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PROCEEDINGS OF THE NUTRITION SOCIETY

ABSTRACTS OF COMMUNICATIONS

The Three Hundred and Thirty-seventh Meeting of the Nutrition Society was held at the Queen Elizabeth College, London, on Thursday, 6 *December* 1979, *when the following papers were read:*

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The immunological effect of a high dietary intake of soya protein in man.

By N. J. GOULDING, M. J. GIBNEY, P. J. GALLAGHER, D. B. JONES, JANE B. MORGAN and T. G. TAYLOR, *Departments of Nutrition and Pathology, University of Southampton, Southampton SO9 5NH*

A recent study failed to demonstrate any adverse physiological effects of a high intake of soya in man (Van Stratum *et al.* 1978). However, studies have shown substantial systemic and gastrointestinal immune reactions to dietary soya protein in calves and pigs (Barratt *et al.* 1979) and rabbits (Gallagher *et al.* 1978). The present study was designed to study the possible immunological consequences of a high intake of soya based textured vegetable protein (TVP) in man.

Fifty-three healthy volunteers (mean age 25·3±1·1 years) took part in the experiment. A 24 h recall was used to determine the initial dietary pattern and a 3 d inventory survey was carried out during week 5 or 6. The subjects were given a selection of commercially available soya-protein based products, including soya milk, meat extenders and prepared dishes. From the second dietary survey it was established that the subjects were consuming 22·7±2·3% of their total intake of protein as soya-bean protein, eating an average of four TVP based main meals per week.

Blood samples were assayed for antibodies to soya protein using an enzyme linked immunosorbent assay (ELISA). The mean values (±SEM) are summarized in the Table.

Time (d)	Food intake /d					Anti soya protein antibodies		
	Energy (MJ)	Protein (g)	Fat (g)	CHO (g)	Fibre (g)	IgG	IgA	IgM
						(ELISA units)		
0	10 (0·7)	87 (7)	102 (9)	276 (19)	20 (2)	63 (6)	17 (1)	26 (3)
42	11 (0·6)	102 (5)	119 (7)	303 (20)	20 (1)	60 (6)	17 (1)	23 (3)
	*	NS	**	*	NS	NS	NS	NS

NS, not significant.
*$P<0·05$, **$P<0·01$ (student's t test).

No evidence of an increase in circulating antibodies of any class to dietary soya-bean protein could be found in spite of a substantial and sustained increase in the intake of soya-bean protein. Therefore, it could be concluded that the presence of small quantities of soya protein in processed foods, e.g. soups, beefburgers, sausages, etc. in normal diets is sufficient to stimulate an efficient gastrointestinal secretory IgA. No detectable differences in serum immune complexes were found at the end of the 6 week period, using a sensitive RAJI cell radioimmunoasssay. The increased intake of energy is not easily explained but may reflect inaccuracies of the 24 h recall method or the result of providing free dinners to a student dominated group of volunteers.

Barratt, M. E. J., Strachan, P. J. & Porter, P. (1979). *Proc. Nutr. Soc.* **38**, 143.
Gallagher, P. J., Muir, C. A. & Taylor, T. G. (1978). *Atherosclerosis* **31**, 361.
Van Stratum, P., Rudrum, M., Ten Hoor, F., Wilson, R. & Pikaar, N. A. (1978). *Proc. Nutr. Soc.* **37**, 11A.

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Dietary fibre and blood pressure. By ANGELA WRIGHT, P. G. BURSTYN and M. J. GIBNEY, *School of Biochemical and Physiological Sciences, University of Southampton SO9 3TU*

Increased dietary fibre can diminish the hypertensive effects of fat enriched diets in rabbits (Gardey *et al.* 1978; Kennedy *et al.* 1978). Although high-fibre diets without extra fat had no effect upon the animals' blood pressures, we felt that dietary fibre might have an effect on the blood pressures of humans whose normal diet contains a great deal of fat.

Volunteers had their resting blood pressures measured three times weekly throughout the 2 week control period and 4 week experimental period. Three day weighed dietary surveys were carried out during both periods.

Seventeen individuals whose usual diet was relatively low in fibre were asked to change to a high-fibre diet and given advice how best to achieve this. Their mean systolic pressure decreased from 121·2±1·6 to 117·3±1·9 mm Hg ($P<0.01$), and diastolic pressure from 78·5±1·7 to 74·8±1·3 mm Hg ($P<0.001$). Their dietary fibre increased from 2·36±0·15 to 3·47±0·12 g/MJ ($P<0.001$).

Fourteen volunteers whose usual diet was relatively low in fibre were given specially baked wholemeal bread with 10% added bran (calculated dietary fibre 110 g/kg) to replace all of their white bread, and asked to consume 5 g bran daily with their food. Their mean systolic pressure decreased from 119·9±2·5 to 118·2±1·4 mm Hg ($0.1>P>0.05$), and diastolic pressure from 79·5±1·5 to 76·8±1·5 mm Hg ($P<0.01$). Their dietary fibre increased from 1·61±0·12 to 3·47±0·12 g/MJ ($P<0.001$).

Eleven volunteers whose usual diet was high in fibre were given white bread to replace all of their wholemeal bread and asked to avoid very high fibre breakfast cereals. Their mean systolic pressure increased from 113·8±2·6 to 121·5±1·4 mm Hg ($P<0.02$), and diastolic pressure from 74·2±1·6 to 77·0±1·1 mm Hg ($0.1>P>0.05$). Their dietary fibre decreased from 3·93±0·37 to 1·78±0·21 g/MJ ($P<0.001$).

Three day dietary surveys were carried out on a total of ninety-four people. People whose dietary fibre intake was greater than the over-all mean value were classified as 'high fibre' (3·44±0·21 g/MJ, n 45), and those whose intake was less than the mean were 'low fibre' (1·64±0·12 g/MJ, n 48). Both the systolic and diastolic pressures of the former (116·2±1·5 mm Hg; 75·2±1·0 mm Hg) were lower than those of the latter (123·3±1·3 mm Hg; 78·5±0·8 mm Hg). The differences were statistically significant ($P<0.001$; $P<0.02$). The age and sex distributions of the two groups were similar.

The results reported here can account for much of the difference in blood pressures between vegetarians and meat eaters (e.g. Armstrong *et al.* 1977).

Armstrong, B., van Merwyk, A. J. & Coates, H. (1977). *Am. J. Epidemiol.* **105**, 444.
Gardey, T., Burstyn, P. G. & Taylor, T. G. (1978). *Proc. Nutr. Soc.* **37**, 97A.
Kennedy, M., Burstyn, P. G. & Husbands, D. R. (1978). *Proc. Nutr. Soc.* **37**, 98A.

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Morphological changes in the retinas of rats fed semi-synthetic diets. By W. M. F. LEAT, *ARC Institute of Animal Physiology, Babraham, Cambridge CB2 4AT* and R. W. COX, *Institute of Ophthalmology, Judd Street, London WC1H 9QS*

The retinas of three rats remaining from an experiment investigating the role of essential fatty acids in growth and reproduction in the rat (Leat & Northrop, 1979) were examined by light and electron microscopy. The basal semi-synthetic diet low in essential fatty acids consisted of (g/kg) sucrose 670, casein 160, hydrogenated coconut oil 50, minerals 40, vitamins 10, methyl cellulose 70.

