

## **Nutrition education: a questionnaire for assessment and teaching**

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## Abstract

It is generally recognized that there is a need for improved teaching of nutrition in medical schools and for increased education of the general population. A questionnaire, derived in part from a study of physician knowledge, was administered to first year medical students in order to assess their knowledge of various aspects of nutrition and metabolism and as a teaching tool to transmit information about the subject. The performance of first year students was consistent with a generally educated population but there were surprising deficits in some fundamental areas of nutrition. Results of the questionnaire are informative about student knowledge and immediate reinforcement from a questionnaire may provide a useful teaching tool. In addition, some of the subject matter can serve as a springboard for discussion of critical issues in nutrition such as obesity and markers for cardiovascular disease. A major barrier to improved teaching of nutrition is the lack of agreement on some of these critical areas and there are apparent inconsistencies in recommendations of government and health agencies. It seems reasonable that improved teaching should address the lack of knowledge of nutrition, rather than knowledge of official guidelines. Student awareness of factual information should be the primary goal.

## Background

Like many medical schools, SUNY Downstate Medical Center has been trying to improve the teaching of nutrition in the curriculum. The study presented here had two goals. First, we wanted to assess the knowledge of the first year class on the subject and, second, we hoped to use the questionnaire method, with immediate feedback, as a mechanism for imparting information on the areas covered. Whereas some form of nutrition education is part of the curriculum of most medical schools [1], it is generally believed that both medical professionals and the general public have serious limitations in their knowledge of the field (e.g. [2, 3] and references therein). Four of the 14 questions presented to the first year medical class were included in a recent survey of physicians published in this journal [4]. That paper was critical of the level of physician knowledge and it seemed appropriate to compare performance of students with that of practitioners. In addition, the mechanism of providing information by presenting an anonymous quiz with immediate feedback could address one of the problems cited as a barrier to introducing nutrition into the medical curriculum, that is, that the first year basic science curriculum is already very concentrated, leaving little room for new material. The quiz format provides motivation and, because it is anonymous, does so in a relatively unstressful way.

Perhaps the most important problem in introducing nutrition into the medical curriculum is the lack of agreement on what should be taught. There is strong, even contentious debate about the most fundamental issues such as obesity, cardiovascular disease and diabetes. Thus, concerns about inadequate physician knowledge frequently refer to ability to counsel patients according to standard guidelines [4-6]. Here we suggest that a more appropriate goal would be the understanding of basic nutritional information and that this information is not always in agreement with official guidelines. The details of these problems are left to Results and Discussion since we first want to offer the reader a chance to take the questionnaire as given to students.

The quiz is presented twice in the Methods section: first, as given to medical students, and then, a second time, with the answers and with the comments given to students immediately upon completion of the quiz. A follow-up email was also sent to students after results were tabulated and this is also reproduced in the Methods section. Results and Discussion provides data on student performance and additional discussion.

## Methods

The following is a verbatim reproduction (with addition of references) of the questionnaire given to first year medical students at SUNY Downstate Medical Center. The first four questions were taken from Flynn, *et al.* [4]. Following Flynn, we did not attempt to define the term "low fat diet" which is usually used without elaboration. No specific time limit was given for the quiz but a class of 111 students

finished in about 20 min with a few stragglers. Students were given the answer sheet (shown after the quiz itself) in exchange for their questionnaire. Students were in the middle of the metabolism course, part of a subdivision characterized as Gastrointestinal Block. They had been taught bioenergetics, carbohydrate and lipid metabolism and would be expected to know the answers to some of the questions based on that material. Other questions tested general knowledge and questions 12.-14. emphasized material taught later in the course.

### Questionnaire

This questionnaire is anonymous and does not affect your grade. Make up a User Name (in case there is a follow-up) that only you know and that is not common, like Sherlock-37)

User Name \_\_\_\_\_

The questionnaire is designed to test your general knowledge, not anything you have learned in the course.

1. A good source of monounsaturated fat is: (check all that apply)

<input type="checkbox"/> Butter	<input type="checkbox"/> Olive Oil
<input type="checkbox"/> Canola Oil	<input type="checkbox"/> Safflower Oil
<input type="checkbox"/> Corn Oil	<input type="checkbox"/> Soybean Oil
<input type="checkbox"/> Flaxseed Oil	<input type="checkbox"/> don't know

2. The diet component that is most likely to raise triglycerides is (select one)

<input type="checkbox"/> Fat	<input type="checkbox"/> Protein
<input type="checkbox"/> Carbohydrate	<input type="checkbox"/> don't know

3. In general, what effect does a low-fat diet have on triglycerides?

<input type="checkbox"/> Increase	<input type="checkbox"/> no change
<input type="checkbox"/> Decrease	<input type="checkbox"/> don't know

4. In general, what effect does a low-fat diet have on HDL-c (high density lipoprotein-associated cholesterol) ?

<input type="checkbox"/> Increase	<input type="checkbox"/> No change
<input type="checkbox"/> Decrease	<input type="checkbox"/> Don't know

5. In the past thirty years the per cent fat in the American Diet has:

<input type="checkbox"/> Increased
<input type="checkbox"/> Decreased
<input type="checkbox"/> Stayed about the same.

6. The most energy dense food (most calories/gram) is:

<input type="checkbox"/> Carbohydrate.
<input type="checkbox"/> Protein.
<input type="checkbox"/> Fat.

7. High total blood cholesterol can be lowered significantly by:

- |  |  |
|--|--|
| <input type="checkbox"/> Diet                  | <input type="checkbox"/> Diet or drugs are equally effective |
| <input type="checkbox"/> Drugs such as statins | <input type="checkbox"/> Neither                             |
| <input type="checkbox"/> Don't know            |  |

8. The dietary change that is most likely to **increase** the risk of cardiovascular disease:

- unsaturated fat → saturated fat (that is, replace unsaturated fat with saturated)
- unsaturated fat → carbohydrate
- carbohydrate → unsaturated fat
- carbohydrate → saturated fat
- saturated fat → carbohydrate
- saturated fat → unsaturated fat

9. Glycemic Index measures the increase in blood sugar over 2 hours per gram of carbohydrate, compared to glucose (=100). For each food indicate the approximate glycemic index as: H, high (70-100), M, Medium (40-70) or L, Low (< 40). You may enter a number if you think you know or can figure it out:

- |  |  |
|--|--|
| <input type="checkbox"/> white bread       | <input type="checkbox"/> sucrose (table sugar) |
| <input type="checkbox"/> whole wheat bread | <input type="checkbox"/> fructose              |
| <input type="checkbox"/> ice cream         | <input type="checkbox"/> bran muffin           |
| <input type="checkbox"/> carrots           | <input type="checkbox"/> banana                |

10. The substances in the following list that either are themselves or are considered to contain large amounts of complex carbohydrates.

- |  |  |
|--|--|
| <input type="checkbox"/> white bread       | <input type="checkbox"/> sucrose (table sugar) |
| <input type="checkbox"/> whole wheat bread | <input type="checkbox"/> corn starch           |
| <input type="checkbox"/> ice cream         | <input type="checkbox"/> fiber                 |
| <input type="checkbox"/> fructose          |  |

11. In the first column check the vitamins that are generally considered to have antioxidant activity. In the second column check the vitamins that are precursors for oxidative coenzymes. (check all that apply)

#### ANTIOXIDANTS

- ascorbic acid (vitamin C)
- niacin
- riboflavin
- thiamine
- pyridoxal phosphate (Vitamin B<sub>6</sub>)
- vitamin B<sub>12</sub>
- vitamin D
- vitamin E

#### REDOX PRECURSORS

- ascorbic Acid
- niacin
- riboflavin
- thiamine
- pyridoxal phosphate
- vitamin B<sub>12</sub>
- vitamin D
- vitamin E

12. Megaloblastic anemia is a prominent feature of deficiencies of:





of Atkins-type low carbohydrate diet show that they can be effective and therefore there is no great over consumption even though portion sizes are unlimited. It is also argued that the wrong kind of fat is being consumed although no effect of fat *per se* on obesity, independent of calories, has been found.

6. The most energy dense food (most calories/gram) is:

- Carbohydrate.  
 Protein.  
 Fat.

