The Two Hundred and Seventy-second Scientific Meeting of the Nutrition Society was held in the Atkins Building, Queen Elizabeth College, Campden Hill, London W8 7AH on Friday, 27 September 1974, at 11.00 hours, when the following papers were read:

Fasting heat loss in the growing pig. By W. H. CLOSE and L. E. MOUNT, *ARC Institute of Animal Physiology, Babraham, Cambridge*

Fasting heat loss has been measured in pigs, 25–45 kg body-weight, at environmental temperatures of 20° and 30°. At each temperature the pigs were given either 34 or 45 g food/kg body-weight per d in the periods preceding and following fasting. Heat loss was measured consecutively for 14 d throughout the 24 h on each of four individual animals at each of the four combinations of temperature and level of feeding. At each combination three animals were fasted from the 6th to the 10th day of the measurement period while the fourth was fed throughout as a control.

Prefasting heat loss (days 1–5) (Table 1) was dependent on the environmental temperature and on the plane of nutrition at each temperature, suggesting that 30° was above the critical level for both higher levels of feeding (Close, Mount & Start, 1971; Verstegen, Close, Start & Mount, 1973). Following the withdrawal of food, heat loss reached a minimum during the 3rd and 4th days of fasting. Fasting heat loss was significantly related to the ambient temperature, the values at 20° being significantly higher ($P<0.001$) than those at 30°, but the previous nutritional state of the animal had no significant effect ($P>0.05$) on the fasting heat loss at either temperature. On refeeding, heat loss reached the prefasting levels by the 3rd day and was again dependent on the level of feeding at each temperature.

Table 1. *Mean rates of heat loss from pigs during feeding and fasting*

Environmental temperature (°)	Feeding level (g/kg body-wt per d)	Mean rates of heat loss ($kJ/kg^{0.75}$ per d)		Fasting rate as a percentage of feeding rate
		Feeding	Fasting	
20	39	602·4	448·8	75
20	45	660·0	468·0	71
30	39	662·4	362·4	55
30	45	736·8	398·4	54

From the present results and those of Deighton (1923) and Thorbek (1974) it may be concluded that 30° is within the zone of thermal neutrality for the fasting pig of this weight, with a probable critical temperature of 25°. The mean value from a number of authors of the maintenance energy requirement within the zone of

thermal neutrality was given by Verstegen *et al.* (1973) as 475 kJ/kg$^{0.75}$ per d. The mean minimal fasting heat loss (at 30°) was 380 kJ/kg$^{0.75}$ per d. The apparent efficiency of utilization of metabolizable energy for maintenance (k_m), that is, minimal fasting heat loss divided by minimal maintenance energy requirement, is therefore 0·80. This value is similar to that of 0·81 determined by Breirem (1936).

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Oxygen consumption of obese and anorectic patients. By ELENI GREEN and D. S. MILLER, *Queen Elizabeth College, London W8 7AH* and V. WYNN, *St Mary's Hospital Medical School, London W2*

There is considerable controversy as to whether the obese have a depressed basal or postprandial metabolic rate. One suspects that this arises because the earlier workers did not pay sufficient attention to whether their subjects were in the dynamic or static phase of obesity. It is well known that a reduced food intake depresses basal metabolic rate in both the obese and the lean. It has also been suggested that the obese in their dynamic phase utilize their food more efficiently than normal.

We were fortunate to be able to study both refractory obese subjects and those with anorexia nervosa in the same hospital, after a period of controlled intake. The former were given a diet containing 2·5 MJ (600 kcal) and the latter 14·2 MJ (3400 kcal). Neither group changed weight as much as would be expected from their prescribed intake. The obese lost 0·6 kg/week whilst the anorectic gained 0·8 kg/week.

Table 1.

	No. of subjects	Relative body-weight*	Oxygen consumption: Basal (ml/min)	Basal HB	Postprandial (ml/min)	Postprandial SDA
Obese	8	1·39	196	0·93	222	1·13
Anorectic	6	0·73	185	1·06	240	1·29

HB, basal: Harris-Benedict standard; SDA, specific dynamic action (postprandial: basal).

*Relative to the Metropolitan Life Assurance Standard.

The basal metabolic rates of both groups were similar and within the normal range, but when height, weight, sex and age are considered the values for the anorectics are somewhat higher than those for the obese. But the responses to a standard breakfast were substantially different. The increase in the postprandial metabolic rate with the anorectics was more than twice that with the obese. These results help to explain the poor responses to the prescribed diets and illustrate the

ability of some people to resist changes in weight when subjected to changes in food intake. They tend to support the buffer control theory of energy balance regulation in man but do not rule out the set-point theory (see Garrow, 1974).

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The effect of overfeeding on normal adult rats. By K. J. McCracken, *Agricultural and Food Chemistry Research Division, Department of Agriculture, Queen's University, Newforge Lane, Belfast BT9 5PX, Northern Ireland*

Whilst it is generally accepted that weight gain or loss in farm animals is closely associated with energy intake, there have been conflicting reports as to the effect of overfeeding on the energy balance and weight gain of normal adult humans. Passmore, Meiklejohn, Dewar & Thow (1955) obtained large positive energy balances in overfed, thin young men, whereas Miller & Mumford (1967) found that energy retention, calculated from body-weight gain, was much less than that expected on the basis of the excess intake. The laboratory rat has a similar level of activity to fairly sedentary people and can be given large excesses of energy for long periods by gastric intubation. Furthermore, body composition can be accurately determined, thus eliminating many of the assumptions which have to be made in experiments on human subjects. It therefore provides a good model for detailed study of the energy balance of overfed normal adults.

Female rats, 5 months old and of average weight 220 g, were force-fed with a diet consisting of (g/kg): starch 490, sucrose 250, casein 100, maize oil 100, minerals–vitamins 60, for 40 d at a level providing 180 or 360 kJ/rat per d. The lower level of intake was calculated to maintain energy balance, and the upper level was 50% above the *ad lib.* intake of similar rats consuming the diet in powder form. During the latter part of the experimental period three 22 h measurements of daily heat production were made on each group of animals using a closed-circuit respiration chamber.

The mean weight gains of the animals on the two treatments during the 40 d period were 10 g and 164 g respectively. The energy balances are shown in Table 1.

Table 1. *Energy balance of adult rats force-fed with* 180 *or* 360 *kJ/rat per d*

(Mean values for four rats/group)

	Date	ME intake (kJ/ rat per d)	Heat production (kJ/ rat per d)	Heat production (kJ/ kg per d)	Energy retained (kJ/ rat per d)	Respiratory quotient
Low intake	3 July	173	181	783	−8	0·89
	9 July	176	160	697	16	0·89
	18 July	177	176	767	1	0·89
High intake	2 July	355	225	664	130	1·09
	4 July	356	232	668	124	1·01
	10 July	360	231	623	129	1·02

ME, metabolizable energy.