Rat 19 (control) was a second generation animal maintained on a commercial rat nut-diet. The retina was normal and consisted of the usual eleven layers, namely; pigment cells, outer segments of visual cells, inner segments of visual cells, outer limiting membrane, outer nuclear, outer plexiform, inner nuclear, inner plexiform, ganglion cells, nerve fibres and inner limiting membrane.

Rat 1 had been maintained on the basal diet from 3 weeks of age until 28 weeks of age and had then been dosed with methyl α linolenate (9.12.15 octadecatrienoic acid; 160 μl/d) for a further 46 weeks. The retina of this animal was similar to that of the control rat but displayed a relative decrease in the thickness of its outer nuclear layer.

Rat 14 was a second generation animal which had been fed on basal diet supplemented with methyl linoleate (9.12 octadecadienoic acid; 160 μl/d) from 3 weeks until 54 weeks of age. Its dam had also been maintained on the same dietary regime since 3 weeks of age. The retina of rat 14 showed an absence of the outer and inner segments of the visual cells, the outer limiting membrane, the outer nuclear layer and most, if not all, of the outer plexiform layer. This lesion could be classified as an atrophy of the outer layers of the retina and represented a complete loss of the photoreceptor cells. In addition there was a notable dilatation of the retinal vessels.

The absence of photoreceptor cells in the retina of rat 14 could be the result of either a toxic component of the diet or a deficiency of some essential component in the diet. Retinal lipids are known to be rich in docosahexaenoic acid (22:6 ω 3), a derivative of α linolenic acid (see Tinoco *et al.* 1979), and it is provisionally concluded that the retinal atrophy in rat 14 could be a consequence of a deficiency of linolenic acid.

Leat, W. M. F. & Northrop, C. A. (1979). *J. Physiol, Lond.* **290**, 37P.
Tinoco, J., Babcock, R., Hincenbergs, I., Medwadowski, B., Miljanich, P. & Williams, M. A. (1979). *Lipids* **14**, 166.

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A follow-up study of nutrition and anthropometry in pre-school children.

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We have previously reported (Morgan *et al.* 1976) on the food intake and anthropometry of a sample of children living in the south of England. Subsequently, on two occasions at 12 monthly intervals, these children were re-surveyed and similar information was collected. Table 1 describes the sample by age and socio-economic status (SES).

Survey	Mean age (months)	*n*	SES (response rate %) AB	C1	C2	DE
1	30	93	16 (94)	26 (84)	44 (71)	7 (70)
2	42	66	12 (75)	20 (77)	27 (61)	7 (100)
3	54	56	12 (100)	15 (75)	23 (85)	6 (86)

Weights and heights of the sample, when plotted on British standard growth charts (Tanner & Whitehouse, 1973) showed normal growth patterns over 3 years. Using a weight for height index (Poskitt & Cole, 1977), the percentage of children categorized as overweight was 14%, 18% and 12% at surveys 1, 2 and 3 respectively. Subscapular skinfolds were positively related to Poskitt's indices at all surveys ($P<0.05$) for both sexes. Tricep values revealed a similar trend, though at survey 2 this was not statistically significant.

7 d quantitative food intake was recorded on the sample when they were under 2 years of age. An examination of this information was made on children who were subsequently identified as overweight. Results showed that this population did not have excessively high intakes in their infancy of energy, protein or any other nutrient. Similarly, large eaters (+1 SD of group mean for energy) were identified in infancy and examination of anthropometric measurements from the follow-up surveys showed no tendency to overweight. Small eaters (−1 SD of group mean for energy) in infancy showed no subsequent tendency to be underweight.

The sample was predominantly bottle fed (85% wholly formula fed). 35% had received solids by 3 months of age. Yet, the follow-up surveys gave no indication that there was a high incidence of overweight or obesity in this group of children as may have been suggested from the infant feeding patterns adopted by the mothers.

Morgan, J. B., Mumford, P. M., Evans, E. & Wells, J. (1976). *Proc. Nutr. Soc.* **35**, 74A.
Poskitt, E. M. & Cole, T. J. (1977). *Br. Med. J.* **1**, 7.
Tanner, J. M. & Whitehouse, R. H. (1973). *Archs Dis. Childh.* **48**, 786.

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The rate of passage of ciliate protozoa from the ovine rumen. By G. S. COLEMAN, R. M. C. DAWSON and D. W. GRIME, *Biochemistry Department, ARC Institute of Animal Physiology, Babraham, Cambridge*

Comparison of the rates of disappearance from the rumen of ^{14}C-labelled rumen ciliates with that of a soluble marker (polyethylene glycol; PEG) has been used to determine if these protozoa are selectively retained in the rumen. The protozoa were labelled with ^{14}C-choline which is incorporated into phosphatidyl choline in cell membranes (Broad & Dawson, 1975), but which is not taken up by rumen bacteria, or with ^{14}C-glycine.

Washed mixed rumen ciliates (B-type population; Eadie, 1962) from 100 ml rumen contents, were incubated for; Expt A, 15 min with [Me-^{14}C]choline (50 μCi; 0·83 μmol) or Expt B, 18 h with [U-^{14}C]glycine (50 μCi; 5 μmol) and then harvested, rewashed twice and resuspended in 70 ml salt solution containing 12·5 g PEG. In Expt C the protozoa were labelled by incubation of the choline with crude rumen contents (150 ml) for 15 min before addition of 100 ml 12·5% (w/v) PEG. These preparations were introduced into the rumen via the cannula 1·5 h after feeding (800 g hay, 100 g oats) and at intervals the ratio of the radioactivity in a washed protozoal fraction to the concentration of PEG was measured. This was taken to be 1·0 in the first sample taken after 1·5 h. All experiments were made with one animal kept on a constant ration under constant conditions.

	Protozoa:PEG									
Time (h) . . .	1·5	2·0	3·0	4·5	6·0	7·0	8·0	11·0	23	30
Expt										
A	1·0	1·03	1·60	1·13		1·80		1·48	1·93	8·2
A	1·0		1·06	1·42		1·04	0·96	0·79	1·19	1·34
A	1.0		1·27	0·62	0·44		0·47	0·47	0·50	1·11
B	1·0	1·05		1·71	1·79		1·76		2·18	
C	1·0	0·97	0·99	0·73	1·25		1·33	1·87	2·9	3·2

The results show there was considerable variation between experiments in the rates at which protozoa leave the rumen especially during the first 6 h. However, protozoa:PEG tended to increase thereafter showing that the protozoa may be selectively retained. In one experiment (C) where this ratio was also measured in abomasal contents it was on average only 27% (in nine samples over 30 h) of that in rumen contents.

Broad, T. E. & Dawson, R. M. C. (1975). *Biochem. J.* **146**, 317.
Eadie, J. M. (1962). *J. gen. Microbiol.* **29**, 579.