The operational numbers in kcals/g are 4, 4 and 9 for carbohydrate, protein and fat. This is the basis of traditional recommendations for low fat diets for obesity. The reduction in percentage fat and the obesity epidemic noted above, however, suggests that this is not a good universal principle. The role of macronutrient composition on satiety, taste, total consumption and effect on weight loss is largely unknown due to the multiple factors and individual differences although some experimental support can be found for just about any idea.

7. High total blood cholesterol can be lowered significantly by:

- Diet  Diet or drugs are equally effective  
 Drugs such as statins  Neither  
 Don't know

Drugs such as statins (HMGCoA reductase inhibitors) are very effective at reducing cholesterol. Diet can also be effective but far less so. Combination diet and drugs, however, may be most effective but there is, again, not universal agreement as to what that diet should be.

8. The dietary change that is most likely to **increase** the risk of cardiovascular disease:

- unsaturated fat → saturated fat (that is, replace unsaturated fat with saturated)  
 unsaturated fat → carbohydrate  
 carbohydrate → unsaturated fat  
 carbohydrate → saturated fat  
 saturated fat → carbohydrate  
 saturated fat → unsaturated fat

In addition to the effect on risk factors, epidemiologic evidence suggests that replacing fat with carbohydrate is deleterious. Replacing unsaturated fat with saturated will also increase the risk of cardiovascular disease [8, 9, 14, 25]. Of course, in terms of obesity, reducing calories by removing fat and not replacing it with anything is good. Removing carbohydrate, however, may be better, at least in terms of cardiovascular disease.

9. Glycemic Index (GI) measures increase in blood sugar over 2 hrs per gram of carbohydrate, compared to glucose (=100). For each food indicate the approximate glycemic index as: H, high (60-100), M, Medium (40-60) or L, Low (< 40). You may enter a number if you think you know it:

- |                                 |                                     |
|---------------------------------|-------------------------------------|
| <b>H (70)</b> white bread       | <b>H (70)</b> sucrose (table sugar) |
| <b>M (52)</b> whole wheat bread | <b>L (20)</b> fructose              |
| <b>M (50)</b> ice cream         | <b>HM (60)</b> bran muffin          |
| <b>M (47)</b> carrots           | <b>M (50)</b> banana                |

The GI is a very rough indicator of rise in blood sugar and is influenced by absorption and the concentration of glucose. Fructose has a low GI (20) indicating slow conversion to glucose in 2 hrs but far from being considered a “good” sugar, at high levels may be very deleterious. The concept of glycemic load (GL) which corrects for the amount of carbohydrate per serving may be a better parameter but runs into problems about serving size. So muffins and candy bars have GL = 15 and carrots only 3 but 80 g of carrots may not be a lot for some people [26-28].

10. The substances in the following list that either are themselves or are considered to contain large amounts of complex carbohydrates.

- |   |                   |   |                       |
|---|-------------------|---|-----------------------|
| <input type="checkbox"/> ? <input type="checkbox"/> | white bread       | <input type="checkbox"/> <b>NO</b>                  | sucrose (Table Sugar) |
| <input type="checkbox"/> ? <input type="checkbox"/> | whole wheat bread | <input type="checkbox"/> ? <input type="checkbox"/> | corn starch           |
| <input type="checkbox"/> <b>NO</b>                  | ice cream         | <input type="checkbox"/> ? <input type="checkbox"/> | fiber                 |
| <input type="checkbox"/> <b>NO</b>                  | fructose          |   |                       |

If you had trouble with this, it is because nobody knows how the term should be used and, in fact, we recommend it not be used at all. The original chemical definition – to some extent still used in organic chemistry -- is that a complex carbohydrate is a polysaccharide (not mono- (glucose, fructose) or di- (sucrose, lactose)). Any starch, corn starch or white bread (poly-glucose: amylose or amylopectin) fits the definition, and it used to be nutritional dogma that, at least in terms of raising blood glucose, complex carbohydrates (that is, polysaccharides) were better than simple sugars. When the dogma was finally tested this turned out not to be true and the concept of glycemic index arose. It is clear from the question above that white bread is nutritionally essentially the same as pure glucose. Probably because of the evocative nature of the word, the term “complex” is still used. Sometimes it means foods that have a low glycemic index due to poor absorption usually due to the presence of fiber, but it is never precise. When people say complex carbohydrate they usually mean the carbohydrate recommended in their diet and missing from somebody else’s diet. Suggested nomenclature is “polysaccharides, starch, high fiber,” although fiber itself is a heterogeneous category.

11. In the first column check the vitamins that are generally considered to have antioxidant activity. In the second column check the vitamins that are precursors for oxidative coenzymes. (check all that apply)

- | ANTIOXIDANTS  | REDOX PRECURSORS                  |   |                         |
|---|-----------------------------------|---|-------------------------|
| <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | ascorbic acid (vitamin C)         | <input type="checkbox"/>  | ascorbic acid           |
| <input type="checkbox"/>  | niacin                            | <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | niacin                  |
| <input type="checkbox"/>  | riboflavin                        | <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | riboflavin              |
| <input type="checkbox"/>  | thiamine                          | <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | thiamine                |
| <input type="checkbox"/>  | pyridoxal phosphate (Vitamin B-6) | <input type="checkbox"/>  | pyridoxal phosphate     |
| <input type="checkbox"/>  | vitamin B <sub>12</sub>           | <input type="checkbox"/>  | vitamin B <sub>12</sub> |
| <input type="checkbox"/>  | vitamin D                         | <input type="checkbox"/>  | vitamin D               |
| <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | vitamin E                         | <input type="checkbox"/>  | vitamin E               |

12. Megaloblastic anemia is a prominent feature of deficiencies of:

- |                          |                         |   |                         |
|--------------------------|-------------------------|---|-------------------------|
| <input type="checkbox"/> | Vitamin B <sub>12</sub> | <input type="checkbox"/>  | Neither.                |
| <input type="checkbox"/> | Folic Acid              | <input checked="" type="checkbox"/> <b>X</b> <input type="checkbox"/> | Deficiencies of either. |

13. Addition of folic acid to the diet can relieve all the symptoms due to deficiencies of:

- |                                     |                         |                          |          |
|-------------------------------------|-------------------------|--------------------------|----------|
| <input type="checkbox"/>            | Vitamin B <sub>12</sub> | <input type="checkbox"/> | Both.    |
| <input checked="" type="checkbox"/> | Folic Acid              | <input type="checkbox"/> | Neither. |

14. Vitamin B<sub>12</sub> deficiency is most commonly seen in:

- |                          |                                  |                                     |                                     |
|--------------------------|----------------------------------|-------------------------------------|-------------------------------------|
| <input type="checkbox"/> | children due to poor nutrition.  | <input type="checkbox"/>            | the elderly due to poor nutrition.  |
| <input type="checkbox"/> | children due to poor absorption. | <input checked="" type="checkbox"/> | the elderly due to poor absorption. |

The most obvious symptom of a folic acid deficiency, anemia, is due to a requirement for folic acid in the synthesis of DNA. Deficiencies lead to poor maturation of red blood cells (megaloblasts). Megaloblastic anemia can also be caused by a B<sub>12</sub> deficiency which, indirectly, has the same effect.

There are only two reactions in humans requiring vitamin B<sub>12</sub>. First, vitamin B<sub>12</sub> is a cofactor in formation of the amino acid methionine from homocysteine and the folic acid derivative, methyl-tetrahydrofolic acid (methyl-THF):  
 $\text{Homocysteine} + \text{methyl-THF} \rightarrow \text{Methionine} + \text{THF}$   
 This explains the relation between dietary folic acid and high homocysteine which is a marker for cardiovascular disease and potential birth defects.

A deficiency in folic acid or the cofactor, B<sub>12</sub>, will prevent this reaction from occurring. The effect of B<sub>12</sub> deficiency on folic acid is indirect: if methionine synthesis cannot be carried out, methyl-THF will build up (“methyl trap”). This is effectively a folic acid deficiency and anemia is the outcome. The second requirement for B<sub>12</sub> involves organic acids and deficiencies can lead to neurologic damage. The anemia in a B<sub>12</sub> deficiency may be successfully treated with folic acid, swamping out the methyl trap. Neurologic damage, however, may still occur unless the B<sub>12</sub> deficiency is also treated. A dietary deficiency of B<sub>12</sub> is rarely seen since little is needed and it is stored well. Deficiency is usually detected in the elderly due to decreased production of intrinsic factor, a protein required for absorption.

