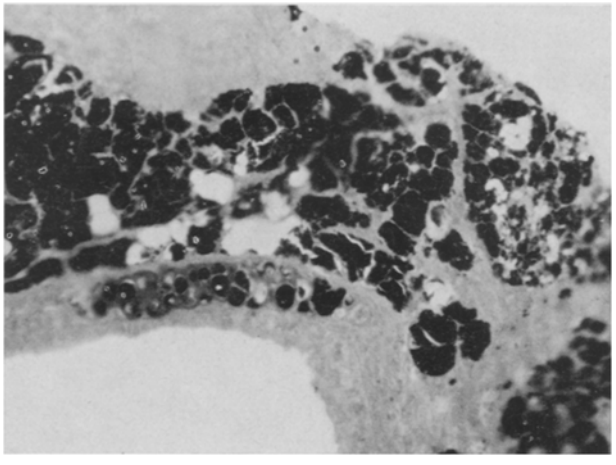
Atherogenic Effect of Sucrose and White Flour Fed to Obese Mice

High carbohydrate diets free of added cholesterol induce hypercholesteremia and atherosclerosis. In fact, PAGE[1] and MCCARRISON[2] consider refined sugar as well as white flour as one of the great nutritional problems of our time because they have such a detrimental effect on body chemistry. A high 40% carbohydrate diet fed to rabbits for 33 weeks revealed that starch produced a high serum cholesterol and a marked atheromata[3]. However, YURKIN[4] and DALDERUP[5] found no relationship between dietary carbohydrate and the level of serum cholesterol. Possibly, a high food intake with an excess body weight and decreased physical activity may be an important consideration[6,7]. In the present study we attempted to show the hypercholesteremic and atherogenic influence of white flour plus sucrose fed in the diet to obese adult male and female mice (C57BL/6J). Some attention was given to this animal as a laboratory model for studying atherosclerosis over a short period of time.

Methods. Adult male and female obese mice (C57BL/6J) were fed a libitum 50% Purina laboratory chow + 25% white flour + 25% refined sucrose for 6 weeks. Control animals were fed only the powdered chow diet. Daily food intake and final body weights of all animals were recorded. At the end of 6 weeks each mouse was decapitated and serum was obtained for total cholesterol determination[8]. Specimens of aorta near the heart were removed and fixed in 10% formalin and stained by the osmium tetroxide method for lipid deposition[9]. By using the formula $\sqrt{\Sigma d^2/N\,(N-1)}$ we calculated the standard error of the various means and applied the Students *t*-test for significant difference[10].

Results and discussion. Male obese mice fed the mixture of 50% chow diet + 25% white flour and 25% sucrose had a total serum cholesterol level (491.8 ± 1.7 mg/100 ml) which was 2.7 times greater than male animals fed only the commercial chow diet (182.1 ± 1.1 mg/100 ml) ($P < 0.001$) for 6 weeks. However, sucrose and white flour failed to elevate female serum cholesterol (Table). In male mice fed sucrose plus white flour aortic medial sections manifested extensive lipid material (black deposits) (Figure) whereas aortic medial sections from males fed laboratory chow alone were normal with no fat deposition. All animals were hyperphagic on laboratory chow as well as when the chow was mixed with carbohydrate. However, female mice were heavier than males of similar age as reflected by the greater number weighing more than 30 g. All obese mice were quite active even when fed the additional white flour and sucrose.

The choice of the laboratory animal model for studying atherosclerosis remains a subject of intense discussion. The rabbit as a model falls short of the mark because the lesions are predominantly 'foam cell' lesions limited to the intima with little extension into the media of the aorta. In the present study male but not female obese mice developed hypercholesteremia which agrees with clinical experience. The rise in serum cholesterol began to



Aortic media of obese male mice fed white flour and refined sugar for 6 weeks showing massive black deposits of fat. ×128.

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Serum cholesterol levels of adult male and female C57BL/6J obese mice fed sucrose and white flour in chow diet for 6 weeks

	Male mice		Female mice	
	Normal[a] powdered chow diet	Chow diet + 25% sucrose + 25% white flour	Normal[a] powdered chow diet	Chow diet + 25% sucrose + 25% white flour
Number of mice	8	9	9	9
Final body weight (g)	28.2 ± 3.0	30.8 ± 1.2	37.4 ± 1.6	34.7 ± 3.3
Number of animals over 30 g	3	3	6	5
Average daily food intake (g)	13.5 ± 0.2[b]	10.9 ± 0.1	10.9 ± 0.2	12.6 ± 0.0
Serum cholesterol 6 weeks (mg/100ml)	182.1 ± 1.1	491.8 ± 1.7	231.3 ± 3.2	224.4 ± 1.0

[a] Purina laboratory diet. [b] ± = Standard error of the mean.

rise after 2 weeks on the high carbohydrate diet. While these results cannot be related directly to human atherosclerosis we feel that the obese mouse should receive future consideration. The hyperphagia and increased body weight of obese mice may be essential for the induction of atherosclerosis over a short period of time despite the fact that their physical activity appeared to be normal. These data suggest that refined sugar and white flour play some role in the development of atherosclerosis.