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Insulin secreting ability in relation to fatness in cattle. By N. G. GREGORY, T. G TRUSCOTT and J. D. WOOD, *ARC Meat Research Institute, Bristol BS18 7DY*

In many mammalian species obesity is associated with a high insulin secreting ability, which is believed to be secondary to peripheral resistance to insulin (Stern *et al.* 1972). Low insulin secretion is associated with leanness, but it is not always attributable to enhanced sensitivity to insulin (Spergel *et al.* 1968; Gregory *et al.* 1977).

The relationship between the plasma insulin response to intravenous sodium tolbutamide (32 mg/kg$^{0.75}$) and body composition was examined in Hereford and Friesian cattle.

Plasma insulin concentrations were measured in five blood samples taken over 17 min after tolbutamide infusion in fifteen steers of each breed, at 12 and then 20 months of age. The cattle had been reared together on a pelleted ration (11·3 MJ ME/kg DM) fed *ad lib.* but were fasted for 27 h before the tolbutamide tests (fasting began after an 8 h pre-fast followed by a standard meal).

The insulin response to tolbutamide (area under insulin curve above basal) was greater ($P<0·05$) in the Friesians than the Herefords, and was greater ($P<0·01$) at 20 months than at 12 months (Table 1). At 20 months, the percentage of dissectible fat from the empty body (± SE) was greater ($P<0·05$) in the Herefords (30·5±0·6) than Friesians (27·6±1·0) and was estimated by regression analysis to be greater in the Herefords at 12 months (18·8% *v* 16·0%). The insulin response was not correlated with percentage body fat at 20 months within breed (pooled r −0·05). It is concluded that for cattle, high insulin secreting ability is associated with age-related fatness within animals, but not with differences in fatness between animals of the same age as has been shown in non-ruminants.

Table 1. *Area under insulin curve (min×μU per ml)*

	Hereford	Friesian	SED
12 month	471	723	111
20 month	619	855	111
SED	61	61	

Gregory, N. G., Lovell, R. D., Wood, J. D. & Lister, D. (1977). *J. agric. Sci., Camb.* **89**, 407.
Spergel, G., Bleicher, S. J. & Ertel, N. H. (1968). *New Engl. J. Med.* **278**, 803.
Stern, J., Johnson, P. R., Greenwood, M. R., Zucker, L. M. & Hirsch, J. (1972). *Proc. Soc. exp. Biol. Med.* **139**, 66.

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Renal lipogenesis and gluconeogenesis in streptozotocin-diabetic rats: effect of dietary sucrose. By S. S. KANG, S. NOIROT and J. YUDKIN, *Departments of Physiology and Nutrition, Queen Elizabeth College, Campden Hill Road, London W8*

The effects of sucrose and diabetes on liver metabolism is well documented. These experiments were designed to investigate whether similar changes occur in the kidney.

Forty male Wistar rats (170–180 g) were maintained on synthetic diets containing either sucrose or starch as the only source of carbohydrate. The rats were divided into four groups; two groups were rendered diabetic by the injection of streptozotocin (65 mg/kg body-weight) into the tail vein. After 24 to 29 d on the experimental diets rats were anaesthetized with nembutal (7·2 mg/100 g body-weight; intraperitonealy) and a portion of liver and the whole right kidney were excised and homogenized in ice-cold 0·14 M-KCl. Homogenates were centrifuged for 30 min at 15 000 rev./min in a refrigerated centrifuge. The activities of glucose-6-phosphate dehydrogenase (G6PDH), pyruvate kinase (PK), fructose-1-6-diphosphatase (FDP) and glucose-6-phosphatase (G6Pase) were estimated in the supernatant.

In the kidneys from non-diabetic rats, sucrose increased the activity of pyruvate kinase and of fructose-1-6-diphosphatase. The induction of diabetes resulted in an increase in the activities of glucose-6-phosphate dehydrogenase, pyruvate kinase, fructose-1-6-diphosphatase and glucose-6-phosphatase, indicating a stimulation of lipogenesis and gluconeogenesis. The influence of sucrose feeding on the diabetic kidney was to produce a further elevation of pyruvate kinase and glucose-6-phosphatase activities.

The changes in the kidney metabolism resulting from sucrose feeding were similar, in direction, to those produced by diabetes. The ingestion of sucrose by diabetic animals exacerbated the changes produced by diabetes alone.

Table 1. *Effect of carbohydrate source on enzyme activities in kidneys from normal and streptozotocin-diabetic rats*

(Values are means with their standard errors. No. of observations in parentheses)

	Normal				Diabetic				Analysis of variance	
	Starch		Sucrose		Starch		Sucrose			
Enzyme (Units/100g body-wt)	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Diet	Diabetes
G6PDH	1·25	0·11 (8)	1·55	0·16 (9)	2·50	0·20 (11)	3·27	0·35 (9)	NS	$P<0·001$
PK	11·2	0·4 (8)	14·8	1·2* (9)	26·5	1·8 (11)	39·7	3·9** (9)	$P<0·001$	$P<0·001$
FDP	3·91	0·33 (8)	5·08	0·4* (9)	8·57	0·88 (11)	10·14	1·10 (9)	NS	$P<0·001$
G6Pase	0·10	0·01 (7)	0·14	0·02 (8)	0·29	0·03 (9)	0·55	0·1** (8)	$P<0·001$	$P<0·001$

NS, not significant
*$P<0·05$, **$P<0·001$. (Student's t test).

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Extraction of collagenase of possible leucocyte origin from ulcerating corneas of vitamin A deficient rats. By M. CHRISTINE LEONARD and L. K. MADDISON (Introduced by ANTOINETTE PIRIE), *Nuffield Laboratory of Ophthalmology, Walton Street, Oxford OX2 6AW*

In severe vitamin A deficiency associated with malnutrition, perforation of the cornea can occur leading to loss of sight. Histological evidence shows that perforation is preceded by infiltration of leucocytes into the corneal stroma (Wolbach & Howe, 1925; Kuming & Politzer, 1967) of which the major structural component is collagen. Pirie *et al.* (1975) suggested that these infiltrating cells could be the source of collagenolytic enzymes. We have investigated this hypothesis in a rat model.

Human leucocyte collagenase in contrast to the tissue collagenases, is distinctive in that it can be extracted directly without the need for tissue culture (Lazarus *et al.* 1968). We have extracted rat leucocytes with 50 mM-tris-HCl (pH 7·6) containing 5 mM-$CaCl_2$, 0·1% triton X-100 and 0·02% azide, and examined the ability of the extract to digest soluble rabbit-skin collagen. The products of digestion were analysed by SDS–polyacrylamide gel electrophoresis. Two collagenolytic activities were found; one was a typical, mammalian collagenase capable of producing $\frac{3}{4}$, $\frac{1}{4}$ fragments of collagen, and the other was an enzyme which converted γ and β chains to α chains i.e. it attacked the telopeptide region of the tropocollagen molecule. The collagenase was inhibited by metal chelators such as EDTA (5 mM) and 1,10 phenanthroline (2 mM). It was unaffected by serine proteinase inhibitors, including $AC(ala)_2$ pro ala chloromethyl ketone (0·1 mM), a specific elastase inhibitor, which did, however, inhibit the second enzyme. This second enzyme was confirmed as elastase by its ability to solubilize insoluble [3H] elastin.