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Whilst heat production of the animals on the high intake was higher in absolute terms, it was lower than that of the animals on the low intake (652 *v.* 748 kJ/kg body-weight per d) when compared on a body-weight basis. The high respiratory quotients on the high intake indicate the conversion of dietary carbohydrate to fat, despite the 100 g oil/kg diet.

Assuming that all the energy retained was fat, the average fat retention of the rats on the high intake was 3·2 g/d. This corresponds to 80% of the daily weight gain. Since some protein retention probably occurred, water retention must have been minimal, in agreement with the results of Passmore *et al.* (1955). This would partly explain the discrepancy between found and 'expected' weight gains in the experiments of Miller & Mumford (1967). Taken as a whole the results are clear evidence of a lack of 'dietary-induced thermogenesis' in the overfed adult rat.

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Hypocholesterolaemic action of wheat bran and a mould (*Fusarium*) in rats and hamsters. By D. E. OWEN, K. A. MUNDAY, T. G. TAYLOR and M. R. TURNER, *Department of Physiology and Biochemistry, The University of Southampton, Southampton SO9 3TU*

Male Wistar rats weighing 150 g were fed for 6 weeks on diets containing similar amounts of 'dietary fibre' from cellulose (Solka Floc), wheat bran or a *Fusarium* mould (Lord Rank Research Centre, High Wycombe, Bucks). Protein (approx. 180 g/kg dry diet) was supplied by casein in the cellulose and the bran groups, whereas the mould itself supplied most of the protein in the third group, the remainder being supplied by casein. Cholesterol (10 g/kg) and sodium cholate (2·5 g/kg) were added to each diet. As a negative control, the cellulose diet without added cholesterol or cholate was fed to an additional group of animals.

The addition of cholesterol and cholate to the cellulose diet resulted in a 63% increase in the plasma cholesterol level and a 97% increase in the concentration of cholesterol in the liver. In the groups fed on the bran and mould diets, plasma and liver cholesterol levels were significantly lower. Mean values ± SEM for six observations per group were:

	Dietary components (g/kg)			Added cholesterol +cholate	Cholesterol	
Diet	Casein	Fibre			Plasma (mg/l)	Liver (μg/g)
1	200	Cellulose	100	−	1453±38†	2712±136†
2	200	Cellulose	100	+	2366±78***	5350±244***
3	200	Bran	100	+	1613±55*†	3124±155†
4	50	Mould	400	+	1698±60**†	3247± 79**†

Significance of difference from diet 1: *$P<0.05$, **$P<0.01$, ***$P<0.001$. Significance of difference from diet 2: †$P<0.001$.

In a second experiment, male Golden Syrian Hamsters weighing 63 g were fed for 6 weeks on the cellulose diet, a mould diet (without added casein) or on diets containing a mixture of casein and mould. A further group was maintained on the stock diet (PMD; Christopher Hill Ltd, Poole, Dorset). All experimental diets supplied 180 g protein/kg and had a 'dietary fibre' content of 120 g/kg (mould diet), 100 g/kg (cellulose diet) and 110 or 105 g/kg in the mixed casein–mould diets (diets 3 and 2 respectively). No cholesterol or cholate was added to any of these diets.

The plasma cholesterol level was significantly higher (58%) in the animals fed on the cellulose diet than in those given the mould diet. The concentrations of cholesterol in both plasma and liver decreased progressively as the proportion of mould in the diet increased. The animals fed on the stock diet (cereal fibre) had plasma and liver cholesterol levels similar to those observed in hamsters fed on the mould diet. Mean values ± SEM for five observations per group were:

	Dietary components (g/kg)		Cholesterol	
Diet	Casein	Fibre	Plasma (mg/l)	Liver (μg/g)
1	200	Cellulose 100	2228±109††	3144±111
2	150	Mould 100	2052±82††	3030±60
3	100	Mould 200	1818±135*†	2998±65
4	0	Mould 400	1410±41***	2592±100**†
5	Stock diet	Several cereals	1380±32***	2874±48

Significance of difference from diet 1: $*P<0.05$, $**P<0.01$, $***P<0.001$. Significance of difference from diet 5: $\dagger P<0.05$, $\dagger\dagger P<0.001$.

The hypocholesterolaemic effect of wheat bran has been confirmed, and an equally potent hypocholesterolaemic action of a mould has been demonstrated both in rats and in hamsters.

The effect of wheat fibre on the plasma cholesterol in rats. By RUTH M. KAY and A. S. TRUSWELL, *Department of Nutrition, Queen Elizabeth College, London W8 7AH*

It has been suggested that the dietary fibre of wheat may lower plasma cholesterol in man (Trowell, 1972). Few direct human experiments have been done, and results so far are difficult to interpret (Eastwood, 1969). There is a need for good animal models in which the variables can be studied. We report here three experiments on rats.

(1) Three groups of ten mature, male Sprague-Dawley rats were given diets containing 0, 100 or 200 g bran/kg, and 10 g cholesterol/kg. At the end of 44 d, plasma cholesterol was slightly but not significantly higher in animals given the highest concentration of bran. There were no differences in liver cholesterol.

(2) Ten sets of three litter-mates were placed on diets containing 600–700 g wholewheat flour, white flour or maize starch/kg. After 42 d, plasma cholesterol was

the same in all groups, but liver cholesterol was lower in animals fed on the white-flour diet ($P<0.01$).

(3) To ten litter-mate pairs of male weanling rats, bran or white flour was fed at 500 g/kg in a diet containing 10 g cholesterol/kg. Sodium cholate (3 g/kg) was also added in this experiment. After 40 d, plasma cholesterol levels of the bran-fed rats were no lower than in the white-flour group, but liver cholesterol and total lipid were lower ($P<0.01$) in the bran group. This group ate 20% more food. Ranhotra (1973) has also reported variable results from similar work with rats.

We suggest that plasma cholesterol concentrations of rats may respond to dietary fibre in the same way as cholestyramine. Rats are relatively resistant to its cholesterol-lowering action compared with other species (Huff, Gilfillan & Hunt, 1963; Gallo, Hurkins, Sheffner, Surett & Cox, 1966).

Our work is at present supported by the British Heart Foundation.

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Methylxanthine consumption from coffee and tea. By W. AL-SAMARRAE, M. C. F. MA and A. S. TRUSWELL, *Department of Nutrition, Queen Elizabeth College, London W8 7AH*

In the Boston Collaborative Drug Surveillance Program (Jick, Miettinien, Neff, Shapiro, Heinonen & Slone, 1973) a positive association was found between myocardial infarction and heavy coffee consumption. The same association was not found with tea drinking. If coffee does predispose to myocardial infarction, this could be via its content of caffeine. However, standard textbooks of nutrition state that coffee normally contains about as much caffeine as tea (Sinclair & Hollingsworth, 1969; Davidson, Passmore & Brock, 1972).