Résumé. Des souris mâles obèses nourries ad libitum avec 50% de céréales, 25% de farine blanche, et 25% de sucrose ont présenté une augmentation en cholestérol de sérum 2,7 fois plus grande que celle des animaux nourris seulement de céréales. Des dépôts de matières grasses ont été trouvés dans la média aortique.

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Saliva Viscosity Reflects the Time of Ovulation

Our previous work in women[1] suggests that we can detect the fertile period by measuring the saliva glucose levels. The appearance of the Dextrostix blue color indicative of saliva glucose correlated well with ovulatory pain. The amounts of saliva glucose (depth of blue color) were greatest at the time of ovulation and faded away within a few days depending upon the glucose levels reached by a particular woman. In a few women, the blue color was present a day or so before our estimated time of ovulation. Furthermore, ovulation altered the pattern of mesothelial cells and polymorphonuclear leukocytes in peritoneal fluid in such a manner that we could identify the stages of the menstrual cycle. The proportion of mesothelial cells was lowest at ovulation whereas the proportion of polymorphonuclear leukocytes was maximum. Larger than normal amounts of fluid (2 to 8 ml) were aspirated immediately after what we interpreted as ovulation[2]. Following these studies, we have related urinary protein levels with ovulation[3]. Urinary protein increased at ovulation but urinary pH and glucose values remained unchanged throughout the cycle. These data correlate well with 'spinnbarkeit' and vaginal smear tests.

During ovulation the follicular contents of the ovary empty hormones, carbohydrates and protein into the peritoneal cavity which are absorbed into the blood and become deposited into the saliva. The present study attempts to correlate the relative saliva viscosity with basal body temperature in relation to the time of ovulation which will be compared with previous work.

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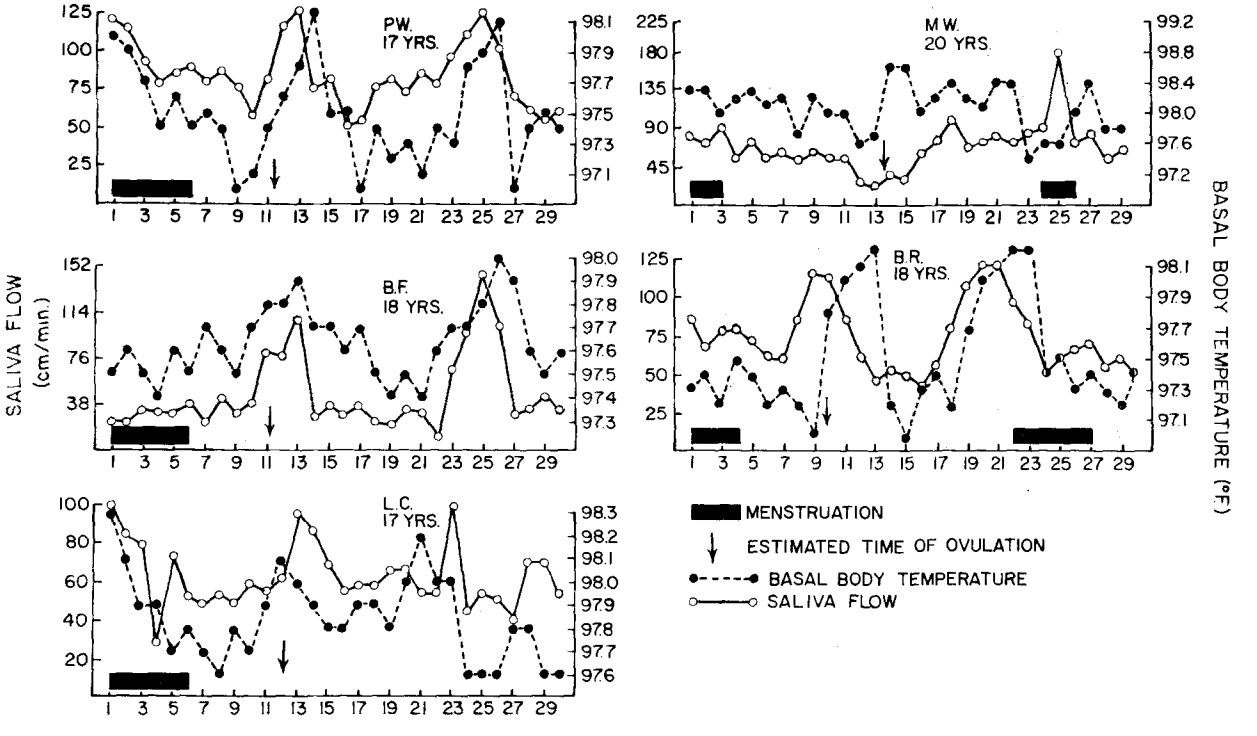

Saliva flow reflects the time of ovulation.