Corneas from vitamin A deficient rats were then assayed for collagenase. The existing literature on corneal collagenase comes from tissue culture experiments. We found it was possible to extract collagenase directly from the ulcerating corneas of vitamin A deficient rats using 50 mM-tris-HCl buffer (pH 7·6) containing 5 mM-$CaCl_2$, 1 M-NaCl, 0·1% triton X-100, 0·2% azide, 200 U/ml penicillin and 200 μg/ml streptomycin, thus supporting the hypothesis that the collagenase is derived from a leucocyte source. No collagenase could be extracted from non-ulcerating corneas or from normal corneas. The collagenase extracted from the ulcerating corneas was in a latent form. It could be activated by treatment either with 0·67 mM-amino-phenyl mercuric acetate or with 3 M-NaSCN. We consider that this latent form is complexed with inhibitor and is an artefact of extraction and that in vivo it is in an active state. Other tissue collagenases, e.g. from uterus (Woessner, 1979), have also been extracted largely in latent form and require activation.

Kuming, B. A. & Politzer, W. M. (1967). *Br. J. Ophthal.* **57**, 649.
Lazarus, G. S., Daniels, J. R., Brown, R. S., Bladon, H. A. & Fullmor, H. M. (1968). *J. clin. Invest.* **47**, 2622.
Pirie, A., Werb, Z. & Burleigh, M. (1975). *Br. J. Nutr.* **34**, 297.
Woessner, J. F. (1979). *Biochem. J.* **180**, 95.
Wolbach, S. B. & Howe, P. R. (1925). *J. exp. Med.* **42**, 753.

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Zinc and dietary fibre: observations on a group of vegetarian adolescents.

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It has been questioned whether an increased intake of dietary fibre may interfere with zinc absorption (Reinhold *et al.* 1976). In this work the Zn nutritional status of subjects with relatively high intakes of dietary fibre (vegetarians) was compared with that of subjects on lower intakes (omnivores) by using hair content of Zn as an index.

Seventeen volunteers, all lacto-ovo vegetarian adolescents, were pair-matched with seventeen omnivores by age, sex and hair type. The volunteers completed a detailed, weighed food-intake record for 3 d, answered a questionnaire about food habits and provided a hair sample for analysis of Zn content by atomic absorption spectrophotometry. Hair samples were dry-ashed in a muffle furnace overnight at 500° and dissolved in 0·01 M-hydrochloric acid.

	Vegetarians	Omnivores
Zinc intakes (mg/d)		
Median	9·2	6·5
In relation to total wt of food	0·5	0·3
Hair zinc (μg/d)		
Median	217	248
Range	138–278	188–330
Fibre intake (g/d)		
Median	29	16
Range	22–57	5–23

Results of hair analysis revealed that vegetarians had lower levels of Zn in their hair than had the omnivores. These differences were significant ($P<0·01$) and were not attributable to lower dietary intakes in the vegetarians. Several variables were investigated across the whole sample as possible factors responsible for hair Zn differences. Genetic factors were considered but the similarity found in the hair Zn levels of siblings could equally be attributed to similarities of diet. No connexion was revealed between hair Zn and growth, puberty, sex difference or hair colour. Dietary variables were then considered. Calculated Zn intake correlated in linear fashion with total weight of food; mean Zn intake was greater in the vegetarians than in the omnivores.

Calculated dietary fibre intakes were compared across the two groups and correlated with hair Zn levels. Tau correlation coefficients revealed a significant positive correlation between hair Zn and fibre intake in the omnivores ($\tau<0·58$, $P<0·05$). No correlation was revealed by statistical methods in the case of the vegetarians, but the evidence of the results pointed to a slight inverse correlation between hair Zn and fibre intakes. It was suggested that this inverse relationship could indicate a manifestation of the chelation effect by dietary fibre, and possibly by phytic acid, on Zn in the vegetarians.

Reinhold, J. G., Faradji, B., Abadi, P. & Ismail-Beigi, F. (1976). In *Trace Elements and Human Disease*, [A. S. Prasad, editor]. New York: Adademic Press.

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Bioavailability to man of carbohydrate in foods. By D. J. A. JENKINS[1], T. M. S. WOLEVER[2], R. H. TAYLOR[3], HELEN M. BARKER[3], HASHMEIN FIELDEN[3], JANET M. BALDWIN[3], HILARY C. NEWMAN[2], A. C. BOWLING[2] and D. V. GOFF[2], [1]*Department of the Regius Professor of Medicine, Radcliffe Infirmary, Oxford,* [2]*University Department of Physiology, Oxford* and [3]*Department of Gastroenterology, Central Middlesex Hospital, London NW*10

Practical interest in dietary fibre has been greatly stimulated by the publication of revised food tables with values for dietary fibre (Paul & Southgate, 1978). In addition evidence is accumulating to suggest that changing both the fibre content (Jenkins *et al.* 1977) and the nature of the available carbohydrate (Jenkins *et al.* 1978) in the diet may be beneficial in diabetes. Most results have been based on specially-prepared test meals.

In this study we have tested the effect of eating standard carbohydrate portions of commonly eaten foods on the post-prandial blood glucose increase. Differences in the pattern of increase for different foods were compared with the amount and type of fibre present and the form of the carbohydrate in the food. From these results 'glycaemic indices' have been calculated to compose a new form of carbohydrate food table based on bioavailability.

Groups of four–six health volunteers took 50 g carbohydrate portions of over forty foods as single meals on separate mornings after an overnight fast. Meals were made up to 600 ml and eaten over a standard 10 or 15 minute period. Capillary blood samples for glucose analysis were taken at 0, 15, 30, 45, 60, 90 and 120 min from the start of the meal. Foods tested included cereal products (white and wholemeal bread, Ryvita crispbread, white and brown rice, white and wholemeal pasta), breakfast cereals (cornflakes, Shredded Wheat, Weetabix, All-Bran and muesli), biscuits (sweet wheatmeal, oatmeal, plain and water biscuits), leguminous seeds, fruit, vegetables and confectionery. After every five–six tests subjects took a 50 g glucose tolerance test for comparison as a standard.

There were marked differences in the effects of different foods on the post-prandial glycaemia. Comparing the areas under the 2 h blood glucose curve, cereal products, fruit and vegetables were 80–100% of that for glucose, biscuits and breakfast cereals 50–70%, while leguminous seeds raised the blood glucose to only 30–50%. No relationship to total fibre content was seen and an apparent relationship with protein content could not be reproduced by adding extra protein to test meals.

These results suggest that the nature of the fibre and starch content of legumes warrants further investigation and that such 'low glycaemic index' foods should be included in diets where otherwise carbohydrate may need to be restricted.

Jenkins, D. J. A., Wolever, T. M. S., Hockaday, T. D. R., Leeds, A. R., Howarth, R., Bacon, S., Apling, E. C. & Dilawari, J. (1977). *Lancet* ii, 779.

Jenkins, D. J. A., Wolever, T. M. S., Nineham, R., Taylor, R. H., Metz, G. L., Bacon, S. & Hockaday, T. D. R. (1978). *Br. med. J.* **2**, 1744.