Previous methods have usually measured caffeine and other methylxanthines by relatively non-specific techniques in chloroform extracts of dry beans and leaves. This does not directly indicate how much people actually drink in the cup. Our present method uses aqueous extracts, as made in everyday beverages. Methylxanthines were separated by thin-layer chromatography (solvent system modified from Heftmann & Schwimmer, 1971), the spots scraped off and extinction measured in water at 273 nm.

Table 1. *Caffeine content of tea and coffee (mg/cup)*

(Mean values and ranges)

	Restaurants	Homes
Coffee	99 (60–168)	92 (58–125)
Tea	56 (43–92)	70 (51–87)
Statistical significance of difference between mean values, P	<0.001	<0.001

We found that instant coffee on the British market contains only caffeine. Tea brands contain caffeine and a little theobromine but we have not detected theophylline. Caffeine per cup in tea and coffee as made and served in restaurants and cafés and in people's homes is shown in Table 1.

The final caffeine intake is higher, on the average, from a cup of coffee than from a cup of tea, both at home and in catering establishments, though home-made tea is somewhat stronger than tea in restaurants.

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Effects of prolonged centrifugation on body-weight regulation. By D. S. MILLER and A. WISE, *Department of Nutrition, Queen Elizabeth College, London W8 7AH*

Dodds (1950) suggested that 'to keep weight constant . . . it is possible that there is some relation between the body and the gravitational pull', and he recommended centrifuging animals for long periods in order to test the hypothesis. Many authors have centrifuged animals at high gravities for space research but in this instance a lesser gravity is more appropriate to weight regulation.

Weanling rats were centrifuged at 1·3 *g* or rotated near the axis at a mean gravity of 1·02 *g*. Other groups acted as controls (1 *g*). Rats were fed either a low-protein diet or stock diet. Weight regulation would be supported if the stock-fed centrifuged rats (1·3 *g*) had a lower mass than both their controls (1 *g*) and the rotated rats (1·02 *g*). Growth retardation due to the low-protein diet was expected to be greater than any effects of increased gravity on a weight feedback mechanism.

There were four rats/group, and for each diet, two groups were centrifuged (1·3 *g*), two were rotated (1·02 *g*) and two were controls (1 *g*). One group of each experimental type was killed after 10 d. After 7 weeks, all the rats eating the low-protein diet were killed. The remaining rats were killed 3 weeks later. At death, the stock diet-fed, treated rats (1·3 *g* and 1·02 *g*) had significantly lower weights than their controls (1 *g*), while there was no such difference for rats fed on the low-protein diet. Conversely the food intake of the stock diet-fed treated animals was lower than the controls, and the treated animals fed on the low-protein diet had higher food intakes than their controls. These results are shown in Table 1.

It is concluded that either rotation or vibration stressed the animals, either by reducing their food intake or increasing their energy expenditure. The centrifuge rotated at 33 rev./min and, in order to reduce rotation stress, the radius would have to be increased, e.g. to 7·4 m at 10 rev./min. Weight regulation by a weight feed-back mechanism is not supported by these experiments.

Table 1. *The effect of diet and centrifugation and rotation on body-weight and food intake of rats*

	Stock diet				Low-protein diet			
	Days on expt	Weight (g) Mean	Weight (g) SE	Food intake (MJ/ period per rat)	Days on expt	Weight (g) Mean	Weight (g) SE	Food intake (MJ/ period per rat)
Control	10	108	5	1·6	10	61	3	0·9
(1 *g*)	70	347	34	19·7	49	79	8	5·0
Centrifuged	10	96	4	1·3	10	58	4	0·9
(1·3 *g*)	70	302	33	17·6	49	84	6	7·7
Rotated	10	99	3	1·3	10	55	2	0·9
(1·02 *g*)	70	304	20	18·4	49	82	5	7·5

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The absence of lipolytic activity in the abomasal (gastric) secretion of the preruminant calf. By JOYCE TOOTHILL, J. D. EDWARDS-WEBB and S. Y. THOMPSON, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

Fat digestion in the simple-stomached animal has been ascribed mainly to the action of lipase from the pancreatic juice, though salivary (Scheer, 1928; Ramsey, Wise & Tove, 1956) and gastric (Marks, Bank, Krut & Bronte-Stewart, 1962) lipases probably also contribute. In the calf, the evidence for gastric lipase has been inconclusive because of possible contamination of gastric secretion by salivary or pancreatic lipases. To determine whether uncontaminated gastric secretion contained lipase, calves were fitted with cannulas into the abomasum and into surgically prepared innervated pouches, and comparisons were made of the enzyme activities in the abomasal and pouch contents.

After feeding, pepsin and rennin were found in the pouch secretions and abomasal contents, but only the latter samples hydrolysed tributyrin emulsion. Since the high acidity of the pouch secretions (pH 1·2–1·9) could have caused loss of lipolytic enzyme activity, diet was introduced into the pouch at feeding time to create conditions similar to those in the abomasum. Two liquid diets were used, one containing vegetable fat, the other milk fat; the same diet was introduced into the abomasal pouch as was given orally. After 20 min, samples were taken from both the pouch and abomasum. The pH values of the pouch and abomasal contents were between 4·4 and 6·1. Pepsin and rennin were present in samples of the pouch and abomasal contents, but again, only the latter hydrolysed tributyrin. No increase occurred in the free fatty acid contents of the abomasal pouch, but in the abomasal contents there were increases of 5·9% and 11·9% when the calf was given the vegetable- and milk-fat diets, respectively.

Our finding that no lipolytic enzyme is secreted by the abomasum supports the conclusion of Otterby, Ramsey & Wise (1964) that salivary pregastric esterase is

responsible for most of the lipolysis occurring in the abomasum of the preruminant calf.

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Observations on the volatile fatty acids present in the hind-gut and in the blood of the domestic rabbit. By R. T. McMillan, N. A. Edwards and D. S. Parker, *Department of Physiology and Biochemistry, The University, Reading RG6 2AJ*

Bacterial fermentation of the rabbit's caecal contents yields volatile fatty acids which in wild rabbits are present in similar concentrations at night and during the day (Henning & Hird, 1972). Domestic rabbits (New Zealand White) fed on commercial rabbit food *ad lib.* were presently investigated to see whether in captivity the levels of the acids vary with time.

The mean molar concentrations of the acids both in the caecum and colon of six rabbits killed at noon resembled those of six rabbits slaughtered at midnight (Table 1), indicating no clear diurnal variation in acid production, and suggesting a continuous and thorough mixing of the caecum and colon contents (Pickard & Stevens, 1972). The mean concentrations of the acids in blood taken under anaesthetic from the caecal vein, portal vessel and an ear vein were similar in the two groups of rabbits at each site of sampling. There was, therefore, no obvious variation in the uptake of the acids into the blood-stream.

On the other hand, in a third group of six rabbits from which food was withdrawn 12 h before slaughter, the concentrations of the acids in the hind-gut and in blood samples were lower (Table 1). Presumably the reduced flow of digesta provided less substrate for fermentation resulting in a correspondingly decreased caecal absorption of the acids.

