	9.211	8.386	14.577	-0.210	15.000	0.420	0.032	23.838	-1.[illegible]4
101	2.930	2.330	17.938	-0.193	18.709	1.453	0.059	22.545	+4.[illegible]
102	2.316	1.901	16.014	-0.198	16.190	1.724	0.056	19.871	+0.[illegible]1
103	3.196	3.676	16.443	-0.566	16.443	1.038	0.023	20.[illegible]	-0.[illegible]
104	2.871	2.406	16.022	-0.317	16.114	1.064	0.071	19.[illegible]	-1.[illegible]

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
105	2.319	1.844	14.982	-0.003	14.982	0.912	0.059	17.797	-0.94
106	4.807	4.052	16.653	-0.360	16.603	0.762	0.050	21.467	-1.56
107	3.478	2.733	15.957	-0.222	15.269	1.234	0.060	19.296	-0.56
108	2.609	2.094	14.506	-0.104	14.462	0.745	0.008	17.309	-3.85
109	6.070	5.395	16.115	-0.746	16.163	1.076	0.063	22.697	+3.04
110	7.428	6.733	15.865	-0.273	16.198	0.806	0.051	23.788	+0.69
111	8.339	7.274	17.307	-0.109	17.013	2.033	0.031	26.351	+0.25
112	3.186	2.326	13.873	-0.203	14.372	0.842	0.048	17.588	-11.12
113	4.364	3.384	15.469	-0.401	15.686	2.179	0.065	21.314	+10.64
114	3.527	2.782	16.112	-0.004	15.725	2.919	0.131	21.557	-0.37
115	3.069	2.389	16.595	-0.269	16.595	2.780	0.122	21.886	-1.07
116	8.398	7.123	15.826	-0.191	15.873	1.788	0.250	25.094	-2.19
117	4.724	3.939	15.427	-0.293	15.689	5.063	0.082	24.773	-6.78

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
118	4.485	3.510	14.012	-0.385	14.572	2.776	0.049	20.907	-1.21
119	4.706	3.771	15.768	-0.206	15.090	3.425	0.167	22.453	-0.35
120	4.166	3.321	16.693	-0.152	16.810	2.439	0.101	22.671	-3.52
121	4.981	4.026	17.727	-0.195	17.479	2.523	0.178	24.206	+0.19
122	6.147	5.142	18.162	-0.233	17.490	2.903	0.125	25.660	+0.87
123	5.650	4.755	15.140	-0.412	15.912	1.616	0.052	22.335	-1.21
124	4.908	3.978	16.192	-0.594	16.305	2.270	0.069	22.622	-0.66
125	5.666	4.776	16.357	-0.321	16.357	2.045	0.080	23.258	+0.39
126	8.243	6.973	17.126	-0.135	17.075	5.088	0.178	29.314	-5.97
127	4.410	3.415	16.384	-0.354	16.335	4.319	0.144	24.213	+0.38
128	4.581	3.516	16.008	-0.310	16.232	4.007	0.123	23.878	-2.83
129	4.176	3.241	16.185	-0.239	16.703	2.650	0.081	22.675	-3.19
130	6.033	4.798	16.882	-0.019	16.713	3.209	0.115	24.835	-3.22

Table (38) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
131	10.149	8.949	16.335	-0.199	17.037	1.294	0.091	27.371	+3.80
132	9.048	7.833	16.607	-0.439	17.022	1.667	0.128	26.650	-1.19
133	9.937	8.502	16.992	-0.070	16.210	1.132	0.158	26.002	-0.50
134	6.679	5.629	15.832	-0.231	16.576	1.857	0.117	24.179	-0.60
135	8.803	7.638	17.452	-	-	-	0.346	27.413	-
136	2.591	2.299	7.028	-0.255	7.206	0.271	0.109	9.885	+2.57
137	2.991	2.668	7.372	-0.129	7.423	0.242	0.069	10.402	+2.69
138	3.389	3.089	7.863	-0.529	7.785	0.315	0.019	11.208	+2.66
139	3.035	2.733	7.727	-0.351	7.889	0.351	0.039	11.012	+2.26
140	3.078	2.762	7.918	-0.374	8.258	0.404	0.069	11.493	+2.08

Table (39)