Paul, A. A. & Southgate, D. A. T. (1978). *McCance and Widdowson's The Composition of Foods.* London: HM Stationery Office.

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Nitrogen balance and postoperative recovery. By S. SAGAR and R. SHIELDS, *Department of Surgery, Royal Liverpool Hospital*

After surgery, attempts have been made to reduce the negative nitrogen balance by early intravenous and oral feeding. A positive balance is said to be necessary to provide anabolic substrate for tissue repair. However, the relationship between patient recovery and N balance has not been shown. Detailed metabolic studies were carried out in seventy-four patients after major abdominal surgery and several measurements of protein turnover such as total protein, serum albumin, creatinine and potassium, urinary urea, creatinine and N were monitored daily during the first postoperative week. The patients were randomly allocated into two groups; a control group, who were managed conventionally during this period, and an elemental diet group (ED), who were fed naso-enterically from the first postoperative day, in an attempt to achieve a positive N balance.

In patients in the control group, a conventional nasogastric tube was used for aspiration only. They were given 1 l saline (9 g sodium chloride/l) and 2 l dextrose (5%) intravenously, and allowed nothing by mouth for the first 2 d. On the third postoperative day they were given 30 ml water orally if there were no contraindications. Thereafter, oral intake was gradually increased until the patient was able to take as much fluid as desired by the fifth day. Intravenous fluids were stopped on the fifth postoperative day, and a light diet introduced on the sixth and seventh days.

Total N deficit was greater in those patients managed conventionally than in the ED group. The N output was significantly greater in the control group than in the ED group on the first four postoperative days ($P<0.05$, $P<0.001$ and $P<0.01$ respectively). Regression lines for the N balance were parallel with a vertical displacement of 6·2 g of N and a horizontal displacement of 4 d. This 4 d difference is also seen in the mean postoperative hospital stay which is a good index of patient recovery. It is therefore concluded that there is a positive correlation between patient recovery and a positive N balance. Several clinical and metabolic aspects of this study will be discussed.

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The effect of anxiety on metabolic rate. By SANDRA E. BLAZA and J. S. GARROW, *Clinical Research Centre, Watford Road, Harrow*

Corey (1948) and Udalov & Sibunev (1964) observed increased oxygen consumption, in pilots under certain conditions, which they attributed to stress. Landis (1925) measured oxygen consumption whilst attempting to induce anxiety in three subjects, but the results were inconclusive.

The direct calorimeter at the CRC has an accuracy of 0·5% and a within subject reproducibility of less than 2·6% (on runs of a few hours duration where activity is severely restricted). Three subjects participated in this trial (see Table 1). SS was measured the day before an oral examination, feeling extremely apprehensive and on two later occasions and JG and SB had anxiety induced for 1 h, in the middle of a calorimetry run, by a combination of mental arithmetic and mild electric shocks. Heat losses, deep body temperature, heart rate and activity were measured on all occasions and JG and SB also had urine analysed for free cortisol and catecholamines.

Subject	Mode	No. of runs	Heat loss (± SEM; watts)	Increase in heat loss (%)	Mean temperature change (°)	Heart Rate (± SEM; beats/min)	Increase in heart rate (%)
SS (♀)	Stress	1	132·5	16·2	+0·5	94·6	19·9
	Control	2	114·0±1·5		+0·15	78·9±0·5	
JG (♂)	Stress	3	110·0±1·1	3·5	+0·4	77·4±0·8	2·2
	Control	1	106·4		+0·3	75·7	
SB (♀)	Stress	1	98·1	4·3	0·0	68·8	9·6
	Control	1	94·1		−0·4	62·8	

Table 1 shows the consistent increase observed in heat loss and heart rate. The changes in heat loss reflect differences in metabolic rate rather than heat balance, as can be seen from the temperature measurements. Large increases in urinary cortisol and catecholamines were also seen. The effect of anxiety on metabolic rate is therefore a real effect, which should be considered in energy balance studies.

The authors are grateful to J. F. Parker for the catecholamine results and to Rachel Bourne for the JSG cortisol assays.

SB is an MRC scholar.

Corey, E. L. (1948). *J. appl. Physiol.* **1**, 35.
Landis, C. (1925). *Am. J. Physiol.* **74**, 188.
Udalov, E. F. & Sibunev, A. G. (1964). *Nutr. Abstr. Rev.* **34**, 524.

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Fasting heat production and maintenance requirement of early-weaned pigs. By K. J. McCRACKEN, *Agricultural and Food Chemistry Research Division, Department of Agriculture and The Queen's University of Belfast, Newforge Lane, Belfast BT9 5PX, Northern Ireland*

During the immediate post-weaning period the young pig undergoes a period of sub-maintenance nutrition before it becomes adapted to the new diet. It is well known that in adult animals and humans sub-maintenance intakes reduce the basal metabolic rate (Benedict, 1938; Marston, 1948; Westerterp, 1977) and recent results (Gray & McCracken, 1979) suggest that even a reduction of energy intake to 70% of appetite causes a marked decline in the maintenance requirement of young pigs. In view of the significance of alterations in the maintenance requirement during the post-weaning phase to the interpretation of studies on the growth and energy retention of early-weaned pigs a series of experiments has been conducted with pigs weaned at 10 and 17 d of age.

Immediately post-weaning at 10 d groups of six litter-mate Large White× Landrace pigs were transferred to a metabolism cage in an open-circuit respiration chamber at a temperature of 29°. They received no food for the first 48 h. On days 3 to 7 post-weaning they were offered 60, 90, 120, 150, 180 g pelleted diet respectively (McCracken & Caldwell, 1980) of metabolizable energy (ME) content 17·2 MJ/kg. On days 8 and 9 they were fed to appetite or received no food. Daily heat production was measured for the 9 d period with each group. In addition the fasting heat production of pigs weaned at 17 d was determined. *Combined* collections of excreta and waste feed were analysed to estimate ME intake and nitrogen retention.

Fasting heat production (FHP; kJ/kg $W^{0.75}$) values immediately post-weaning at 11 and 18 d were respectively 531 and 495 and were not significantly different. The corresponding values for basal metabolic rate (BMR) were 448 and 429.

The mean FHP at 11 d of four litters weaned at 10 d and subsequently fed from day 3 was 545 but heat production declined to 506 on day 4 post-weaning and only returned to 540 by day 7. FHP measured at 18 d-of-age, after the period of undernutrition, was 462 and was significantly lower ($P<0.01$) than the 11 d value. The corresponding BMR values at 11 and 18 d were 444 and 367 and were significantly different ($P<0.01$).

From the heat production results on days 4 and 5 the ME requirement for zero energy balance (maintenance; M) was estimated as 510 for the undernourished pigs. Hence the value for FHP:M was 0·89. Applying this factor to the FHP results for the pigs immediately post-weaning gives a mean value for M of 576.

Benedict, F. G. (1938). *Vital energetics.* Publ. no. 503. Washington: Carnegie Institutes.
Gray, R. & McCracken, K. J. (1979). *Publs Eur. Ass. Anim. Prod.* (In the Press).
McCracken, K. J. & Caldwell, B. J. (1980). *Br. J. Nutr.* (In the Press).
Marston, H. R. (1948). *Aust. J. scient. Res.* **31**, 93.
Westerterp, K. (1977). *Physiol. Zool.* **50**, 331.