The mean molar proportions of the acids in the caecum contents and in caecal venous blood of the rabbits killed at noon were respectively: acetate, 72·1 and 74·6%; propionate, 9·8 and 7·4%; butyrate, 15·5 and 14·2%; other acids, 2·5 and 3·8%. Similar values were obtained in the rabbits killed at midnight, except that in the blood butyrate was higher and acetate lower by 7% ($P<0·1$). The general similarity of the proportions in the blood and digesta at both times suggests that absorption of the acids is unrelated to the time of day, and occurs with little or no metabolic change in the individual acids. Typically in mammals in which digestive fermentation occurs, the level of propionate exceeds butyrate. This feature appears to distinguish the domestic and wild rabbit from most other species.

This work is supported by the Science Research Council.

Table 1. *Concentrations of volatile fatty acids in the contents of the hind-gut (μmol/g dry weight) and in the blood plasma (μmol/l)*

(Mean values with their standard errors for groups of six rabbits)

	Noon	Midnight	After 12 h fast
Caecum	188 ± 24^{a}	200 ± 14^{a}	100 ± 15^{b}
Proximal colon	190 ± 22^{a}	148 ± 20^{ab}	94 ± 21^{b}
Caecal vein	1605 ± 207^{p}	1572 ± 177^{p}	852 ± 54^{r}
Hepatic portal vein	1002 ± 196^{qps}	1259 ± 195^{pr}	614 ± 69^{s}
Ear vein	681 ± 169^{q}	672 ± 196^{q}	382 ± 142^{q}

Mean values with unlike superscripts differ significantly ($P<0.05$).

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Survey of dietary policy in British diabetic clinics. By A. S. TRUSWELL and B. J. THOMAS, *Nutrition Department, Queen Elizabeth College, London W8 7AH*

Diabetic diets come second only to reducing diets in frequency of usage, but unlike the latter they are nearly all prescribed by a limited number of specialists. In 1973 we sent questionnaires to all the physicians (471) in charge of diabetic clinics in England, Scotland and Wales. Of these, 72% replied but some of the replies could not be used, so that our analysis is based on 281 completed questionnaires.

The number of patients per clinic varied widely. On the average, diabetic clinics see 163 new patients/year and have 1260 patients on their records; general medical clinics with a special interest in diabetes usually see smaller numbers. Policy depends on whether patients are insulin-dependent (ID), maturity-onset of average weight (MOAW) or maturity-onset and overweight (MOOW).

Carbohydrate exchanges are used for most ID and MOAW patients. The carbohydrate unit is now becoming standardized at 10 g (in 83% of clinics). Most clinics prescribe a diet that appears to aim at about 40% of energy as total carbohydrates and 86% aim to restrict sucrose completely. Most clinics do not restrict dietary fat except for MOOW patients and very few encourage polyunsaturated fats. The energy content of the diets is prescribed in kcal by 167 clinics and in kJ by only one.

Some clinics have special diet sheets for immigrant patients. Most clinics now measure blood glucose routinely. Some do this for plasma cholesterol; few do it for triglycerides. Some doctors considered their dietary policy strict but most are 'middle of the road' except for MOOW patients. The physicians estimated that most ID patients adhere to their diets fairly well but most MOOW patients do not.

This survey provides a basis for discussion at a time when diabetic diets are thought to be more important than hitherto, when unconventional types of diets are

being tried experimentally (Weinsier, Seeman, Herrera, Assal, Soeldner & Gleason, 1974) and while there is concern about our effectiveness in communicating the diet to patients (West, 1973).

This work is supported by the British Diabetic Association.

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Detection of sucrose and trehalose in the urine of normal human subjects.

By A. H. AL-HAIDARI and A. S. TRUSWELL, *Department of Nutrition, Queen Elizabeth College, London W8 7AH*

Exogenous sucrose is known to be excreted in the urine only when there is intestinal damage, sucrase deficiency or when there is a high concentration of sucrose in the diet. Endogenous sucrosuria is rare and is associated with pancreatic disease (Rosenfeld, Lukomskaya, Gorodezky, Zarubina & Zarezky, 1965; Rosenfeld, Gorodezky & Zarubina, 1969).

Gorodezky, Mikhailoff & Rosenfeld (1971) have reported that sucrose is a usual component of human and animal urines, independent of the diet.

Trehalose does not appear to have been isolated from human urine (Smith, 1969). The enzyme trehalase (*EC* 3.2.1.28) is present in the intestinal mucosa but its function is not fully understood (Birch, 1973).

The methods we used were thin-layer chromatography, Technicon AutoAnalyzer and gas–liquid chromatography. Sucrose was further identified by chromatography before and after invertase treatment, and trehalose by acid-hydrolysis with the production of glucose.

We detected sucrose in the urine of each of eleven subjects taking their usual diets, and in the urine of four out of four volunteers who took a load of 150 g sucrose by mouth. In the same four volunteers it was still present after 28 h without food. Sucrose was also detected in the urine of each of four obese patients on a 3·3 MJ (800 kcal)/d diet, very low in sucrose.

We detected trehalose in the urine of each of four symptom-free volunteers; the urine samples of two of them were obtained after overnight fasting.

The preliminary qualitative findings suggest that sucrose and trehalose may be synthesized endogenously in man, possibly in the kidney.

We thank Professor L. Hough and Dr J. Garrow for their help.

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Prediction of the digestibility of forage from solubility in fungal cellulase solutions. By D. I. H. JONES, *Welsh Plant Breeding Station, Aberystwyth*

A good correlation has been established between the solubility of herbage in cellulase solutions and in vivo digestibility (Jones & Hayward, 1973). The accuracy of prediction was not improved by treatment with pepsin following the cellulase incubation.

It has subsequently been found that a marked improvement in precision can be achieved by prior incubation of the herbage samples (200 mg) with acid pepsin (0·2%, 1:10 000 units in 0·1 M-HCl) for 24 h. The supernatant fraction is then removed by filtration through a filter stick and the residue incubated with cellulase solution (20 ml citrate–phosphate buffer, pH 4·6, containing 125 mg *Trichoderma viride* cellulase) for a further 48 h. The final residue is isolated by filtration through tared filter paper, dried and weighed.

The Table shows the correlation coefficients and related parameters for the relationship between pepsin plus cellulase solubility and in vivo digestibility of nineteen grass samples; the correlations for in vitro digestibility (Tilley & Terry, 1963) and cellulase solubility without pepsin are included for comparison.

	Correlation with in vivo dry-matter digestibility (y)		
	Correlation coefficient	Residual SD	Equation
Pepsin plus cellulase solubility	0·93*	2·88	$y=0{\cdot}54\,x+35{\cdot}0$
Cellulase solubility	0·87*	3·74	$y=0{\cdot}54\,x+39{\cdot}0$
In vitro digestibility	0·90*	3·42	$y=0{\cdot}83\,x+11{\cdot}7$

*$P<0{\cdot}001$.

