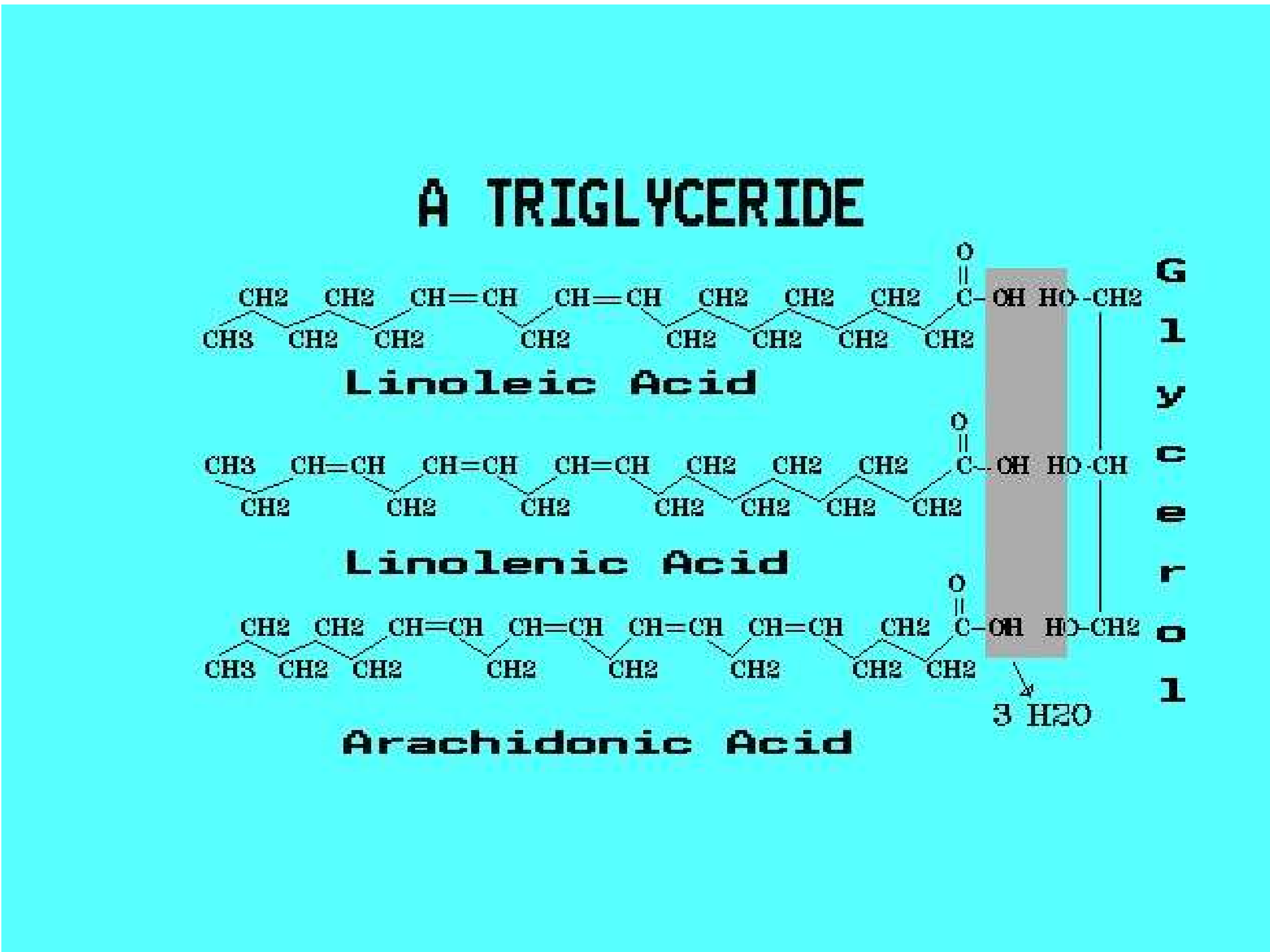
III. THE FAT FOLLIES

"The United States is the only nation where even the poor people are pudgy."

-Anon.

Linoleic acid and linolenic acid are apparently the only fats required in the human diet[1]. They are synthesized only by plants and are needed in the amount 1-2% of Calories/day (about 3-6 grams)[2]. From them dozens of other fatty acids can be synthesized by adding or removing two carbons at a time and adding or removing double bonds, all by enzymatic processes within the body. It's difficult to design a whole food vegan diet which has less than 6 grams of linoleic and linolenic acid/day or which has less than the recommended minimum of 10-14% total Calories from fat[3]. The average American fat intake is 38%[4].