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Possible palliative role of cortisol treatment in protein-deficient pregnant rats. By M. DE LA HIGUERA, ISABEL GOÑI and G. VARELA, *Departamento de Fisiologia Animal, Facultad de Farmacia, Madrid-3, Spain*

Protein deficiency during pregnancy frequently produces congenital disorders, intrauterine death, low birth weight, etc. In a similar way, glucocorticoids have been reported to produce a growth delay in mammals apart from other congenital consequences. Assuming that pregnancy and protein deficiency increase cortisol levels in blood, we have tried to enhance that physiological response by exogenous administration of cortisol in therapeutic doses (0·5 mg/100 g body-weight per d; subcutaneously) to Wistar rats (150 g) fed on a 4% protein diet (casein + 5% DL-methionine) during pregnancy. Controls were given sham injections of saline (9 g sodium chloride /l). Animals were adapted to the experimental diet 2 weeks before mating.

	Control		Treated		Student's
	Mean	SE	Mean	SE	*t* test
Food intake (g DM/rat per d)	12·62	0·81	12·88	0·82	NS
Gastrocnemius wt (g)	0·83	0·05	0·61	0·05	$P<0·01$
Gastrocnemius:body-wt (x1000)	5·78	0·17	4·76	0·17	$P<0·001$
Gastrocnemius total nitrogen (mg)	29·74	0·86	26·62	0·34	$P<0·005$
No. of pups	7·85	0·59	8·00	0·85	NS
Pup wt (g)	4·05	0·28	4·62	0·34	$P<0·001$
Pup total nitrogen (mg)	54·57	5·61	66·09	6·15	$P<0·001$
mg nitrogen:g pup wt (DM)	104·51	4·99	114·34	4·83	$P<0·001$

NS, not significant.

Results show that cortisol administration, at the forementioned dose, favours foetal protein anabolism by acting on maternal peripheral tissues, causing mainly muscle catabolism. The increase in amino acid availabilities for foetal growth may be one of the main causes of the result obtained. It is also important to consider that neither urinary nitrogen nor balance of N were altered by cortisol administration in the same circumstances (Goñi *et al.* 1978) when determined during pregnancy at 2 d intervals. Consequently a net transfer of amino acids from mother to foetus took place without any losses of N through urine compared to controls.

The result is, at least in terms of protein deficiency, an attempt to meet amino acid requirements for optimal foetal growth. Furthermore, although mothers suffered the consequences of the treatment the better foetal growth and amino acid availability could help to alleviate or even palliate some of the congenital disorders which follow gestational malnutrition, while mothers could recover their metabolic homoeostasis, aspects to which future work should be directed.

Goñi, I., de la Higuera, M., Mataix, R. J. & Varela, G. (1978). p. 121 XVII Congreso National de la SECF, Badajoz.

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Variation in probable feed intake of ewes given concentrates with varying trough-space allowance or self-help feedblocks. By P. T. KENDALL, R. G. HEMINGWAY and M. J. DUCKER, *Animal Husbandry Department, Glasgow University Veterinary School, Bearsden, Glasgow G61 1QH*

Foot & Russel (1973) showed that the coefficient of variation (CV%) of individual intake of concentrates by ewes fed in groups from troughs was about 50% at a mean intake of about 100 g/head per d declining to about 13% at about 453 g/head per d intake. Two experiments were conducted during pregnancy with Greyface ewes trained to eat concentrates and self-help feedblocks. Initially the grazing (4 ha) was good. Afterwards, hay was given.

In Expt 1 chromic oxide-containing concentrates were given for 8 d periods at either 84, 252 or 504 g DM/head per d with trough-space (both sides) either 530 (generous), 400 (adequate) or 300 (restricted) mm/head. Faecal samples (for Cr determination) were taken on the last day of each period. The CV% increased with restriction of trough-space particularly at the 84 g/d intake and decreased with higher levels of feed intake.

Concentrate per DM g/head per d	Trough-space (mm)			Mean CV
	540	400	330	
84	45·9	57·8	73·6	59·1
252	36·7	37·2	42·9	38·9
504	26·8	37·9	34·3	33·0

In Expt 2 seven Cr-containing feedblocks made by four different processes were given for 12 d periods in sequence. The mean daily intakes (g) and CV% for the Cr of the faeces were: Rumevite Standard, 69 and 61·1; Rumevite High Energy, 102 and 53·7; BOCM Silcock W291 (Type 1), 304 and 63·2; BOCM Silcock W290 (Type 1), 407 and 53·0; BOCM Silcock W290 (Type 2), 457 and 54·4; Colborn Sheep Energy, 462 and 34·8. In all cases (except for the last feedblock which was the softest) the intake variation was greater than when the same sheep were given concentrates in troughs (unless trough-space was restricted).

Subsequently, Cr-containing cobs (approximately 40×40×17 mm, individual weight about 25 g) were given on the ground at 840 and 960 g DM/head per d. The CV% for faecal Cr contents were 29·5 and 27·1, indicating a more uniform consumption.

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Foot, J. Z. & Russel, A. J. F. (1973). *Anim. Prod.* **16**, 293.

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Physiological effects of marginal riboflavin deficiency in young adults and geriatrics: a reduction in the in vivo survival time of erythrocytes. By HILARY J. POWERS and D. I. THURNHAM, *Department of Human Nutrition, London School of Hygiene and Tropical Medicine, London WC1E 7HT*

Erythrocytes were separated into fractions of different mean ages on a density gradient of Ficoll/Triosil. The haemoglobin (Hb) content of the human erythrocyte remains constant as the cell ages (Murphy, 1973) and therefore the Hb distribution through the gradient is considered to reflect the relative proportions of erythrocytes of different ages in a sample of blood.

The Table shows a reduction in the proportion of old (denser) cells and an increase in the proportion of young cells in subjects with marginal riboflavin deficiency (EGR-AC$\geqslant$1·30) when compared with normal subjects. This effect was more clearly seen among the elderly (65 years or older). Elderly subjects with normal riboflavin status showed an increase in the proportion of old cells when compared with young subjects; this may have contributed to the apparently greater effect of marginal riboflavin deficiencies in the elderly than in the young.

(Mean values with their standard errors of the mean)

Density of erythrocyte fraction (Increasing density 1→9)			1	2	3	4	5	6	7	8	9
Subjects		EGR-AC	Haemoglobin (%)								
Young (4)		$\geqslant$ 1·30	5±1	23±8	29±5	15±1	10±2	9±2	6±3	2±0	3±1
Young (11)		< 1·30	3±1	15±4	31±8	17±5	11±3	8±2	8±2	3±1	4±1
	P<		NS	NS	NS	NS	NS	NS	NS	0·01	0·05
Elderly (7)		< 1·30	4±1	13±4	27±4	13±2	11±2	11±1	9±3	7±1	7±2
	P<		NS	NS	NS	NS	0·02	NS	0·05	0·01	0·05
Elderly (5)		$\geqslant$ 1·30	14±6	24±4	35±7	13±2	4±1	6±3	3±2	2±1	2±1

NS, not significant.