Using the two-stage technique a high correlation has been established with the in vitro digestibility of grasses ($r=0{\cdot}94$ ($P<0{\cdot}001$); residual SD 2·96) and legumes ($r=0{\cdot}94$ ($P<0{\cdot}001$); residual SD 2·68). The improvement in correlation following pepsin treatment was particularly marked for legumes. Following pepsin treatment closely similar results were obtained with cellulases from *T. viride* and Basidiomycetes, although without pepsin treatment the *T. viride* enzyme was much more efficient in solubilizing herbage than the Basidiomycete enzyme.

The two-stage enzyme technique is considered to be a simpler and more precise alternative to the conventional in vitro method using rumen inoculum and has obvious advantages for laboratories without access to fistulated animals. The technique is currently being applied in plant-breeding programmes aimed at improving the nutritive value of herbage.

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The effect of age on the blood and liver folate concentrations of laboratory animals. By S. J. G. AMYES*, PHYLLIDA M. M. ROBERTS† and PATRICIA P. SCOTT, *Department of Physiology, Royal Free Hospital School of Medicine, London WC1N 1BP*

At birth the blood folate concentrations of human infants are high in comparison with their mothers'; they subsequently decline (Vanier & Tyas, 1966).

We have determined blood and liver folate concentrations in neonatal laboratory animals using *Lactobacillus casei* as the assay organism. Total liver folate was determined by assaying after treatment with chick pancreas conjugase.

The blood folate levels of the four species examined (rat, dog, guinea-pig and rabbit) all fell following birth (Table 1). The only unusual feature was a subsequent rise in plasma folates in the rabbit. This was found to be related to the onset of coprophagy at about 4 weeks of age.

Total liver folate concentrations were determined in neonatal cats, rats, guinea-pigs and rabbits (Table 1). Significant ($P<0.05$) falls in folate concentrations were only observed for the cat and rabbit, the concentration in rabbit liver subsequently rising at the time of commencement of coprophagy.

Possible reasons for these changes in folate concentrations were discussed.

Table 1. *Erythrocyte, plasma and liver folate concentrations of five species of laboratory animal at different ages*

(Mean values with their standard errors; number of animals in parentheses)

Species	Age (d)	Erythrocyte (ng/ml)	Plasma (ng/ml)	Liver (μg/g)
Cat	0	732±111 (6)	16·2± 4·6 (6)	3·4±0·6 (4)
	8	337± 22 (4)	7·0± 0·7 (4)	2·4±0·2 (4)
	32	195± 39 (4)	5·2± 1·1 (4)	2·7±0·5 (4)
Rat	0	—	—	7·2±1·1 (6)
	10	—	—	3·6±0·4 (8)
	20	—	—	2·8±0·2 (8)
Dog	0	407± 20 (13)	36·0± 2·4 (13)	—
	14	282± 15 (12)	12·0± 0·7 (12)	—
	56	187± 13 (8)	5·3± 0·7 (8)	—
Guinea-pig	0	1013± 91 (4)	28·0± 6·0 (4)	8·5±0·7 (4)
	5	474±120 (4)	6·1± 2·5 (4)	9·6±1·0 (4)
	20	515± 66 (4)	12·9± 4·0 (4)	10·8±1·2 (4)
Rabbit	0	374± 75 (7)	78·0± 9·0 (7)	7·1±1·0 (7)
	8	135± 29 (5)	10·2± 1·7 (5)	4·1±0·8 (5)
	32	98± 21 (5)	42·0±12·0 (6)	8·7±0·3 (6)

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The digestibility and availability of lysine and methionine in isolated soya-bean protein after severe heat damage. By S. C. AMADI and D. HEWITT, *National Institute for Research in Dairying, Shinfield, Reading RG2 9AT*

The adverse effects of severe heat treatment of protein foods have been studied in various laboratories, but the mechanisms involved and the structural modifications produced are not fully understood.

In the present study we measured the digestibility, by ileal analysis, and the availability of lysine and methionine in unheated (control) and heated (steam at 121° for 18 h) isolated soya-bean protein (assay protein C1).

Table 1. *Digestibility and availability coefficients of lysine and methionine in control and heated isolated soya-bean protein*

	Lysine		Methionine	
	Control	Heated	Control	Heated
Digestibility*	0·97	0·40	0·95	0·50
Availability:				
Chick†	1·00	0·32	0·84	0·59
Rat‡	0·98	0·30	—	—
Microbiological§	—	—	0·90	0·48
FDNB‖	0·98	0·44	—	—

*Based on analyses of ileal digesta from 6–8-week-old chicks (eight chicks per protein), by the method of Varnish & Carpenter (1971).
†Unpublished procedure for lysine using a basal diet with sesame-seed meal; procedure of Carpenter, McDonald & Miller (1972) for methionine.
‡Method of Bjarnason & Carpenter (1969), slightly modified.
§Ford (1962) using *Streptococcus zymogenes*.
‖Reactivity to fluorodinitrobenzene (Carpenter, 1960).

The digestibility and availability of both amino acids in the control protein was very high (Table 1). Heat treatment reduced the digestibility and availability of methionine by about half. The digestibility and reactivity to fluorodinitrobenzene (FDNB) of lysine were similarly reduced by heating. However, the availability of lysine in the chick and rat bioassays was reduced by heating to about one-third. Thus reduced availability of lysine in heated soya-bean protein was only partially explained by reduced digestibility.

These results also suggest that some of the lysine with a free ϵ-NH_2 group was not absorbed, or was absorbed but not fully utilized. Possible reasons for the overestimation by FDNB of the amount of lysine available to the chick and the rat will be discussed. More free amino acids and 'unavailable' peptides were recovered in the ileum of chicks given the heated protein in contrast to the control chicks.

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The regulation of protein metabolism during pregnancy in the rat. By D. J. NAISMITH and B. L. G. MORGAN, *Department of Nutrition, Queen Elizabeth College, London W8 7AH*

In early pregnancy in the rat, a store of protein is built up in the maternal tissues which undergoes obligatory catabolism in late pregnancy (Naismith, 1966). The benefit to the foetus of this biphasic system of protein metabolism has been clearly demonstrated in dietary supplementation studies (Naismith & Morgan, 1974). A number of enzymes involved in amino acid catabolism, including alanine aminotransferase (*EC* 2.6.1.2) (AAT), show greatly reduced activity in the latter half of pregnancy (Naismith & Fears, 1971); the activity of the enzyme tryprophan pyrrolase (*EC* 1.13.1.12) (TP) which initiates the degradation of tryptophan to nicotinic acid has, however, been reported to rise in late pregnancy (Harding, Rosen & Nichol, 1961).

We have measured the activities of AAT and TP in the livers of rats at different stages of gestation. A high-protein diet was used, containing 250 g casein and 2·5 g DL-methionine/kg.