The considerations above bear on the recommendation to add folic acid to manufactured food. Critics point out that by preventing anemia, a B<sub>12</sub> deficiency could be masked. Since the major deficiency is not dietary but absorptive, the problem can't be solved by simply adding B<sub>12</sub> as well.

## Follow up

The following analysis was sent as an Email to students after the scores on the quiz were tabulated.

### Results of Nutrition Questionnaire.

As indicated in the answer sheet, the first four questions are taken from a recent paper (Flynn, M., et al. (2003) *Nutrition Journal* 2: 19) that reported the results of a questionnaire designed to assess the level of knowledge of physicians. Their conclusion was that “Physicians showed a poor understanding of the effects of changing the relative intake of carbohydrates and fats on triglycerides and HDL.”

Interestingly the rationale for the study was determining “Physicians’ ability to effectively counsel patients with elevated cholesterol to initiate a Therapeutic Lifestyle Changes Diet (TLC)” (as proposed by the Third Report of the National Cholesterol Education Program Adult Treatment Program (ATP III) which recommends lowering triglycerides as a secondary target to lowering LDL. The TLC Diet recommends total fat as 25-35 % and carbohydrate at 50-60 %. Paradoxically, Flynn, et al.’s assessment of physician knowledge focused on the deleterious effect of carbohydrate and the poor

protective effect of low fat on triglycerides. Given this association, one is at a loss to understand why ATP III would counsel people trying to lower triglycerides to undertake such a diet.

In any case, your performance compared to their sample is shown in Figure 2.

Two questions of importance:

Question 5:

In the past thirty years, the per cent fat in the American diet has declined by about 10 %, close to the target level set back in the 70's. In order to explain why this has been associated with an obesity epidemic, the nutritional establishment has blamed portion-size, the fast-food industry, consumers themselves and just about everybody except our own rush to institute low-fat guidelines. In any case, most people did not know that per cent fat consumption had gone down. Answers were:

Increased: 76 %

Decreased 22 %

Same 3 %

Question 6. Again, it was surprising that so many people did not know the relative energy density. The answers:

Carbohydrate 19 %

Protein 7 %

Fat 74 %

### **Analysis**

Questionnaires were collected from 111 students, all but 6 answered all the questions. Student answers were tabulated and discrimination coefficients were determined by point biserial correlations [29] using LXR-TEST™ software (Logic eXtension Resources (<http://www.lxrtest.com/>)). The discrimination coefficient varies between -1 and means +1 and measures the extent to which performance on a particular question reflects performance on the quiz as a whole, that is, whether a question discriminates high performers from low performers. A typically high value of +0.4 means that the question was answered correctly by most students who did well on the exam and answered incorrectly by most who did not.

Because the questions had different goals (knowledge assessment vs. motivation for accepting new information), and because some (e.g. questions 2-4) are interrelated, no measure of performance or statistics were carried out for the quiz as a whole.

## **Results and Discussion**

### **Student and physician knowledge of nutrition**

#### **Questions 1-8.**

Results from the first eight questions and the data from Flynn, et al. [4] are shown in Tables 1 and 2 and in Figure 2. Flynn, *et al.* used four questions that succinctly identified both practical and conceptual knowledge bearing on the ability to implement dietary recommendations from the Adult Training Program (ATP III) of the National Cholesterol Education Program (NCEP)[6].

**Table 1: Student and physician responses (%). Discrimination coefficients indicate**

discrimination of high and low performers on quiz overall as described in the text.

	Cardiologists	Internists	Students	discrim coeff
<b>1. A good source of monounsaturated fat</b>				
Butter	4	4	8	0.39
<b>Canola Oil</b>	<b>43</b>	<b>51</b>	<b>26</b>	<b>0.21</b>
Corn Oil	13	16	22	0.32
Flaxseed Oil	12	10	25	0.32
<b>Olive Oil</b>	<b>82</b>	<b>73</b>	<b>58</b>	<b>0.35</b>
Safflower Oil	24	32	25	0.26
Soybean Oil	18	16	38	0.35
don't know	6	6	16	
<b>2. Diet component most likely to raise triglycerides</b>				
Fat	16	47	63	-0.2
<b>Carbohydrate</b>	<b>78</b>	<b>47</b>	<b>32</b>	<b>0.17</b>
Protein	0.8	0.6	0	
don't know	5	5	2	
<b>3. Effect of low-fat diet on triglycerides</b>				
<b>Increase</b>	<b>16</b>	<b>4</b>	<b>14</b>	<b>0.22</b>
Decrease	52	73	68	-0.17
no change	26	26	15	0.01
don't know	6	4	3	
<b>4. Effect of low-fat diet on HDL-c</b>				
Increase	11	24	31	-0.08
<b>Decrease</b>	<b>30</b>	<b>23</b>	<b>32</b>	<b>0.25</b>
no change	52	44	23	-0.18
don't know	7	9	14	

First year students did not do as well as physicians at identifying sources of monounsaturated fats. On the other hand, the good discrimination coefficient indicates that knowledge of fat composition is a good indicator of overall knowledge (at least as assessed by general performance on this quiz).

Although a substantial fraction of cardiologists polled by Flynn knew that carbohydrate raised triglycerides (Figure 2), most internists and most medical students did not. Likewise, a very small fraction of first year students or physicians were aware of the deleterious effects of low fat diets on two markers of CVD. As discussed in the student answers (Methods), there is some irony in that the questions chosen by Flynn bring out the unfavorable effect of carbohydrate on triglycerides while the ATP III recommendation is to maintain 50 % carbohydrate in the diet. Student responses attest to the success of continued popular and government recommendations favoring low fat diets but the content of the answers raises the question of whether sufficient information is being transmitted along with these recommendations, or even whether these recommendations, rather than the basic nutritional knowledge, should be communicated.

**Table 2: Student Responses (%).**

	Students	discrim coeff
<b>5. Past thirty years, per cent fat in American diet</b>		
Increase	76	-0.10
<b>Decrease</b>	<b>22</b>	<b>0.14</b>
Same	3	-0.10
<b>6. Most energy dense food</b>		
Carbohydrate	19	-0.15
Protein	7	-0.10
<b>Fat</b>	<b>74</b>	<b>0.19</b>
<b>7. High blood cholesterol lowered significantly by</b>		
Diet	14	0.06
<b>Drugs such as statins</b>	<b>21</b>	<b>0.17</b>
Diet or drugs equal	61	-0.15
Neither	0	
Don't know	0	
<b>8. Most likely to increase risk of CVD</b>		
UF -> SF	46	0.02
<b>UF -&gt; CHO</b>	<b>7</b>	<b>0.11</b>
CHO -> UF	3	-0.27
CHO -> SF	23	0.09
SF -> CHO	2	0.00
SF -> UF	12	-0.08

Along the same lines, our questionnaire went beyond the area covered by Flynn to consider the changes in diet that have accompanied the epidemic of obesity. It has to be considered shocking that only 22 % of an educated population knew that the per cent fat in the American diet has decreased (Figure 3); for men, in fact, the *total amount* of fat has decreased, whereas for women there has been a slight increase consistent with the much larger increase in caloric intake among women [24]. The observation of a decrease in fat and an increase in carbohydrate in parallel with the obesity epidemic remains as a serious challenge to traditional dietary recommendations. The reduction in fat in the diet from the 1970s to 1995 has been noted by one author [24] to provide a benefit in reduction in serum cholesterol from 213 to 205 mg/dL! Although more difficult to quantify, a decline in exercise is also a likely contributor to the epidemic, but it seems inappropriate, without further evidence, to ignore the *prima facie* evidence of the effect of macronutrients. Despite the clear cut correlation between higher carbohydrate, lower fat and obesity, government and health agencies have been loathe to consider that established guidelines are inappropriate and continue to recommend still higher carbohydrate and still lower fat [6, 30, 31].