WATER BALANCE

Serial No.	Body Weight Gain (g)	Dry Mass of Faeces (g)	Dry Mass of Urine (g)	CHO Metab. (g)	Fat Metab. (g)	Prot. Metab. (N x 3.725) (g)	Dry Mass of Ingesta (g)	Water Balance (Indirect) (g)
1	+3.86	0.37	0.58	5.60	1.63	0.38	10.57	+1.85
2	+3.64	0.29	0.39	4.15	0.60	0.20	7.05	+2.22
3	+2.18	0.17	0.45	2.60	1.81	0.25	6.34	+1.12
4	+2.18	0.31	0.51	3.20	0.63	0.30	5.92	+1.21
5	+1.75	0.45	0.57	2.22	1.23	0.35	7.41	-0.84
6	-2.46	0.47	0.59	6.54	0.59	0.37	7.38	-1.28
7	-2.97	0.43	0.45	-0.87	2.90	0.25	4.77	-4.57
8	+3.21	0.26	0.42	3.85	0.73	0.23	7.30	+1.40
9	+5.14	0.33	0.46	1.55	1.75	0.25	8.70	0.78
10	+3.42	0.32	0.59	5.80	-0.18	0.37	8.66	+1.66

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
11	-4.82	0.34	0.50	2.80	1.40	0.29	5.11	-4.60
12	+2.65	0.32	0.58	2.50	1.43	0.38	6.59	+1.27
13	+2.40	0.32	0.65	-	-	0.43	8.96	-
14	+0.26	0.38	0.74	3.83	0.98	0.51	9.27	-2.57
15	+2.47	0.26	0.78	4.40	0.80	0.54	9.63	-0.38
16	-0.26	0.27	0.72	4.10	0.98	0.49	8.57	-2.27
17	-0.27	0.55	0.72	4.60	0.88	0.50	9.66	-2.68
18	+3.14	0.29	0.75	3.90	1.03	0.52	9.08	+0.54
19	-10.42	0.28	0.54	1.80	1.95	0.33	4.92	-10.42
20	-1.34	0.34	0.79	-	-	0.56	3.06	-
21	-12.56	0.29	0.93	2.15	1.85	0.68	5.65	-13.31
22	+17.22	0.53	1.13	5.15	0.75	0.87	10.10	+15.55
23	+2.12	0.63	1.06	6.50	0.45	0.80	12.64	-1.08

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
24	+3.25	0.66	1.12	7.38	0.03	0.85	11.34	+1.95
25	-1.49	0.56	1.06	3.98	1.60	0.80	11.02	-4.51
26	-0.54	0.36	1.00	6.63	0.25	0.75	10.85	-2.40
27	+3.88	0.50	0.96	5.30	0.90	0.71	8.52	+3.73
28	-0.62	0.59	1.03	5.10	0.98	0.77	8.64	-0.79
29	-5.21	0.36	0.89	4.70	0.90	0.65	7.64	-5.35
30	+7.05	0.50	1.02	4.40	1.05	0.77	10.74	+4.05
31	-0.44	0.43	1.02	4.45	1.10	0.43	8.11	-1.12
32	-9.91	0.41	0.61	-	-	0.39	4.91	-
33	+10.75	0.32	0.86	5.60	0.35	0.62	10.10	+8.40
34	+3.20	0.69	0.84	6.20	0.40	0.60	11.89	+0.04
35	+7.65	0.31	0.88	6.40	0.16	0.64	12.47	+3.57

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
36	+1.37	0.32	0.77	6.00	0.55	0.54	10.92	-1.37
37	-4.66	0.48	0.60	4.00	1.38	0.39	6.65	-4.46
38	+5.01	0.29	1.02	-	-	-	-	-
39	-0.11	0.52	0.69	6.00	0.92	0.47	12.88	-4.39
40	+2.24	0.40	0.90	4.80	1.10	0.66	9.39	+0.71
41	-15.37	0.83	1.23	-	-	-	9.20	-
42	+12.04	0.24	1.26	5.60	1.10	0.99	9.06	+12.17
43	+0.48	0.71	1.16	6.80	0.85	0.89	12.01	-1.03
44	+2.11	0.69	1.17	7.80	0.40	0.90	12.00	+1.07
45	+2.80	0.43	1.06	6.80	1.02	0.81	11.53	+1.39
46	-4.10	0.11	0.49	2.95	0.70	0.29	6.12	-5.68
47	+3.30	0.20	0.54	3.85	0.54	0.33	7.97	+0.81
48	+0.42	0.24	0.54	3.55	0.66	0.33	6.37	+0.70