After an initial small rise, the activity of AAT fell markedly, to one-third of the value for the non-pregnant control. In contrast, TP activity was reduced in early pregnancy, then rose in late pregnancy to a value three times that of the control.

The withdrawal of tryptophan from the amino acid pool, resulting from a rising TP activity, would initiate and maintain the catabolism of muscle protein. Thus the differing responses of these two induceable enzymes to the changing pattern of hormone secretions during pregnancy could provide a mechanism whereby amino acids released from tissue proteins could be conserved.

To test this hypothesis, rats were fed on the high-protein diet throughout pregnancy (group A) or were transferred to a low-protein diet (50 g casein/kg) during the last week (groups B and C). Groups A and B received 20 mg nicotinic acid/kg diet,

Table 1. *Influence of nicotinic acid supplementation on amino acid metabolism in rats and on the birth weight of pups*

(Mean values with their standard errors for eleven litter-matched dams/group)

	Food intake days 15–21 (g)		Mean wt of pups (g)		AAT activity (μmol pyruvate produced/liver per min)		TP activity (μmol kynurenine produced/liver per h)	
Group†	Mean	SE	Mean	SE	Mean	SE	Mean	SE
A	117	7·1*	4·11	0·28*	66·0	3·1*	58·8	1·96*
B	92	4·9	3·39	0·08	44·7	1·7	18·0	0·49
C	94	3·7	3·06	0·06*	44·6	1·8	14·5	0·53*

AAT, alanine aminotransferase; TP, tryptophan pyrrolase.
Value differs significantly from that for Group B: *$P<0.001$.
†For details of groups, see text.

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but for group C, nicotinic acid was raised to 400 mg/kg in order to depress the activity of TP. The results are shown in Table 1.

The high intake of nicotinic acid did not affect food intake, or the activity of AAT, but the activity of TP was reduced by 19%, and the birth weight of the pups by 10%.

We gratefully acknowledge a grant from the Gerber Company.

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The effect of castration on the rate of tissue protein synthesis in vivo.

By A. K. CHATTERJEE, D. O. NNANYELUGO and D. J. MILLWARD, *Clinical Nutrition and Metabolism Unit, Department of Human Nutrition, London School of Hygiene and Tropical Medicine, London WC1E 7HT*

The influence of androgens on the accumulation of proteins by several tissues in addition to accessory sex organs has been recognized on various occasions. The effects were not uniform in the organs studied. Some of these studies involved measurement of in vivo incorporation of ^{14}C-labelled amino acids into tissue proteins following a single injection of the isotope, an approach involving variable precursor pool specific activity.

In the present experiments the constant intravenous infusion technique has been employed to study, in castrated rats, the rate of protein synthesis in vivo. Male Wistar rats (mean weight 137 g) were castrated. The rats, together with the controls, were infused, 8 d later, via the tail vein with trace amounts of [^{14}C]tyrosine for 6 h. The rate of protein synthesis was calculated from a single measurement of the specific radioactivity of the free and protein-bound tyrosine at the end of the infusion.

The results in Table 1 demonstrate that castration exerts variable effects on the rate of protein synthesis in different tissues. Thus the fractional rate of protein synthesis and the rate of synthesis per unit RNA were elevated in liver and unchanged in muscle and heart tissues. The 20% fall in the rate of protein synthesis in the kidney was not statistically significant. The possible implications of these findings were discussed.

Table 1. *Effect of castration on protein synthesis in liver, kidney, muscle and heart of male rats*

(Mean values and standard deviations; number of observations in parentheses)

	Liver		Kidney		Muscle		Heart	
Condition of animals	Fractional synthesis rate (/d)	Synthesis rate per unit RNA (g protein/g RNA per d)	Fractional synthesis rate (/d)	Synthesis rate per unit RNA (g protein/g RNA per d)	Fractional synthesis rate (/d)	Synthesis rate per unit RNA (g protein/g RNA per d)	Fractional synthesis rate (/d)	Synthesis rate per unit RNA (g protein/g RNA per d)
Control	0·489 ± 0·086 (6)	9·55 ± 2·56 (6)	0·508 ± 0·097 (4)	18·76 ± 3·11 (4)	0·121 ± 0·022 (6)	17·73 ± 3·21 (6)	0·199 ± 0·065 (4)	16·54 ± 5·16 (4)
Castrated	0·652* ± 0·141 (7)	13·04* ± 2·61 (7)	0·406 ± 0·068 (6)	17·38 ± 2·73 (6)	0·135 ± 0·014 (6)	18·92 ± 2·43 (6)	0·202 ± 0·045 (7)	16·77 ± 3·77 (7)

*$P<0.05$ (castrated *v.* control).

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A urea cycle enzyme and protein deficiency. By D. B. JEFFERYS and I. R. WHITE, *Department of Physiology, Guy's Hospital Medical School, London SE1 9RT*

Schimke (1962*a*) has shown that the urea cycle enzymes fall in concentration when the diet contains no protein but adequate energy. Stephen (1968) found that the activity of the urea cycle enzyme argininosuccinate lyase (*EC* 4.3.2.1: L-argininosuccinate arginine-lyase) was reduced in weanling female rats fed on a low-protein–high-sucrose diet, but not in male rats. It was therefore decided to assay this enzyme activity in mature Wistar rats to see if the nature of the carbohydrate and the sex of the animal affected the enzyme level for the adult.

A male and a female control group each of five rats received the usual laboratory diet. The other four groups received 800 g carbohydrate/kg diet, either as starch or sucrose, and 50 g calcium caseinate/kg.

These diets have been described in a previous paper (Jefferys & White, 1974).

After an overnight fast, 1 g samples of the liver were removed immediately under diethyl ether anaesthesia. The liver was placed in 10 ml of medium (0·02 M-Tris containing 0·05 M-KCl, pH 7·4) and homogenized in the cold (Stephen, 1968). The argininosuccinate lyase was assayed by a modification of the method of Schimke (1962*b*). The protein content of the liver homogenate was determined by a Biuret method. The results are summarized in the Table:

Regimen	Argininosuccinate lyase activity (μmol urea/h per mg liver protein)		Difference from control	Serum albumin (g/l)
	Mean	SE		
Control male	0·664	0·092	—	40
Control female	0·605	0·071	—	38
Sucrose male	0·193	0·058	$P<0·01$	30
Sucrose female	0·117	0·033	$P<0·01$	33
Starch male	0·547	0·194	NS	24
Starch female	0·083	0·022	$P<0·01$	34

NS, not significant.

There was no significant difference between the levels of the urea cycle enzyme activity for male and female rats. The female groups receiving the low-protein–high-carbohydrate diet showed a significant fall in the enzyme activity. This fall was only found for the male group receiving sucrose, not for the group receiving starch.

The relationship between the enzyme activity and the serum albumin levels for the animals was discussed. The question was also posed as to whether these enzyme activities reflect the degree of fatty infiltration of the liver or whether they contribute to the resistance of the adult female rat to protein deficiency.