The structure of neutral fat (triglyceride) is straightforward. It consists of a molecule of glycerol, synthesized in the body from carbohydrate, and enzymatically linked to various fatty acids. Three of the commonest are shown:

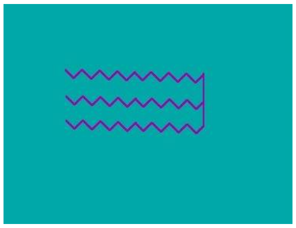


[2] Lindner M. *Nutritional Biochemistry and Metabolism.* Elsevier Science Publishing Co. New York 1985. ISBN 0-444-01241-9. p 36.

[3] N-Squared Computing. *Nutritionist III, v4.5*. Salem OR, 1988.

[4] See note 2, p33.

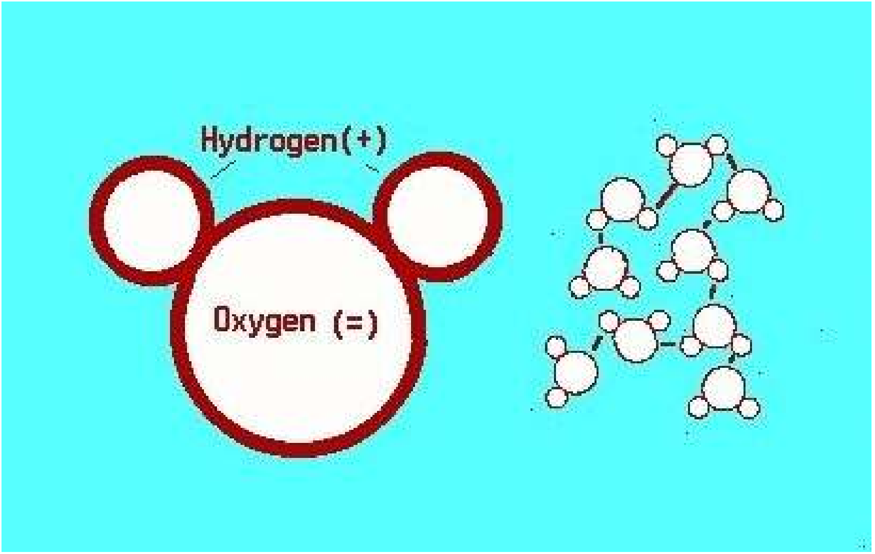
We'll abbreviate triglyceride thus:



Neutral fats are characterized by the number of carbons and the number of double bonds in their fatty acids. Unsaturated fatty acids (mostly vegetable) have up to five double bonds[5], and tend to be short. Saturated (mostly animal) fats have few double bonds, longer carbon chains and they're heavier, have higher melting points and are more likely to be solid at body temperature.

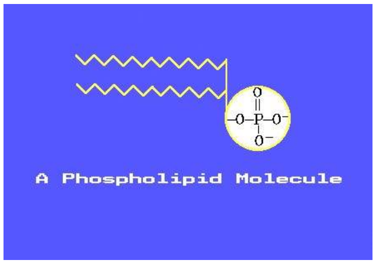
The fatty acids synthesized in an animal reflect the animal species but the type of fatty acid stored in the animal's adipose tissue in part reflects the dietary fat[6]. The fat you eat is the fat you wear[7].

Now water molecules have been around four billion years and they're a very exclusive bunch. If water molecules get together they look like Mickey Mouse:

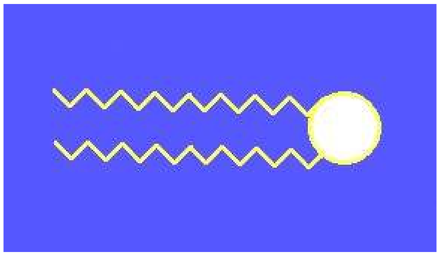


The positively charged hydrogen atoms link transiently to the negatively charged oxygen atoms of adjacent water molecules and because of this "hydrogen bonding" water is liquid at room temperature whereas most other such small molecules are gases[8].