### Question 6

We were surprised by some lapses in student knowledge revealed by the questionnaire. The most basic question -- which macronutrient is the most energy dense -- had only 74 % correct answers. To understand how poor a response this is, it should be understood that the mean score on exams in this section of the medical course is typically 80 % and, on most exams, several questions are answered correctly by 98-100 % of the class. The National Board of Medical Examiners assumes knowledge of caloric value of macronutrients, and we had expected that it was common knowledge. The questionnaire result indicates that no fact in nutrition is too basic to be excluded from course material.

### Question 7-8. Diet and Cardiovascular Disease.

An overwhelming number of medical students believe that diet is as effective as drugs in the prevention of CVD. This again attests to the pervasive message that diets control CVD, an idea continually reinforced by media advertisements, for example, for the cholesterol lowering effect of breakfast cereal. The general effectiveness of statins and the promotion by pharmaceutical companies has, most recently, lead to a movement to reinforce the idea that genetics (which can't be controlled by diet) also plays a role. These competing financial interests have produced, in our view, bizarre and unpatriotic (?) television commercials blaming mother *and* apple pie for high cholesterol.

Few students in the first year medical class knew that replacing unsaturated fat with carbohydrate was the most damaging substitution in terms of CVD risk. The data from Hu, et al., [8, 25] shown in Figure 4 represent, yet another reason to reevaluate low fat recommendations. Similar results have been found in the analysis of risk factors [14]. In other words, whereas everybody agrees that removing fat from the diet as a mechanism of calorie reduction is a good thing, replacing fat with carbohydrate is deleterious to CVD and is likely worse for weight loss. The recent AHA recommendations on obesity [31] do not mention this work and the ATP III itself recommends: "Breads, cereals, pasta, whole grains, potatoes, rice, dry peas, and beans (6 or more servings per day). These foods are high in complex carbohydrates and fiber, provide protein, and also are generally low in saturated fat, cholesterol, and total fat. Dry beans and peas are good sources of plant protein and are fiber rich. They should be substituted for foods high in saturated fat, cholesterol, and total fat [6]."

**Table 3: Student Responses (%) on carbohydrates.**

<b>9. Glycemic Index</b>	<b>Low</b>	<b>Medium</b>	<b>High</b>	<b>discrim coeff</b>
White Bread	5	22	<b>70</b>	0.2
Whole Wheat Bread	39	<b>49</b>	10	0.18
Ice Cream	5	<b>16</b>	77	-0.1
Carrots	68	<b>19</b>	9	0.07
Sucrose	1	10	<b>86</b>	0.16
Fructose	<b>3</b>	22	73	-0.04
Bran Muffin	25	<b>49</b>	<b>23</b>	
Banana	20	<b>53</b>	23	0.23
<b>10. Complex Carbohydrates</b>	<b>Yes</b>	<b>No</b>		
White Bread	60	38		
Whole Wheat Bread	68	32		
Ice Cream	31	68		
Fructose	11	88		
Sucrose	18	81		
Corn Starch	48	51		
Fiber	43	56		

### Questions 9-10. Glycemic Index and Complex Carbohydrates.

These two questions (Table 3) point out the confusion that exists in characterizing dietary carbohydrates. The glycemic index (GI), and the glycemic load (GL) which corrects for total carbohydrate in individual foods, are indicators of rise in blood glucose. Glycemic control is a major variable in the analysis of metabolic syndrome and obesity, and dietary strategies based on the glycemic index [28] have the same rationale as low carbohydrate diets: reduce fluctuations in insulin and associated anabolic effects; a low carbohydrate diet might be described as a very low glycemic load diet. The popular Atkins' diet book, for example, ([32], pp.78-84) describes the GI as a "beautiful tool." Nonetheless, the concepts of GI and GL

have become part of the political controversies surrounding dietary strategies and proponents usually urge a low GI diet as an alternative rather than a variation of low carbohydrate diets (see, e.g. [15]) despite the fact that in at least one isocaloric comparison of high GI and low GI meals, the low GI meal was, in fact, lower in carbohydrate [27]. An important limitation on the concept of GI is that fructose has a low value, and therefore fructose-containing products, sucrose and high-fructose corn syrup may give misleading information. The atherogenic qualities of fructose [33] are one of the ideas that we bring out in the lectures in the medical school course.

We recommend that the term complex carbohydrates not be used since, in practice, it has lost its original meaning of polysaccharide. It is interesting that, to some extent, student answers followed the original definition. Most students picked both white bread and whole wheat bread as complex although, with a slight preference for picking whole wheat over white bread as many nutritionists might.

**Table 4: Student Responses (%) on vitamin question.**

<b>11. Vitamins with indicated activity.</b>		<b>yes</b>	<b>discrim coeff</b>
<b>ANTIOXIDANTS</b>			
	Ascorbic Acid	<b>77</b>	0.47
	Niacin	23	0.39
	Riboflavin	19	0.45
	Thiamine	9	0.57
	Pyridoxal Phosphate (Vitamin B-6)	21	0.31
	Vitamin B-12	31	0.41
	Vitamin D	16	0.38
	Vitamin E	<b>69</b>	0.45
<b>REDOX PRECURSORS</b>			
	Ascorbic Acid	27	0.47
	Niacin	<b>51</b>	0.31
	Riboflavin	<b>43</b>	0.23
	Thiamine	<b>34</b>	0.31
	Pyridoxal Phosphate	33	0.28
	Vitamin B-12	27	0.45
	Vitamin D	11	0.44
	Vitamin E	5	0.43

### **Question 11. Vitamins**

We credit the popular media with the generally good knowledge about the antioxidant vitamins shown in Table 4. In our view, however, this may be a mixed blessing, shifting the emphasis from macronutrient composition which is a major factor in health to micronutrients which, at least for the American population, has to be considered secondary. The very poor performance and good discrimination coefficient in the question on redox precursors has to be considered discouraging, especially in that students had been exposed to the involvement of the three oxidative coenzymes in glycolysis and the TCA cycle. Moreover, the origin of NAD coenzymes in dietary niacin was explicitly taught. We think this means that it is a lack of emphasis on integration of nutritional information and biochemistry, rather than presentation of the material itself, that may be a factor in the poor nutritional knowledge of students and practitioners.

**Table 5: Student Responses (%) on folic acid questions.**

	Students	discrim coeff
<b>12. Megaloblastic anemia: deficiencies of</b>		
Vitamin B-12	39	-0.11
Folic Acid	31	0.17
Neither	6	0.09
<b>Either</b>	<b>19</b>	<b>-0.09</b>
<b>13. Folic acid: relieve deficiencies of</b>		
Vitamin B-12	7	-0.1
<b>Folic Acid</b>	<b>49</b>	<b>0.12</b>
Both	38	-0.07
Neither	3	
<b>14. Vitamin B-12 deficiency commonly seen in</b>		
children due to poor nutrition.	32	-0.11
children due to poor absorption.	23	-0.04
the elderly due to poor nutrition.	9	0.1
<b>the elderly due to poor absorption.</b>	<b>25</b>	<b>0.1</b>

### Questions 12-14. Questionnaires as a teaching method: folate metabolism

These questions were presented as a preview and motivation for studying folate metabolism and therefore it was not unexpected that students did not do particularly well (Table 5). We identify folate metabolism as one of the critical areas of biochemical nutrition. The importance of homocysteine and use of dihydrofolate reductase inhibitors such as methotrexate are two of the most obvious examples of how biochemistry is a practical part of medical practice. At the same time, the biochemical pathways are among the most complex and because folate spans different areas of metabolism it is difficult to teach. The key nutritional issues are covered both in lecture and in a case-based learning session. Anecdotal information suggests that a preview of the information through this quiz seems to be helpful for ultimate understanding. As indicated above student performance on exams is typically very good and it is impossible to say if later performance was improved by exposure to the quiz but the strategy may have contributed to ease of learning.

### Nutrition in the Medical School.

Many papers have been written on the need for, and the difficulty in implementing improvements in teaching nutrition in medical schools [2, 3, 34]. Some of the major problems frequently cited are 1) inflexibility in the curriculum due primarily to time constraints and 2) inability to define what aspects of the subject needs to be taught. There is also considerable disagreement on the best method of teaching the subject. The current study bears on some of these questions.