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
49	+2.23	0.15	0.61	3.75	0.59	0.38	7.48	+0.23
50	+1.74	0.24	0.65	0	2.20	0.43	7.55	-2.29
51	+1.13	0.39	0.77	4.60	0.53	0.54	7.36	+0.60
52	-	0.25	0.46	-	-	-	0.48	-
53	-0.61	0.27	0.78	3.80	0.95	0.55	8.24	-2.50
54	+1.08	0.27	0.73	4.05	0.62	0.51	7.48	-0.22
55	+2.00	0.21	0.75	0.98	1.92	0.53	7.64	-1.25
56	-4.66	0.37	0.75	3.60	0.50	0.52	6.04	-4.96
57	-	-	0.81	-	-	0.58	0.79	-
58	+7.01	0.48	0.80	4.78	0.05	0.57	9.53	+4.16
59	+0.58	0.33	0.93	6.25	-0.40	0.69	9.98	-1.60
60	-2.11	0.49	0.90	7.10	-0.65	0.65	9.03	-2.65

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
61	+0.04	0.18	0.80	4.30	0.88	0.57	8.63	-1.86
62	-0.42	0.34	0.69	7.58	0.66	0.46	6.30	+3.01
63	-0.09	0.19	0.67	2.90	1.31	0.45	7.13	-1.70
64	+1.24	0.13	0.69	5.45	-0.05	0.47	7.02	+0.91
65	+0.18	0.40	0.63	3.97	0.07	0.41	7.06	-0.73
66	-0.73	0.52	1.05	4.50	0.75	0.79	9.25	-2.37
67	+2.17	0.42	1.03	4.40	0.77	0.77	10.08	-0.52
68	+4.99	0.39	0.93	3.60	1.12	0.68	9.97	+1.74
69	+6.06	0.34	0.93	4.80	0.60	0.68	10.28	+3.16
70	+3.56	0.55	0.92	2.80	1.60	0.68	11.72	-1.60
71	+6.67	0.52	1.01	6.15	0.34	0.76	13.48	+1.97
72	+1.94	0.90	0.98	6.00	0.41	0.73	11.36	-0.40
73	+2.46	0.60	0.95	5.82	0.58	0.71	12.13	-1.01

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
74	+0.60	0.48	0.90	5.00	1.05	0.65	12.32	-3.54
75	+2.37	0.80	0.91	6.70	0.35	0.67	12.88	-1.08
76	+5.13	0.72	1.33	4.70	1.15	1.05	12.70	+1.38
77	+2.24	0.63	1.12	5.38	0.73	0.85	11.66	-0.71
78	+2.99	0.47	1.22	2.70	1.73	0.94	11.95	-1.90
79	+5.26	0.53	1.16	3.40	1.60	0.90	11.88	+0.97
80	+0.83	0.60	1.29	2.95	1.85	1.01	13.64	-5.11
81	-	-	-	-	-	-	-	-
82	-	-	-	-	-	-	-	-
83	+8.00	0.84	1.03	-	-	0.89	16.01	-
84	-0.07	0.56	1.01	7.4	0.32	0.92	11.65	-1.51
85	+2.58	0.62	1.00	9.3	-0.45	0.86	13.64	+0.12

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
86	+5.66	0.30	1.25	5.7	0.80	1.02	12.12	+2.61
87	+4.04	0.60	0.97	4.8	1.38	0.85	10.05	+2.59
88	+3.09	0.61	1.24	4.3	1.38	1.06	12.04	-0.36
89	-0.74	0.57	1.27	5.8	0.88	1.08	10.99	-2.15
90	-	-	-	-	-	-	-	-
91	-2.38	0.19	0.39	3.18	0.99	0.20	4.80	-2.23
92	+4.05	0.17	0.37	5.20	0.34	0.18	8.13	+2.18
93	+1.59	0.06	0.34	4.55	0.77	0.15	8.42	-0.96
94	+1.07	0.10	0.30	4.45	0.86	0.11	7.49	-0.60
95	+1.14	0.12	0.32	4.47	0.58	0.13	7.36	-0.60
96	+4.94	0.25	0.75	4.82	0.52	0.52	9.28	+2.52
97	-9.47	0.27	0.60	2.20	1.20	0.39	4.20	-9.01