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Endogenous loss of [1-^{14}C]- and [U-^{14}C]leucine in mature rats on low-protein diets. By R. J. NEALE, *Department of Applied Biochemistry and Nutrition, University of Nottingham School of Agriculture, Sutton Bonington, Loughborough LE12 5RD, Leics.*

The rate of oxidative degradation or endogenous loss of the ^{14}C-labelled essential amino acids leucine and lysine in rats, and the value of this measurement in determining amino acid maintenance requirements, has been reported (Neale & Waterlow, 1973, 1974). Several of the essential amino acids are ketogenic, however, and these amino acids, when labelled uniformly with ^{14}C, could be synthesized into storage fat in vivo and not remain incorporated in body protein. Whole carcass analysis for retained ^{14}C might, therefore, introduce errors in measurement of ^{14}C retained in total body protein. Experiments have therefore been performed by giving two groups of five mature, male Wistar rats 7·5 μCi of either [1-^{14}C]leucine or [U-^{14}C]-leucine, the rats being maintained on a low-protein diet (50 g casein/kg). Over the first 10 d after injection there was a rapid loss of $^{14}CO_2$ from the body from both precursor forms of leucine and the $^{14}CO_2$ specific radioactivity (SR) reached a plateau value at about day 14 – day 17. A further change of diet from the low-protein (50 g casein/kg) to a lower-protein (20 g casein/kg) diet at day 17 caused a small, but insignificant, fall in $^{14}CO_2$ SR from [1-^{14}C]leucine but no change with [U-^{14}C]leucine. Thereafter $^{14}CO_2$ loss was slower with little variation in SR up to the final day, day 30. Analysis of total body fat showed that for [U-^{14}C]leucine, 1·07% of the original dose given was retained, whereas for [1-^{14}C]leucine no detectable ^{14}C was retained. Total ^{14}C radioactivity in the remaining defatted carcass was 32·8% of original dose for [U-^{14}C]leucine and 34·4% for [1-^{14}C]leucine, these values not being significantly different. The ^{14}C retained in fat compared with protein is therefore insignificant. Calculation of the rate of loss of radioactivity between day 20 and day 30 by dividing mean daily output of $^{14}CO_2$ by the mean percentage ^{14}C radioactivity remaining in body protein gave values of 1·30 and 1·46 for [1-^{14}C]- and [U-^{14}C]leucine respectively. This rate of loss is similar to the value of 1·50 obtained in young weanling rats (40–60 g) using [U-^{14}C]leucine (Neale & Waterlow, 1974) and suggests that the value of 80 mg/kg$^{0.75}$ per d for endogenous loss of leucine is independent of age and remains essentially unchanged on lowering the protein content of the diet below maintenance requirement.

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The food-dependent induction of hepatic ornithine decarboxylase during undernutrition and rehabilitation. By P. A. MCANULTY and J. P. G. WILLIAMS, *Department of Growth and Development, Institute of Child Health, London WC1N 1EH*

Following a period of nutritionally-induced growth retardation in young animals and children, a phase of rapid recuperative growth occurs. In the individual organs and tissues, this rapid phase of growth appears to be correlated with increases in RNA (McAnulty & Dickerson, 1974). RNA synthesis has been connected with polyamine synthesis in rapidly growing tissues, and the induction of ornithine decarboxylase (ODC) is rate-limiting for polyamine synthesis (Raina & Jänne, 1970). In rats the activity of ODC has been shown to be dependent upon food intake (Hayashi, Aramaki & Noguchi, 1972).

Weanling rats were maintained at constant body-weight for 4 weeks by restricting their normal diet, and then rehabilitated by allowing unlimited access to food. Hepatic ODC activity was measured during undernutrition at various times after the daily feed, and also during rehabilitation.

ODC activity tended to peak 4 h after the daily feed in the undernourished rats, but as undernutrition progressed the magnitude of the induction decreased (Fig. 1). ODC activity was elevated during the first 15 d of rehabilitation, but then declined to normal levels.

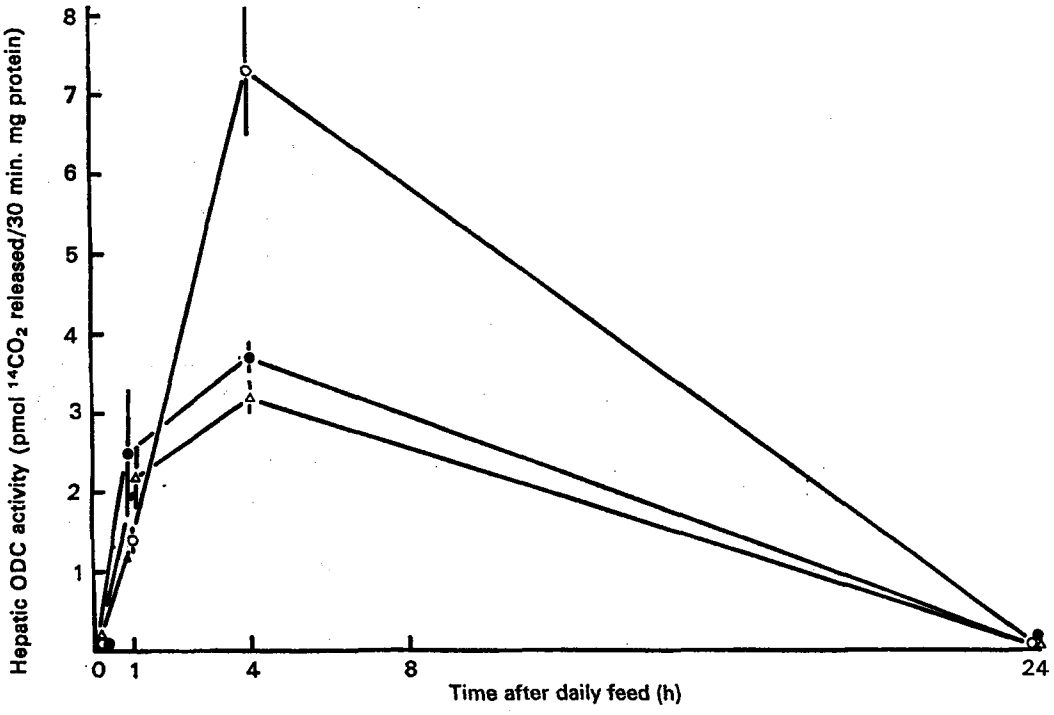

Fig. 1. Hepatic ornithine decarboxylase (ODC) at various times after the daily feed in undernourished rats. Mean values with their standard errors indicated by vertical bars: (○), rats undernourished for 7 d; (●), undernourished for 14 d; (△), undernourished for 21 d.

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The progressive decline in ODC induction during undernutrition suggests that adaptation was occurring, and this may affect the hepatic growth response upon rehabilitation.

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Whole-body protein turnover in malnourished and rehabilitated rats.