### Adding nutritional material to the curriculum.

With respect to point 1) above, the first year medical school curriculum is undoubtedly very dense in content. Adding new material is difficult, especially if it is of the strictly factual type, e.g. macronutrient composition of particular foods. The "low pressure" quiz used here can, in theory, impart a certain amount of specific knowledge and generate student interest without interrupting the general flow of course work. The quiz provides a venue in which interested students can absorb the information, and become aware of the general area if they need to find the information later. Also, in our view, many subjects taught in basic science courses already have nutritional relevance, e.g., cofactors that come from vitamins, and these ideas should be better emphasized. We point out, when the NAD cofactors are introduced, that one would expect global effects of a deficiency disease because of the number of different enzymes that use these cofactors. Although vitamin deficiencies are rare in the absence of gross malnutrition, we see a need for greater emphasis. The tie-in through the quiz may reinforce the basic biochemistry.

### **What to teach in nutrition. Guidelines on macronutrient recommendations.**

We see the question of what to teach as the most critical problem in introducing or expanding nutrition in the medical school course. Whereas individual faculty may be resistant to giving up their own interests, this may depend on making a case for new material. The questionnaire discussed here points up some obvious material that needs to be taught, but others are quite controversial.

The original study by Flynn was designed to test physicians knowledge that might allow them to better implement ATP III recommendations to lower triglycerides. These recommendations, however, have some inherent contradictions. Given that low fat diets tend to raise triglycerides, as brought out in the questionnaire, the associated recommendation to reduce dietary fat and to raise carbohydrate above the level attained during the obesity epidemic appear somewhat contradictory, or at least, inappropriate as guidelines. The major focus of ATP III, however, is control of cholesterol but here, again, the literature is not clear cut. Thus, whereas the association between cholesterol levels and CVD is generally accepted by all but a minority of critics, the effect of diet on CVD, or even cholesterol, is far more controversial. The Chapter on “Diet and Coronary Heart Disease (CHD)” in Willett’s *Nutritional Epidemiology* [35] is 40 pages long with more than 300 references and contains more than one disclaimer on the diet-heart hypothesis, e.g. “Even if a change in dietary lipids influences the incidence of CHD in the direction predicted by its effect on total blood cholesterol level, the quantitative relationship between this dietary change and risk of disease is uncertain because of the possibility of many other potential physiologic effects of this dietary manipulation (p. 422),” or “Although substantial indirect evidence supports the classic diet-heart hypothesis, the magnitude of any association is likely to be modest for ranges of diet found within western culture of attainable by realistic dietary changes if the effects predicted by metabolic studies are correct (p. 443).” Finally, papers are published by respected authors with such titles as: “Dietary fat is not a major determinant of body fat [36],” or “Do high carbohydrate diets prevent the development or attenuate the manifestations (or both) of syndrome X? A viewpoint strongly against [37]” These cautionary points as well as those of other critics of low fat dietary recommendations [8, 19, 38-40] (and the data from which they are derived) are largely ignored by the ATP III and the body of experts who are making current recommendations. The recent demonstration of a beneficial effect of saturated fat and lower carbohydrate in patients on an overall low fat diet [41] has been described in an accompanying editorial as an “American paradox.” [42]. The paradox to us is that such reports do not appear to affect the confidence with which official positions are promulgated.

The above analysis bears on the role of low carbohydrate diets in educating students and physicians. We have previously indicated the use of such diets in teaching basic intermediary metabolism [43] and whereas we do not recommend any diet in the biochemistry course, students are sufficiently impressed with the biochemical rationale of restricted carbohydrates that it is increasingly difficult to justify absolute recommendations for low fat, high carbohydrate guidelines.

The ATP III itself reports “Lack of adequate nutrition education in medical schools has been a contributing factor to low adherence to dietary therapy that fortunately is now being addressed.” Clearly adequate nutrition education in the eyes of the ATP III is promotion of a regimen that is not particularly different in character from the one in place during the obesity epidemic. A better goal might be presentation of the *data* of the type in Figures 2-4 and a discussion of whether the ATP III guidelines are reasonable and appropriate especially given the admission that “physicians in general report little confidence in the patients’ ability to adhere to dietary change.”

In summary, what to teach remains very problematic. There are clear inconsistencies in the dietary recommendations of the ATP III and other health agencies. This has to make one question whether students and physicians should be educated only in currently recommended practice, or whether we should instead emphasize understanding the underlying data. This is especially true, given the disclaimers

in the American Heart statement [31] that “These recommendations may require modification, based on the results of ongoing and future dietary therapy studies.” and that “The available data suggest that it is unlikely that one approach is appropriate for all patients.” Of course, presentation of such controversial questions can be introduced into a problem-based learning session but medical students naturally prefer concrete answers and, appropriately, expect some guidance. The resolution currently depends on individual instructors and departments. It would be good, pedagogically, to establish the idea that not everything is known about nutrition and that many people consider that a rush to guidelines on insufficient evidence is to be avoided. From an educational perspective, medical students may need to consider that health and government agencies are promoting adherence to ideas whose scientific validity is still open to question.

## Conclusions

A questionnaire, derived in part from one previously published to assess physician knowledge, can be used to determine student awareness of nutritional facts. At the same time, such a quiz can be employed as a teaching device to reinforce earlier material, provide preview of new material or expose students to factual information that is not easily incorporated into a formal course. One of the areas chosen, the effect of macronutrients on obesity and cardiovascular disease, can lead to discussion and focus on important current issues. The performance of first year medical students as well as the performance of the physicians in the previous study suggest that improvement is needed in imparting knowledge about some basic ideas in nutrition. The focus should be on these ideas rather than on official recommendations with which the ideas are sometimes in conflict.

Finally, the questionnaire is intended as a practical method. The authors would be grateful for any information on the outcome of its use and/or any suggestions for improving the quiz itself.

## List of Abbreviations

HDL: High Density Lipoprotein

LDL: Low Density Lipoprotein

TAG: Triacylglycerol

THF: Tetrahydrofolic acid

TLC: Therapeutic Lifestyle Changes Diet

ATP III: Third Report of the National Cholesterol Education Program Adult Treatment Program

NCEP: National Cholesterol Education Program

GI: glycemic index

GL: glycemic load

CVD: Cardiovascular Disease

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## References

1. Torti FM, Adams KM, Edwards LJ, Lindell KC, Zeisel SH: **Survey of Nutrition Education in U.S. Medical Schools – An Instructor-Based Analysis.** *Med Educ Online* 2001, **6:8**.