Water molecules are so in love with each other that most other molecules just get squeezed out, but if one of the fatty acids in a triglyceride is replaced by a phosphoryl group the new molecule looks like this:



which we'll graphically abbreviate with this:



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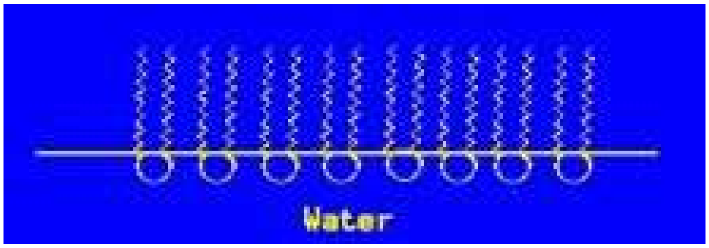
[5] See note 1, p 219.

[6] *Encyclopedia Britannica.* Encyclopedia Britannica, Inc. London 1974. Vol. 13, p 524.

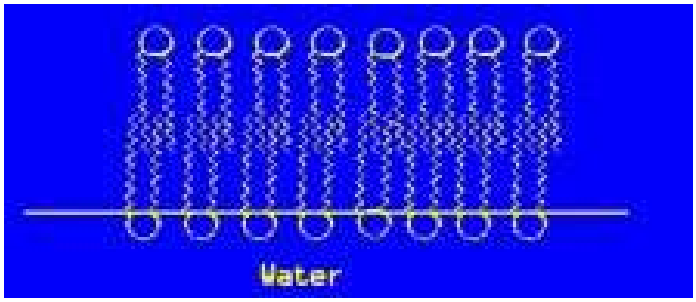
[7] Wohl and Goodhart. *Modern Nutrition in Health and Disease*. Lea and Febiger. Philadelphia 1968. p 191.

[8] Rand McNally. *The Random House Encyclopedia*. Random House, Inc. New York 1977. ISBN 0-394-40730-X. p 1562.

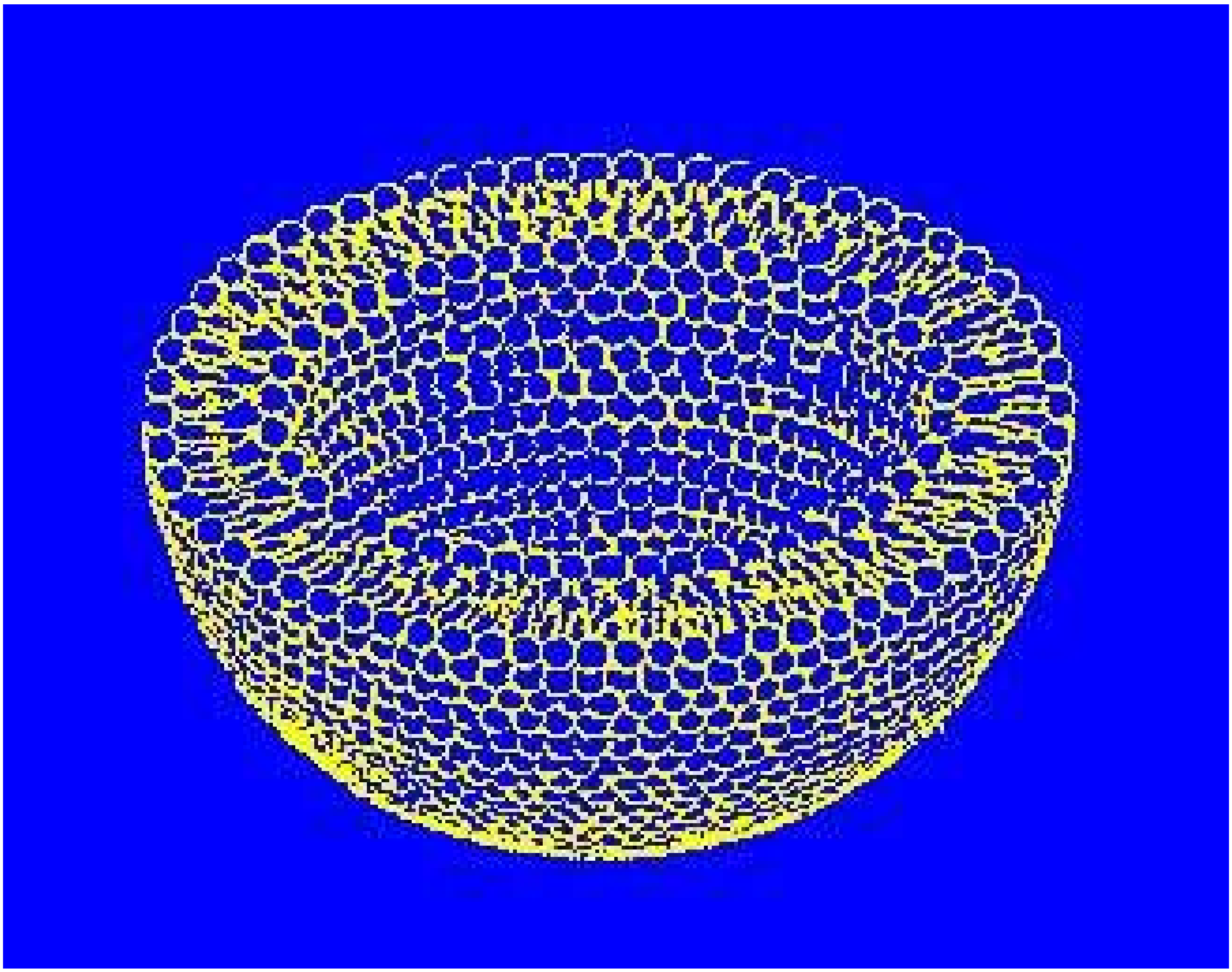
The phosphoryl end of the phospholipid has a negative charge which interests the fickle positive charges on the oxygen atoms in the water. When the first phospholipids turned up 3-1/2 billion years ago they got a grudging acceptance from the water molecules which covered most of the Earth. The phosphoryl end gets to play with water which at the same time rejects the fatty acid tails:



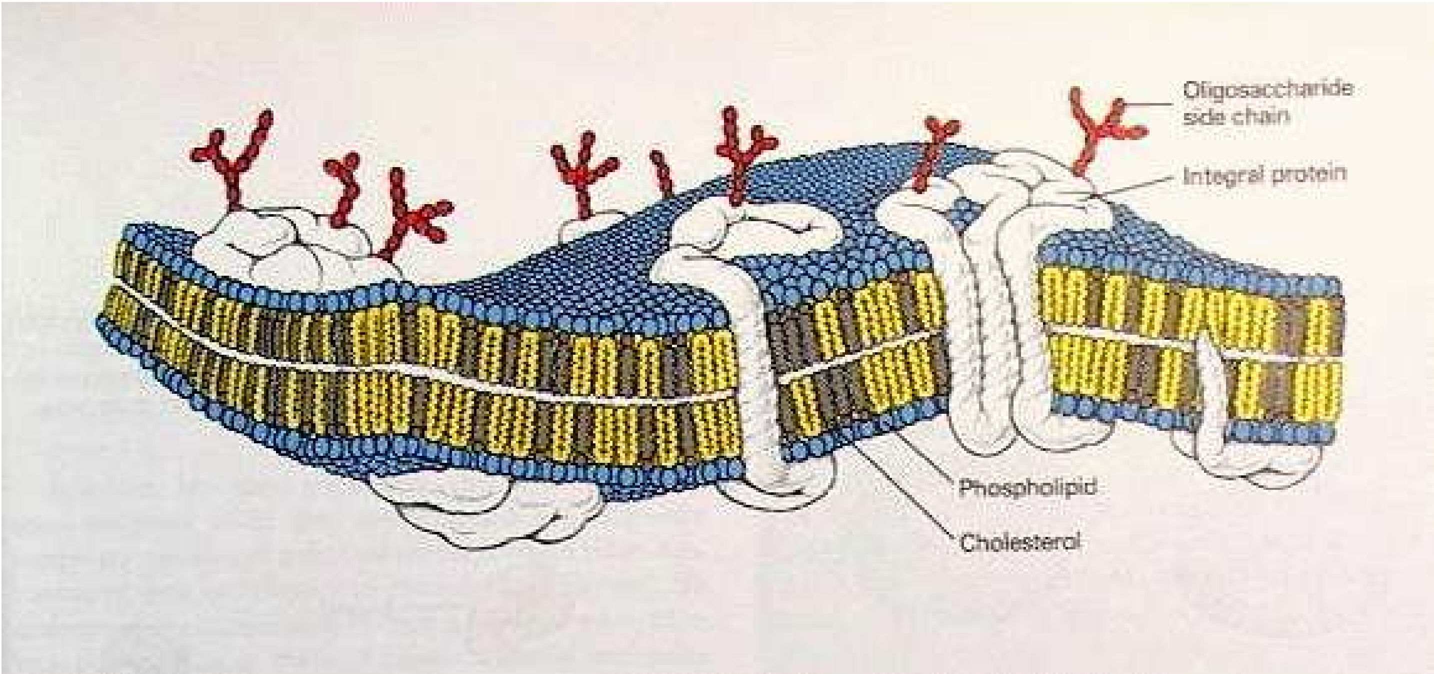
The fatty ends of the phospholipid the water doesn't like get along okay with each other so a natural arrangement is the lipid bilayer which looks like this:



If something (say a breaking wave or a wind) shakes up the bilayer floating on the water we get the perfect segregation scheme, a little bilayer bubble of phospholipids with water on the outside and inside and everybody happy because none of the molecules have to associate with molecules they don't like.

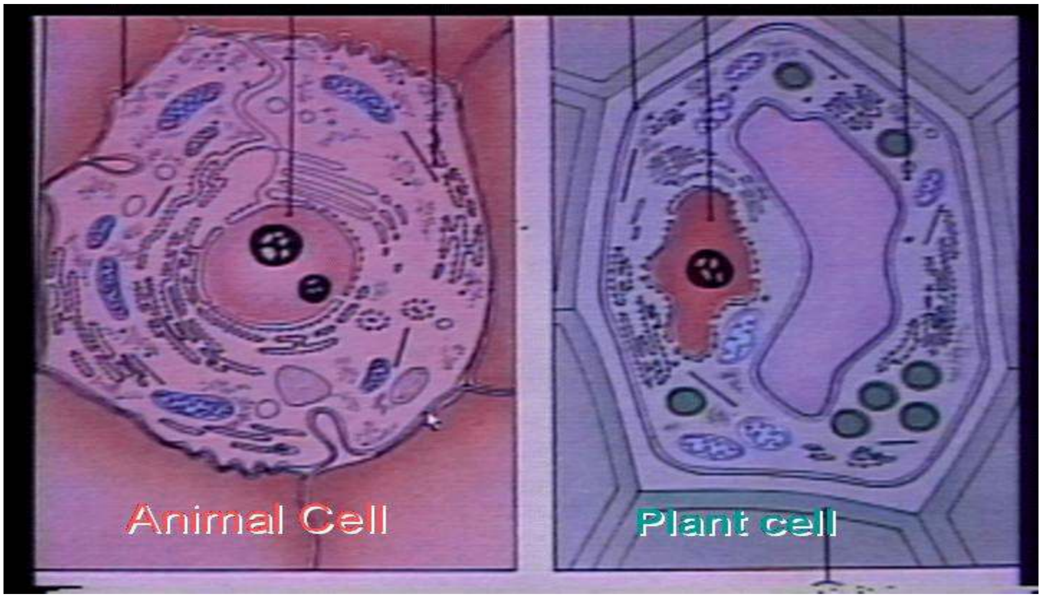


Evolution then threw in a few molecules of that great new invention, cholesterol, to stabilize the bubble membrane and the first animal cells were born. On the outside were predatory molecules looking for customers, on the inside were well behaved molecules of DNA, enzymes, protein, etc. who'd learned to conduct civilized transactions with each other.



Plants use a similar gimmick. Their cell membranes are also made of phospholipids and sterols[9] but the fatty acids have fewer double bonds and no cholesterol.

On the outside of the membrane there's a cell wall made of cellulose, a tough and rigid polymer of glucose. Animal cell membranes are like tough flexible inner tubes. Plant cell membranes are like flimsy inner tubes with tough tires on the outside.



[9] Salisbury p124.