The results suggest that erythrocyte life span may be decreased in marginal riboflavin deficiency and it is possible that this is due to a reduction in structural integrity caused by lowered erythrocyte concentrations of reduced glutathione (GSH) and reduced glutathione reductase (GR) activity (Powers, 1979). GR activity declines with increasing age of erythrocytes and was consistently lower in all fractions of erythrocytes from riboflavin-deficient subjects when compared with the appropriate fraction from 'normal' subjects (Powers & Thurnham, 1976). Glutathione peroxidase ($GSHP_x$) may be the link between the riboflavin deficiency and reduced erythrocyte integrity since $GSHP_x$ requires GSH for its function in removing lipid peroxides from cell structures.

Murphy, J. R. (1973). *J. Lab. clin. Med.* **82**, 334.
Powers, H. J. (1979). PhD Thesis London University.
Powers, H. J. & Thurnham, D. I. (1976). *Nutr. Metab.* **21**, (Suppl. 1), 155.

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Infant feeding: mothers' antenatal attitudes and subsequent practices.

By HELEN MACCAIG, *Department of Home Economics, City of Manchester College,* and J. L. SMART, *Department of Child Health, The Medical School, Oxford Road, Manchester M13 9PT.*

The present study is a replication of part of that of Martin (1978) with the important difference that information on mothers' attitudes was collected antenatally here and not postnatally. Ninety-four primiparous mothers were interviewed during the last 4 months of pregnancy in the antenatal clinic of St. Mary's Hospital, Manchester. They were asked to comment as follows on twenty-six statements about infant feeding; agree strongly, agree, indifferent, disagree, disagree strongly. They were also asked whether they would be embarrassed to breast feed in front of their husband, mother, a girlfriend in their own home, a girlfriend in her home, a girlfriend's husband. Questionnaires were sent to mothers at 6 weeks post partum, enquiring about the method(s) of infant feeding employed. There were seventy replies.

The relationship between intended method of feeding and embarrassment scores was similar to that reported by Martin (1978). 29% of mothers who planned to bottle feed said they would be embarrassed in all the situations, compared with none of the intending breast feeders. Furthermore, none of those who planned bottle feeding said they would not be embarrassed in any situation, compared with 26% of intending breast feeders.

The attitude scores were subjected to a principal factor analysis using Varimax rotation. A two factor solution was most meaningful and revealed factors which we designated (1), distaste for breast feeding and (2) breast feeding is best for babies and mothers. Factor 1 was very much more important than factor 2, accounting for 26% of the total variance compared with 8%. Factor scores were calculated from the attitude scores for each mother. Associations were sought between these antenatal scores and how mothers fed their babies up to 6 weeks postnatally. Mothers who were still breast feeding had displayed markedly different attitudes antenatally from those who never breast fed, on both factors ($P<0.001$). They had shown partiality for the idea of breast feeding (factor 1) and had concurred that breast feeding is best for babies and mothers (factor 2); whereas bottle feeders had shown distaste for breast feeding and had not thought that breast feeding is best. The group who changed from breast to bottle feeding had scored intermediately between the other groups on both factors. Hence, ascertaining attitude scores antenatally may provide a way of identifying mothers who are likely to discontinue breast feeding early.

Martin, J. (1978). *Infant Feeding 1975: Attitudes and Practice in England and Wales.* London: HM Stationery Office.

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Protein synthesis and breakdown in muscle and kidney of diabetic and insulin treated rats. By E. C. ALBERTSE, V. M. PAIN and P. J. GARLICK, *Department of Human Nutrition, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT*

We have demonstrated previously that streptozotocin diabetes in the rat results in a decrease in protein synthesis in the whole body (Albertse *et al.* 1979) and in gastrocnemius muscle and heart (Pain & Garlick, 1974).

In this study we induced diabetes in rats with streptozotocin and then treated them with insulin. We measured tissue protein turnover in one group in which insulin was continued (controls; day 0 and day 3) and in another in which it was withdrawn for 1, 2, or 4 d (diabetic). Protein synthesis rates were determined by the method of McNurlan *et al.* (1979), using [^{3}H]phenylalanine. By determining the mean rate of change in protein mass during the periods immediately before and after each measurement of synthesis (k_s), protein breakdown (k_d) could be estimated as the difference between rates of synthesis and growth.

The results in the Table show that protein synthesis in gastrocnemius muscle, diaphragm and heart was significantly reduced with insulin withdrawal. The gastrocnemius muscle demonstrated the most rapid and pronounced decline at 4 d of diabetes. In all three muscles breakdown rates increased progressively. This response was observed in the gastrocnemius after 1 d of insulin withdrawal and in the heart and diaphragm only after 2 d. These results contrast with previous reports that diabetes resulted in large decreases in both synthesis and breakdown in skeletal muscle (Millward *et al.* 1976).

Hypertrophy of the kidney in severe diabetes was reflected by increases in total protein mass. No significant change could be detected in kidney protein synthesis, but a transient decrease in breakdown was apparent at one day of insulin withdrawal. Thereafter breakdown rates were similar to those of insulin treated controls.

Protein synthesis (k_s) *and breakdown* (k_d) *in control and diabetic rats*

	Change in protein (%/d)	Control				Diabetic					
		Day 0		Day 3		Day 1		Day 2		Day 4	
		Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Gastrocnemius	k_s	18·6	1·1	16·8	1·7	16·2	0·5	9·8	1·1	5·9	1·3
	k_d	3·8		10·1		9·5		12·7		15·0	
Diaphragm	k_s	19·1	1·2	15·4	1·2	17·8	0·8	11·8	0·4	8·6	0·9
	k_d	3·5		8·5		3·7		9·0		14·2	
Heart	k_s	20·9	1·0	20·4	1·1	21·2	0·7	15·7	0·9	12·0	0·7
	k_d	8·0		11·8		7·1		10·6		18·1	
Kidney	k_s	46·7	1·2	42·0	0·4	41·3	1·1	43·1	0·7	39·2	1·8
	k_d	34·6		36·5		22·4		34·8		37·7	

Albertse, E. C., Garlick, P. J., Pain, V. M., Reeds, P. J., Watkins, P. J. & Waterlow, J. C. (1979). *Proc. Nutr. Soc.* (In the Press).
McNurlan, M. A., Tomkins, A. M. & Garlick, P. J. (1979). *Biochem. J.* **178**, 373.
Millward, D. J., Garlick, P. J., Nnanyelugo, D. O. & Waterlow, J. C. (1976). *Biochem. J.* **156**, 185.
Pain, V. M. & Garlick, P. J. (1974). *J. biol. chem.* **249**, 4510.