2. Cooksey K, Kohlmeier M, Plaisted C, Adams K, Zeisel SH: **Getting nutrition education into medical schools: a computer-based approach.** *Am J Clin Nutr* 2000, **72**(3 Suppl):868S-876S.
3. Lo C: **Integrating nutrition as a theme throughout the medical school curriculum.** *Am J Clin Nutr* 2000, **72**(3 Suppl):882S-889S.
4. Flynn M, Sciamanna C, Vigilante K: **Inadequate physician knowledge of the effects of diet on blood lipids and lipoproteins.** *Nutr J* 2003, **2**(1):19.
5. Bruer RA, Schmidt RE, Davis H: **Nutrition counseling--should physicians guide their patients?** *Am J Prev Med* 1994, **10**(5):308-311.
6. **Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report.** *Circulation* 2002, **106**(25):3143-3421.
7. Keys A, ed: **Coronary heart disease in seven countries.** 1970, **41** (Suppl):1-211.
8. Hu FB, Manson JE, Willett WC: **Types of dietary fat and risk of coronary heart disease: a critical review.** *J Am Coll Nutr* 2001, **20**(1):5-19.
9. Hellerstein MK: **Carbohydrate-induced hypertriglyceridemia: modifying factors and implications for cardiovascular risk.** *Curr Opin Lipidol* 2002, **13**(1):33-40.
10. Hellerstein MK: **De novo lipogenesis in humans: metabolic and regulatory aspects.** *Eur J Clin Nutr* 1999, **53** Suppl 1:S53-65.
11. Hudgins LC: **Effect of high-carbohydrate feeding on triglyceride and saturated fatty acid synthesis.** *Proc Soc Exp Biol Med* 2000, **225**(3):178-183.
12. Hudgins LC, Hellerstein M, Seidman C, Neese R, Diakun J, Hirsch J: **Human fatty acid synthesis is stimulated by a eucaloric low fat, high carbohydrate diet.** *J Clin Invest* 1996, **97**(9):2081-2091.
13. Hudgins LC, Hellerstein MK, Seidman CE, Neese RA, Tremaroli JD, Hirsch J: **Relationship between carbohydrate-induced hypertriglyceridemia and fatty acid synthesis in lean and obese subjects.** *J Lipid Res* 2000, **41**(4):595-604.
14. Mensink RP, Zock PL, Kester AD, Katan MB: **Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials.** *Am J Clin Nutr* 2003, **77**(5):1146-1155.
15. Ludwig DS, Jenkins DJ: **Carbohydrates and the postprandial state: have our cake and eat it too?** *Am J Clin Nutr* 2004, **80**(4):797-798.
16. Volek JS, Gomez AL, Kraemer WJ: **Fasting lipoprotein and postprandial triacylglycerol responses to a low-carbohydrate diet supplemented with n-3 fatty acids.** *J Am Coll Nutr* 2000, **19**(3):383-391.
17. Volek JS, Gomez AL, Love DM, Weyers AM, Hesslink R, Jr., Wise JA, Kraemer WJ: **Effects of an 8-week weight-loss program on cardiovascular disease risk factors and regional body composition.** *Eur J Clin Nutr* 2002, **56**(7):585-592.
18. Volek JS, Sharman MJ, Gomez AL, Scheett TP, Kraemer WJ: **An Isoenergetic Very Low-Carbohydrate Diet Is Associated With Improved Serum High-Density Lipoprotein Cholesterol (HDL-C), Total Cholesterol to HDL-C Ratio, Triacylglycerols, and Postprandial Lipemic Responses Compared to a Low-Fat Diet in Normal Weight, Normolipidemic Women.** *J Nutr* 2003, **133**(9):2756-2761.
19. Yancy WS, Jr., Westman EC, French PA, Califf RM: **Diets and clinical coronary events: the truth is out there.** *Circulation* 2003, **107**(1):10-16.
20. Westman EC, Yancy WS, Edman JS, Tomlin KF, Perkins CE: **Effect of 6-month adherence to a very low carbohydrate diet program.** *Am J Med* 2002, **113**(1):30-36.
21. Foster GD, Wyatt HR, Hill JO, McGuckin BG, Brill C, Mohammed BS, Szapary PO, Rader DJ, Edman JS, Klein S: **A randomized trial of a low-carbohydrate diet for obesity.** *N Engl J Med* 2003, **348**(21):2082-2090.
22. Noakes M, Foster P, Keogh J, Clifton P: **Very low carbohydrate diets for weight loss and cardiovascular risk.** *Asia Pac J Clin Nutr* 2004, **13**(Suppl):S64.

23. **Food Consumption, Prices, and Expenditures, 1970-97**  
[<http://www.ers.usda.gov/publications/sb965/>]
24. Enns CK, Goldman JD, Cook A: **Trends in Food and Nutrient Intakes by Adults: NFCS 1977-78, CSFII 1989-91, and CSFII 1994-95.** *Family Economics and Nutrition Review* 1997, **10**:2-15.
25. Hu FB, Stampfer MJ, Manson JE, Rimm E, Colditz GA, Rosner BA, Hennekens CH, Willett WC: **Dietary fat intake and the risk of coronary heart disease in women.** *N Engl J Med* 1997, **337**(21):1491-1499.
26. Brand-Miller JC, Holt SH, Pawlak DB, McMillan J: **Glycemic index and obesity.** *Am J Clin Nutr* 2002, **76**(1):281S-285S.
27. Ludwig DS, Majzoub JA, Al-Zahrani A, Dallal GE, Blanco I, Roberts SB: **High glycemic index foods, overeating, and obesity.** *Pediatrics* 1999, **103**(3):E26.
28. Ludwig DS: **Dietary glycemic index and obesity.** *J Nutr* 2000, **130**(2S Suppl):280S-283S.
29. Kraemer HC: **Biserial Correlation.** In: *Encyclopaedia of Statistical Sciences.* vol. 1. New York: Wiley; 1982: 276-279.
30. Klein S, Sheard NF, Pi-Sunyer X, Daly A, Wylie-Rosett J, Kulkarni K, Clark NG: **Weight management through lifestyle modification for the prevention and management of type 2 diabetes: rationale and strategies. A statement of the American Diabetes Association, the North American Association for the Study of Obesity, and the American Society for Clinical Nutrition.** *Am J Clin Nutr* 2004, **80**(2):257-263.
31. Klein S, Burke LE, Bray GA, Blair S, Allison DB, Pi-Sunyer X, Hong Y, Eckel RH: **Clinical implications of obesity with specific focus on cardiovascular disease: a statement for professionals from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation.** *Circulation* 2004, **110**(18):2952-2967.
32. Atkins RC: **Dr. Atkins' New Diet Revolution.** New York: Avon Books; 2002.
33. Adeli K, Taghibiglou C, Van Iderstine SC, Lewis GF: **Mechanisms of hepatic very low-density lipoprotein overproduction in insulin resistance.** *Trends Cardiovasc Med* 2001, **11**(5):170-176.
34. Walker WA: **Overview.** *American Journal of Clinical Nutrition* 2000, **72**:865S-867S.
35. Willett W: **Nutritional Epidemiology,** vol. 30, Second edn. New York: Oxford University Press; 1998.
36. Willett WC, Leibel RL: **Dietary fat is not a major determinant of body fat.** *Am J Med* 2002, **113 Suppl 9B**:47S-59S.
37. Reaven GM: **Do high carbohydrate diets prevent the development or attenuate the manifestations (or both) of syndrome X? A viewpoint strongly against.** *Curr Opin Lipidol* 1997, **8**(1):23-27.
38. Slyper AH: **The pediatric obesity epidemic: causes and controversies.** *J Clin Endocrinol Metab* 2004, **89**(6):2540-2547.
39. Ludwig DS: **Diet and development of the insulin resistance syndrome.** *Asia Pac J Clin Nutr* 2003, **12 Suppl**:S4.
40. Weinberg SL: **The diet-heart hypothesis: a critique.** *J Am Coll Cardiol* 2004, **43**(5):731-733.
41. Mozaffarian D, Rimm EB, Herrington DM: **Dietary fats, carbohydrate, and progression of coronary atherosclerosis in postmenopausal women.** *Am J Clin Nutr* 2004, **80**(5):1175-1184.
42. Knopp RH, Retzlaff BM: **Saturated fat prevents coronary artery disease? An American paradox.** *Am J Clin Nutr* 2004, **80**(5):1102-1103.
43. Feinman RD, Makowske M: **Metabolic Syndrome and Low-Carbohydrate Ketogenic Diets in the Medical School Biochemistry Curriculum.** *Metabolic Syndrome and Related Disorders* 2003, **1**:189-198.  
[<http://miranda.ingentaselect.com/vl=2236146/cl=61/nw=1/rpsv/cw/mal/15404196/v1n3/s5/p189>]
44. McArdle W, Katch F, Katch V: **Exercise Physiology. Energy, Nutrition, and Human Performance,** Fifth edn. Philadelphia: Lippincott Williams & Wilkins; 2001.

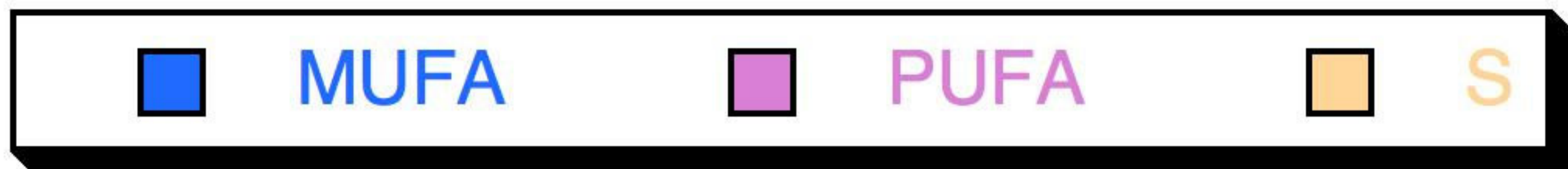
## Figures

Figure 1. Fatty acid composition of common dietary fats and oils. Data from Figure 1.9 of reference [44].