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
98	+11.47	0.19	0.88	4.78	0.32	0.64	8.59	+9.69
99	+2.80	0.51	0.80	5.10	0.26	0.56	8.91	+1.12
100	+1.07	0.25	0.83	4.20	0.61	0.59	8.36	-0.81
101	+11.54	0.34	0.60	3.80	1.45	0.39	12.39	+5.73
102	+1.32	0.33	0.42	10.75	-1.25	0.22	11.38	+0.40
103	+1.85	0.25	0.46	5.40	0.90	0.26	10.24	-1.12
104	+2.16	0.40	0.47	3.90	1.20	0.27	10.18	-1.78
105	+0.91	0.24	0.48	5.45	0.59	0.27	8.78	-0.84
106	+2.81	0.56	0.76	0.60	2.55	0.52	9.79	-1.99
107	+0.69	0.36	0.75	5.05	0.68	0.52	9.56	-1.51
108	-0.81	0.30	0.52	0	2.63	0.31	9.69	-6.74
109	+6.38	0.30	0.68	4.62	0.98	0.45	11.08	+2.33
110	+2.59	0.41	0.70	7.60	-1.25	0.47	11.94	+1.60

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
111	+6.00	0.58	1.07	7.82	0.08	0.81	14.48	+1.88
112	-11.71	0.44	0.86	4.00	1.35	0.62	6.27	-10.71
113	+15.87	0.37	0.98	7.10	-0.08	0.73	14.35	+10.62
114	+3.11	0.64	0.75	7.79	0.18	0.52	13.50	-0.51
115	+2.39	0.54	0.68	6.95	0.45	0.46	12.86	-1.39
116	+0.03	0.72	1.28	8.45	-0.26	1.00	13.17	-1.95
117	-1.23	0.63	0.80	6.70	0.75	0.53	14.82	-4.19
118	+3.11	0.38	0.98	4.20	1.43	0.72	11.77	-0.95
119	+4.38	0.57	0.94	5.80	0.97	0.69	14.80	-1.45
120	+0.81	0.35	0.85	1.67	2.75	0.61	10.60	-3.56
121	+3.46	0.66	0.96	7.50	0.42	0.71	14.03	-0.32
122	+4.88	0.67	1.01	7.40	0.48	0.75	15.27	-0.08

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
123	+1.00	0.45	0.90	6.30	1.06	0.65	11.07	-0.71
124	+1.98	0.40	0.93	5.80	1.12	0.66	12.01	-1.12
125	+3.02	0.74	0.89	6.80	0.78	0.65	12.79	+0.09
126	+1.86	0.88	1.27	8.35	-0.08	0.99	19.47	-6.20
127	+5.44	0.65	1.00	7.60	0.55	0.75	15.96	+0.03
128	+1.40	0.58	1.07	6.90	0.66	0.81	14.30	-2.88
129	-0.16	0.47	0.94	6.85	0.75	0.69	12.33	-2.79
130	+1.50	0.44	1.24	7.08	0.52	0.96	15.22	-3.48
131	+8.67	0.68	1.20	7.95	0.31	0.93	15.33	+4.41
132	+3.15	0.66	1.22	7.48	0.56	0.95	15.05	-1.03
133	+1.83	0.82	1.44	7.60	0.30	1.15	13.71	-0.57
134	+1.77	0.58	1.05	7.00	0.95	0.80	12.13	+0.02
135	1.[illegible]	0.[illegible]	1.17	-	-	-	13.62	-

Table (39) (contd.)

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
136	+3.24	0.39	0.29	2.70	0.22	0.56	4.46	+2.94
137	+4.03	0.17	0.32	3.20	0.17	0.69	5.47	+3.11
138	+3.99	0.15	0.30	2.90	0.34	0.70	5.53	+2.85
139	+3.43	0.12	0.30	3.07	0.27	0.69	5.47	+2.41
140	+3.98	0.19	0.32	3.20	0.33	0.70	5.54	+3.18