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Intra-strain differences in the response to overfeeding in the rat. By NANCY J. ROTHWELL* and M. J. STOCK*, *Department of Physiology, Queen Elizabeth College, University of London, London W8 7AH*

Inter-strain differences in the efficiency of energy utilization and propensity to obesity have often been noted in rats and other animals but variations within strains are much less obvious. However, we have found that these differences can be accentuated by inducing the animals to over-eat. Adult, male Sprague-Dawley rats of the same age (75 d) and approximately the same weight were obtained from two suppliers (Tuck, Essex and Charles River, Kent) and maintained for 8 d on either a conventional stock diet (PRD, Christopher Hill Group Ltd) or a cafeteria system of feeding using a wide variety of highly palatable foods (Rothwell & Stock, 1979). Measurements of energy balance were carried out as described previously (Rothwell & Stock, 1979). Although both cafeteria groups over-ate by 80–90%, 'Tuck' rats gained 2·2 times more weight than their controls whilst Charles River (CR) rats gained only 1·5 times more weight than their controls. In terms of metabolic efficiency (g gained /MJ eaten) the 'Tuck' cafeteria rats were slightly more efficient (12%) than their stock fed controls whereas CR cafeteria rats showed a significant depression (−17%, $P<0·001$). Mean daily energy expenditure was increased in both groups of cafeteria rats (% increase above controls; Tuck 55, Charles River 78) but was significantly greater in CR cafeteria rats (390 kJ/d) than Tuck rats (340 kJ/d, $P<0·01$). Accompanying these changes was an 81% increase in interscapular brown adipose tissue (IBAT) of CR cafeteria rats but only a 41% increase in the 'Tuck' rats which could provide further support for the suggestion (Rothwell & Stock, 1979) that BAT is an effector of dietary-induced thermogenesis.

The influence of subtle differences in genotype or the early environment or both on the propensity to obesity and capacity for DIT seen in this overfeeding study is similar to that seen between different individuals in the human population where variations in thermogenesis originating in BAT have also been implicated (Jung *et al.* 1979; Rothwell & Stock, 1979).

Jung, R. J., Shetty, P. S., James, W. P. T., Barrard, M. & Callingham, B. A. (1979). *Nature* **279**, 322.
Rothwell, N. J. & Stock, M. J. (1979). *Nature* **281**, 31.

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Fat transplantation into nude mice as a model for studying species differences in fat cell metabolism. By MARGARET ASHWELL and C. J. MEADE*, *Clinical Research Centre, Watford Road, Harrow, Middlesex HA1 3UJ*

Nude mice (*nu/nu*) can accept xenogeneic grafts. We have therefore used both lean and obese nude mice as recipients for small pieces of human adipose tissue transplanted for 1 month under the kidney capsule as described previously (Ashwell *et al.* 1977).

Human subcutaneous fat was obtained from ten different donors (two female and eight male) either undergoing elective abdominal surgery or agreeing to a needle fat biopsy. Their ages ranged from 1 year to 81 years and the mean size of their fat cells ranged from 0·17 μg to 0·56 μg. Small pieces of donor fat were transplanted under the left kidney capsule of lean nude mice, aged 6 to 10 weeks. The average gonadal fat cell weight of host mice was 0·06 μg (SD±0·03 μg). In two experiments, gonadal fat from CBA mice (average fat cell weight = 0·05 μg) was also transplanted under the right kidney capsule as a control. In all, ninety-seven lean mice were transplanted. When the grafts were removed after one month from the forty-five surviving mice, comparison of human fat grafts with original human donor fat showed no significant change in average fat cell weight during the transplantation period. Neither was there any significant change in the cell size of grafted mouse fat.

Human fat (from two different donors with fat cells weights of 0·17 μg and 0·34 μg) was also transplanted into sixteen obese nude mice, of which seven survived (mean fat cell weight = 0·41 μg (SD±0·12 μg). Mouse fat (mean cell weight = 0·05 μg) was transplanted under the contralateral kidney capsule. Comparison of fat cell size of the grafts of the surviving obese mice showed that human, as well as mouse, fat cells increased in weight (average increase in weight of human cells = 0·19 μg) ($P<0·001$).

Transplantation of human fat into lean nude mice has not only confirmed a previous observation (Bach-Mortensen *et al.* 1976) that human fat cells can survive in nude mice but has also suggested that they may be insensitive to the fat mobilizing effects of mouse lipolytic hormones. This indicates possible hormone receptor species differences or species differences in receptor sensitivity to hormone concentration. However, transplantation of human fat into obese nude mice suggests that at least some of the hormones controlling fat storage are not species specific since human fat cells can increase in size when the host mouse cells are larger than the human donor cells.

Fat transplantation into nude mice could provide a model for studying species differences in fat cell metabolism.

This investigation had the approval of the Northwick Park Hospital Ethical Committee.

Ashwell, M., Meade, C. J., Medawar, P. & Sowter, C. (1977). *Proc. R. Soc. B.* **195**, 343.
Bach-Mortensen, N., Romert, P. & Ballegaard, S. (1976). *Acta path. microbiol. scand.* Section C. **84**, 283.

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Exercise and wheat bran: effect on whole-gut transit. By R. J. HARRISON, A. R. LEEDS, N. R. BOLSTER and P. A. JUDD, *Department of Nutrition, Queen Elizabeth College, London W8 7AH* and *Department of Gastroenterology, Central Middlesex Hospital, London NW10 7NS*

It has been shown that individuals fed controlled diets show wide variations of their whole-gut transit times. Exercise may be responsible for some of this variability.

In this study eleven subjects (five men and six women, 21–31 years) undertook their usual exercise and ate their usual diets for two weeks. Four subjects then began to supplement their diets with 30 g wheat bran daily: this continued for 1 month. At the same time seven subjects commenced a month long programme of additional exercise. Two weeks later four of the latter subjects began taking 30 g bran daily, and the four subjects already taking bran commenced additional exercise. The exercise consisted of jogging, either on a treadmill or around a park, for 25 to 45 min depending on individual capability. Mean transit time (MTT) was estimated by giving one dose of 20 radio-opaque plastic pellets on Monday and one of different shaped pellets on Tuesday of each week and recording their appearance in the stools by X-radiography. For each single dose of markers the transit times of the first fifteen to be passed were used to calculate a single dose MTT (MTT-s 75%). Daily records of intake of cereal fibre-containing foods were kept by all subjects. The results from the two studies in each week were used to obtain an average value for each two week period.

Changes in MTT which accompanied an increase in exercise did not differ between those taking extra wheat bran and those taking their usual diets. However, the three subjects having the highest initial MTT-s (75%) values (>65 h) showed a fall in mean MTT when they increased their exercise (74 h to 49 h) whilst the eight subjects who had initial MTT-s (75%) values less than 45 h showed an increase (34 h to 44 h). The three subjects with slow initial transit time had a lower mean daily cereal fibre intake than the others, and two of them ate more cereals when taking additional exercise than when following their normal daily routine; this may partly explain the fall in transit time shown by them. The other group of eight subjects ate the same amount of cereals when exercising as when following their regular activities.

The time faeces stays in the distal colon forms a much greater proportion of total transit time in people with very slow transit than in those with rapid transit. Exercise, by producing a more frequent stimulus to defaecation, might reduce MTT in those with slow transit but not in those with rapid transit among whom a daily bowel action results in the distal colon being empty for much of the day. Among those with rapid transit, exercise might increase the segmenting activity of the colon and slow down the transit of the contents, so increasing MTT.

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