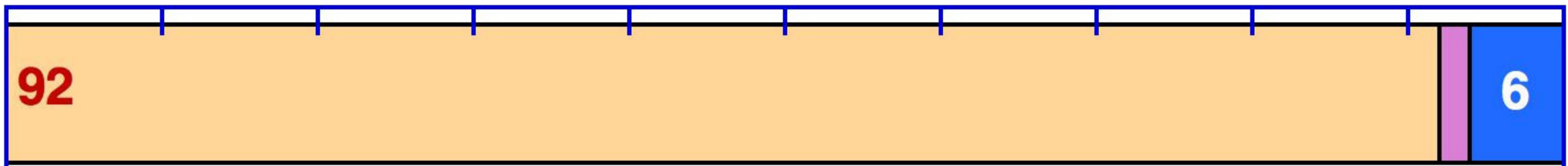
Figure 2. Performance of physicians and first year medical students on questionnaire. Data on physicians from reference [4].

Figure 3. Changes in fat and carbohydrate between 1977 and 1995. Data from USDA as reported in reference [24].

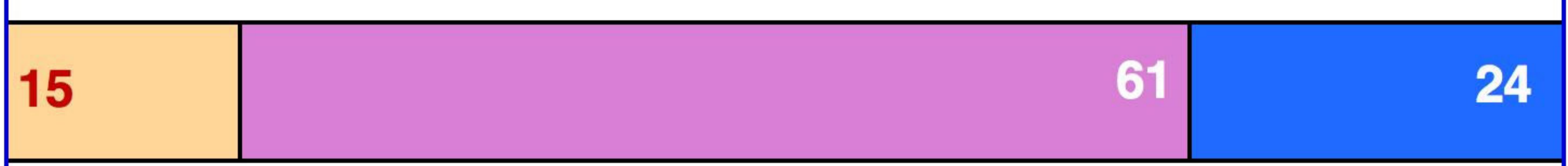
Figure 4. Effect of substitution of 5 % of calories on incidence of cardiovascular disease. Data from Hu, *et al.* [8]



**Coconut Oil**



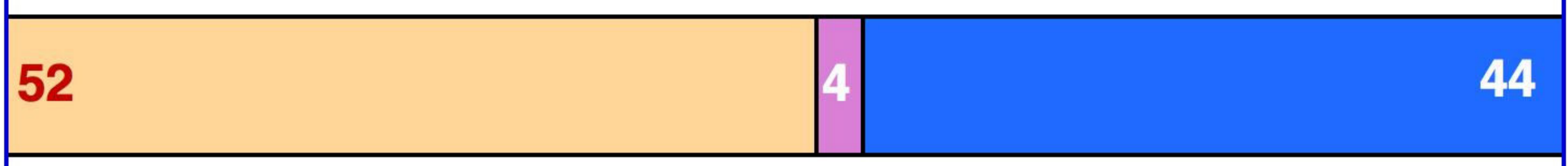
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(~ Corn Oil)**