By D. J. MILLWARD, D. O. NNANYELUGO and P. J. GARLICK, *Clinical Nutrition and Metabolism Unit, Department of Human Nutrition, London School of Hygiene and Tropical Medicine, London WC1E 7HT*

During a continuous intravenous infusion of [^{14}C]tyrosine, the plasma (and tissue) free tyrosine attains a plateau specific activity when the rate of input of radioactivity is equal to the rate at which it is removed, i.e. I=QSp, when I=infusion rate (disintegrations/min per min), Sp=the plateau specific activity (disintegrations/min per μmol) and Q=the flux of tyrosine (μmol/min). The flux rate is related to the whole-body protein turnover rate by the expression Q=I+B=E+S, where I and E are the rates of intake and excretion, and B and S are the rates of protein breakdown and synthesis respectively. The plasma tyrosine flux is converted to whole-body protein nitrogen flux on the assumption that in the rat 1 μmol tyrosine is equivalent to 0·85 mg total N, and that the plasma flux underestimates the whole-body flux by 30%.

Table 1. *Plasma tyrosine flux and whole-body protein flux in rats given protein-free and high-protein diets*

		Body-weight (g)		Plasma tyrosine flux (μmol/h per kg)		Whole-body protein flux (g nitrogen/kg body-wt per d)	
Diet	Days on diet	Mean	SD	Mean	SD	Mean	SD
Protein-free	30	56	4	76·6	14·4	2·03	0·38
High-protein, refed	1	64	4	123·3	13·0	3·27	0·34
	3	78	6	222·5	42·4	5·90	1·12
	8	97	10	268·3	31·9	7·12	0·84
	14	128	12	293·9	50·1	7·79	1·33
Weight controls		110	6	328·1	59·3	8·70	1·57
Age controls		205	6	205·4	26·7	5·45	0·71

The results in Table 1 demonstrate the rapid rate of whole-body protein turnover in the well-fed rat, equal to about one-third of total body N per d in the weight controls and about one-fifth in the older rats. This means that the energy cost of protein synthesis must represent a considerable fraction of the basal metabolic rate, especially

if the experimentally determined, very high values are correct (Blaxter, 1967). The reduction in the malnourished rats may represent an adaptive response in order to conserve energy as well as protein. The possible mechanisms of the restoration of flux to near normal levels on rehabilitation were discussed.

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A malnourished animal colony: its significance for man. By R. J. C. STEWART, *London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT*

Rats from colonies maintained on diets marginally deficient in protein, like members of deprived human communities, develop changes in mean birth weights, proportion of small-for-dates offspring, rate of growth, adult size, sexual maturation, behaviour and learning. Although there are many similarities, there remain differences in the timing of organ development and susceptibility to nutritional stress; these apply especially to the central nervous system. For instance, neuronal multiplication takes place in man at a stage when nutritional stresses seem unlikely, whereas in rats cellular development can be affected. Does this mean that animal models are of little value in understanding the human condition or that we have been looking at the wrong indices?

Deficient mothers given diets of good protein value during the last one-third of pregnancy produce young which grow to a greater length and weight than control animals, but the offspring of deficient mothers fostered at birth to normal females do not overgrow (Stewart, Preece & Sheppard, 1973). These recovery experiments have been continued and members of later generations are not significantly larger than controls. The overgrowth affects therefore only those animals in utero when their mothers were rehabilitated.

Hormone-producing tissues are modified by protein-energy deficiency and respond quickly to refeeding. Many hormonal changes occur during the last one-third of pregnancy, and rehabilitation during this period might cause an over-correction of any disturbances brought about by protein deficiency. Soerjodibroto, Stewart & Heard (1974) found that deficient rats given a daily dose of L-thyroxine during the last one-third of pregnancy produced offspring of normal weight. It is probable that both treatments—giving an improved diet or exogenous thyroxine—lead to alterations in hormonal balance, one indirect and the other direct. The importance of hormones during central nervous system development, and more especially of thyroxine in cell maturation, is well known. Therefore, the nervous changes produced by protein-energy deficiency may be related not to the multiplication of neurons, but to their development in size and complexity which, in both man and animals, occurs during periods susceptible to nutritional stress. If this view is confirmed, then one of the last objections to accepting animal models for the investigation of human problems has been removed.

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Changes in anthropometric measurements of children recovering from protein–energy malnutrition. By ERICA F. WHEELER*, *Tropical Metabolism Research Unit, University of the West Indies, Mona, Jamaica*

Height, weight, mid-upper arm circumference and four skinfold thicknesses (triceps, biceps, supra-iliac and subscapular) were measured in ten Jamaican children during the course of recovery from protein-energy malnutrition. 'Mid-arm muscle circumference' was also calculated (Standard, Wills & Waterlow, 1959). The children's chronological ages were between 15 and 26 months, and their height ages between 5 and 17 months. Body-weights, related to the expected value for height, ranged between 58% and 78% of the expected value. The children were treated with a high-energy recovery diet, which supplied approximately 630 kJ (150 kcal)/kg per d, for periods ranging between 36 and 65 d (Kerr, Ashworth, Picon, Poulter, Seakins, Spady & Wheeler, 1973; Spady, 1974).

After recovery, their body-weights had increased to an average of 92% of the expected value. Table 1 shows arm and muscle circumferences and triceps skinfolds before and after recovery. All the four skinfold thickness measurements increased to the same extent. The relative increase in triceps skinfold is always greater than that in arm and muscle circumference; and this supports the suggestion of Kerr *et al.* (1973) that the body-weight gain, in malnourished children given a high-energy recovery diet, has a higher fat content than that of children undergoing normal growth.

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Table 1. *Upper-arm measurements of ten Jamaican children before and after recovery from protein-energy malnutrition, expressed as a percentage of standard values for height and age**

Child	On admission			At discharge			Increase (%)‡		
	Mid-arm circum-ference	Triceps skinfold thickness	Muscle circum-ference†	Mid-arm circum-ference	Triceps skinfold thickness	Muscle circum-ference	Mid-arm circum-ference	Triceps skinfold thickness	Muscle circum-ference
CR ♂	75	47	83	100	68	110	35	47	10
EM ♂	65	36	73	89	89	93	41	147	26
IB ♂	75	31	84	93	66	101	27	91	20
MS ♀	85	87	83	91	97	91	8	11	7
RC ♂	83	54	91	100	101	100	20	122	20
GB ♂	70	35	82	93	78	104	43	132	33
MW ♀	65	48	69	88	95	89	40	105	28
CC ♂	62	28	71	91	69	101	52	146	48
SE ♂	67	28	76	92	79	95	37	180	24
GF ♂	73	45	84	92	106	89	29	138	13
Mean	72	44	80	93	89	97	33	112	23

*Jelliffe (1966).
†Muscle circumference (M) calculated from arm circumference (A) and triceps skinfold thickness (S), as: $M = A - \pi S$.
‡Increase as a percentage of value on admission.

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