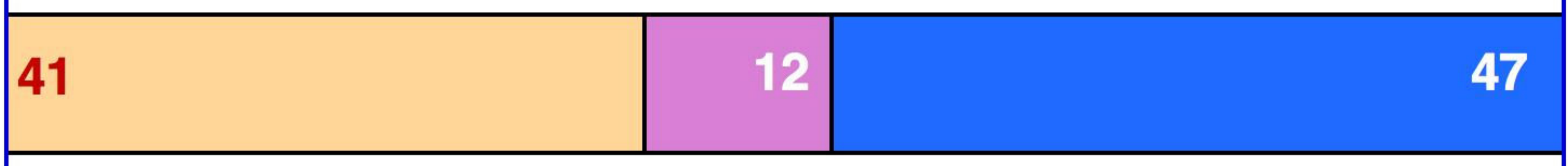
**Butter Fat**



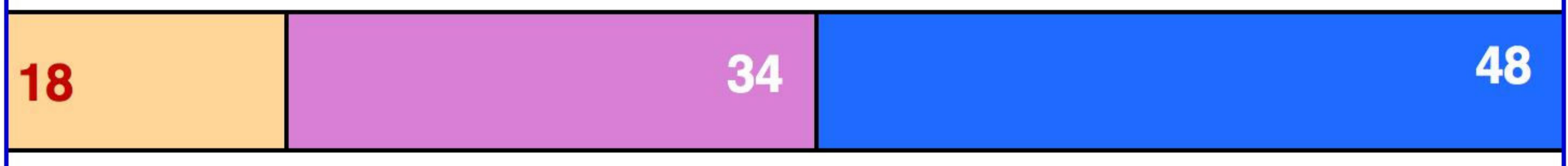
**Beef Tallow**



**Lard**



**Peanut Oil**



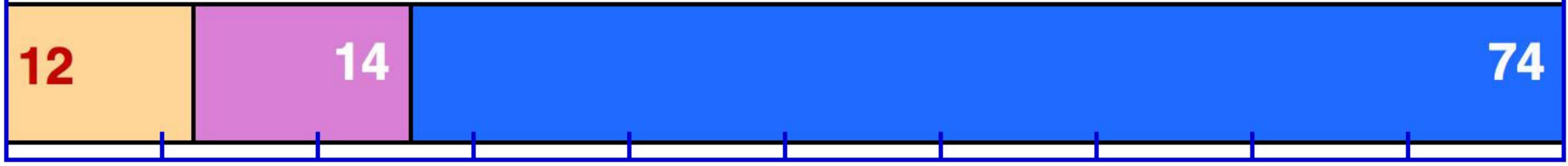
**Canola Oil**



**Olive Oil**



**Avocado Oil**



0 20 40 60 80 100

**Per Cent Fatty Acid**

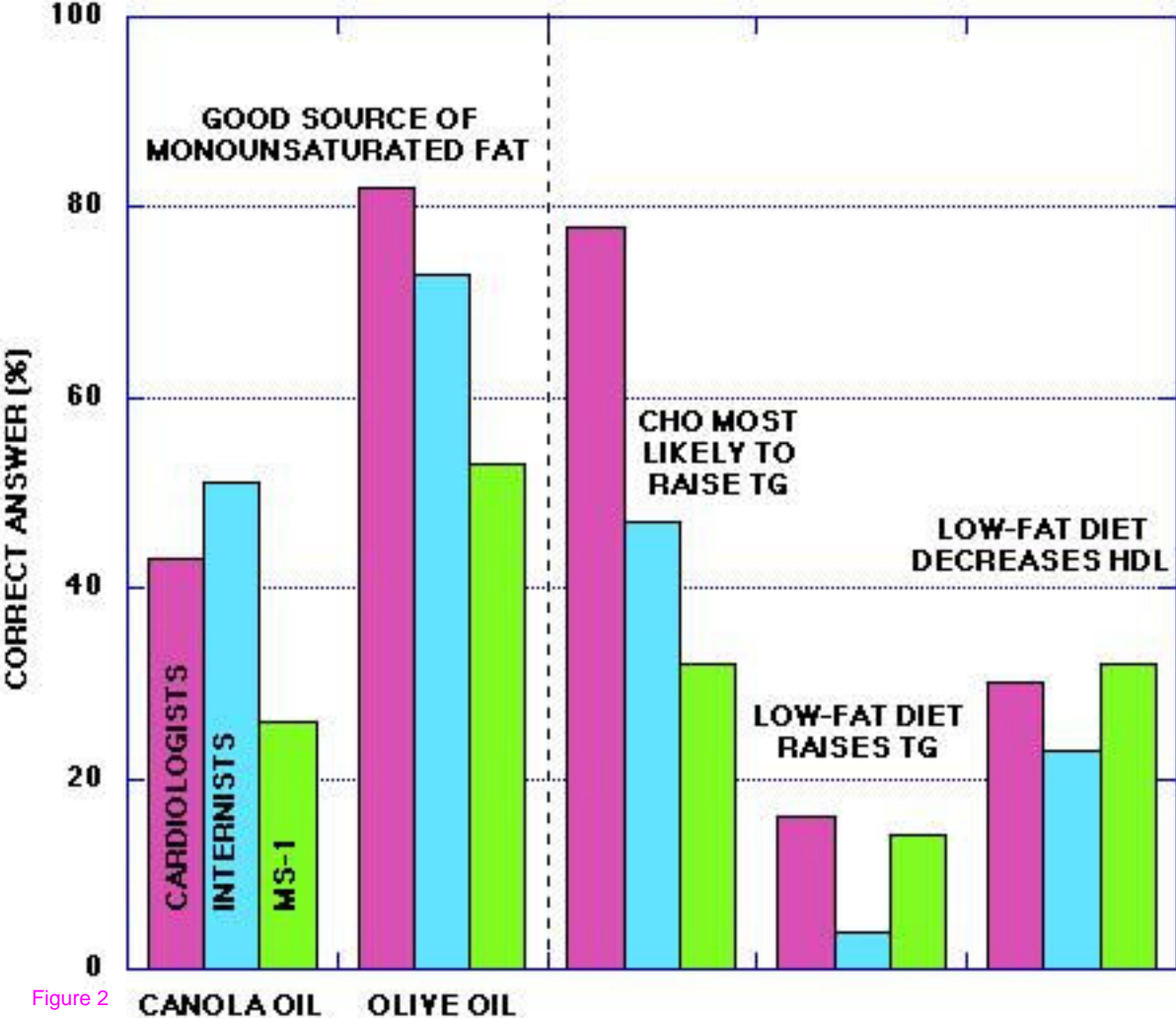


Figure 2

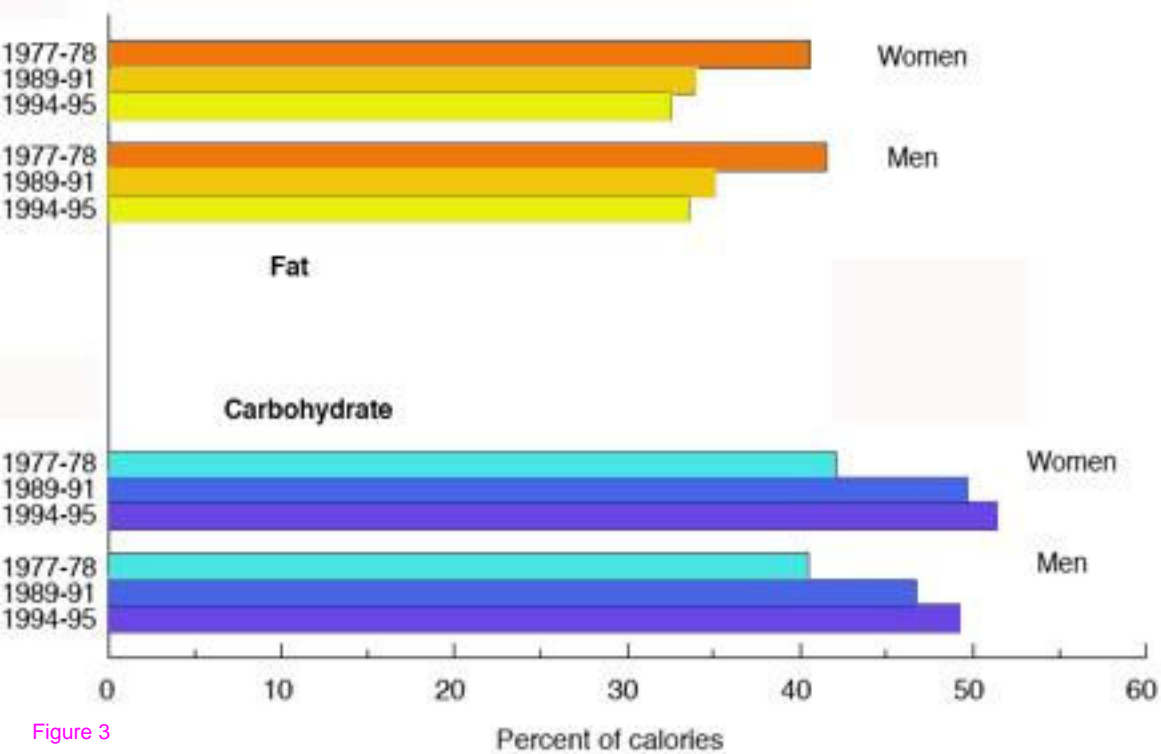


Figure 3

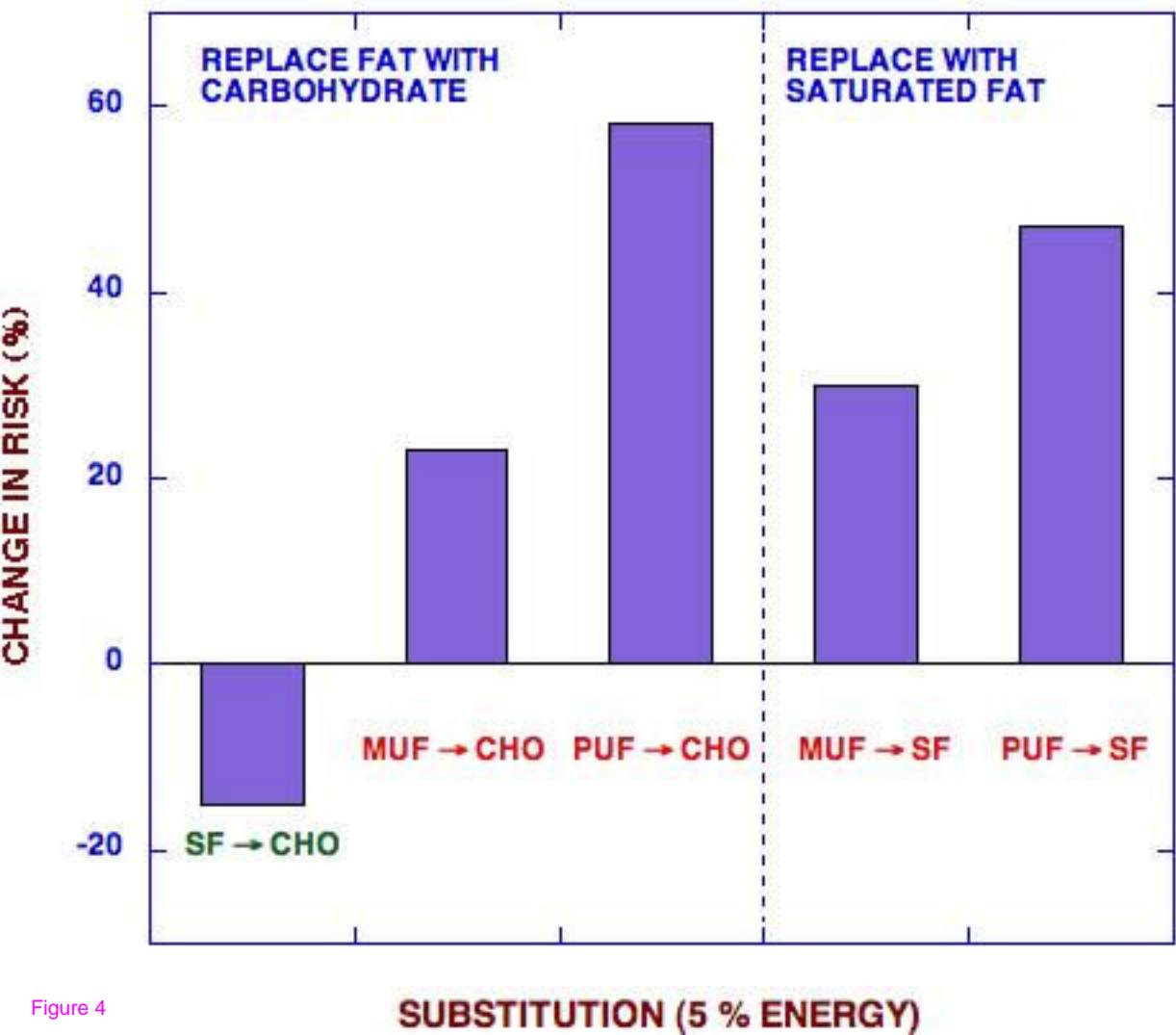


Figure 4