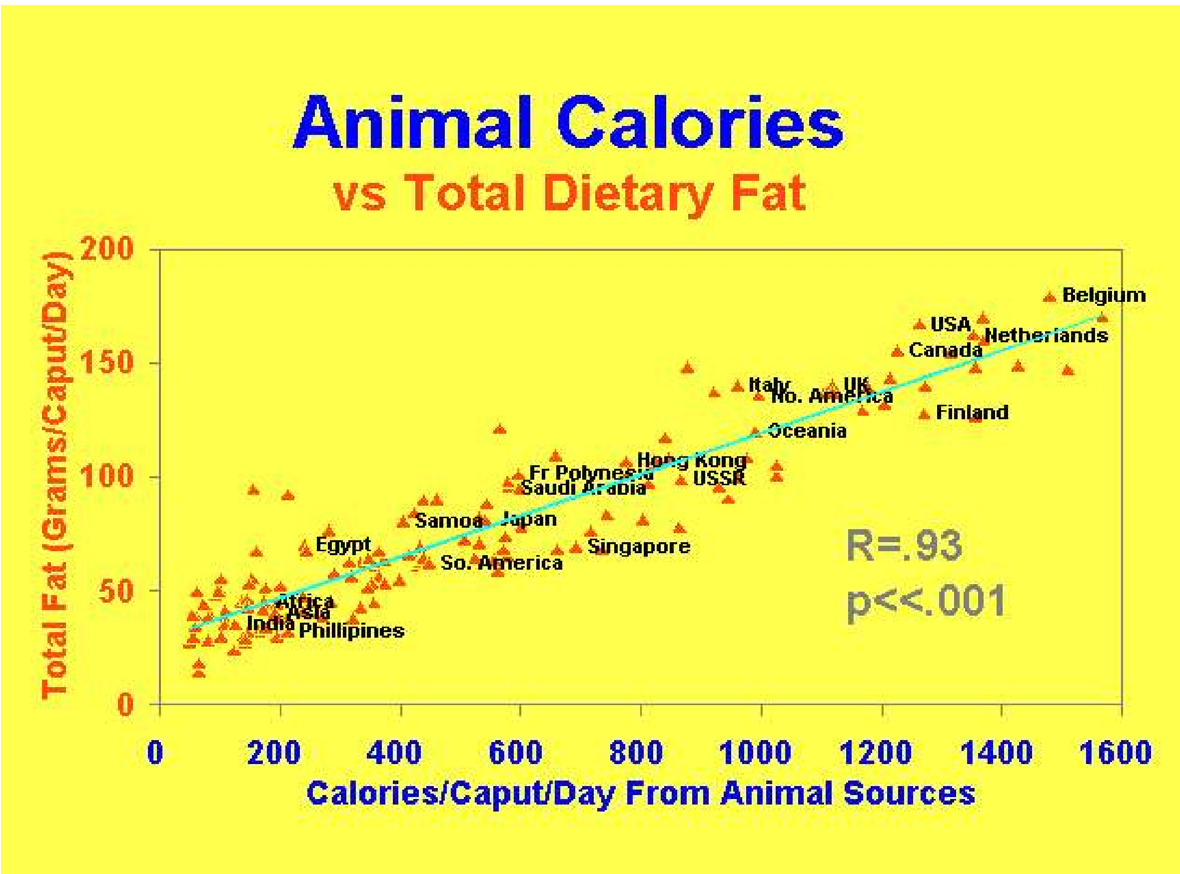
That's the first reason why animal source food is full of fat and cholesterol and plant food isn't. The second reason is that those civilized "inside" molecules learned how to extract nine Calories of biochemical energy from each gram of fat while they could get only four Calories from a gram of carbohydrate or protein. Calories were hard to come by so animals learned to hoard fat in special adipose cells in case of famine. Under those conditions it was still a useful evolutionary strategy for animals to eat other animals, since as we can now see by looking at the girth of our omnivorous friends, fat stores easily and it stays around forever, so there's no danger of starvation.

It seems likely that humans are now a genetically fat-addicted species. Eating fat in lean times was such a life saver that the pre-humans who had a strong taste for it were most likely to survive to become our ancestors. They graciously passed along their fat-craving genes without knowing there would come a time of plenty in which those genes would be a disaster.

Fat is also a dandy thermal and electrical insulator so it's found in quantity under the skin and in the Schwann cells which surround nerves.

Having established the reasons for having fat in the body we should note there are some problems associated with having too much fat in the diet.

It's fairly intuitive that consumption of animal food increases the intake of fat. The data points are so dense that only a few labels are given for clarity[10,11]. Similar linear graphs (not shown) make it clear that in dietary analysis we can interchange the terms "Animal Calories, Total Calories, Animal Fat, and Total Fat".



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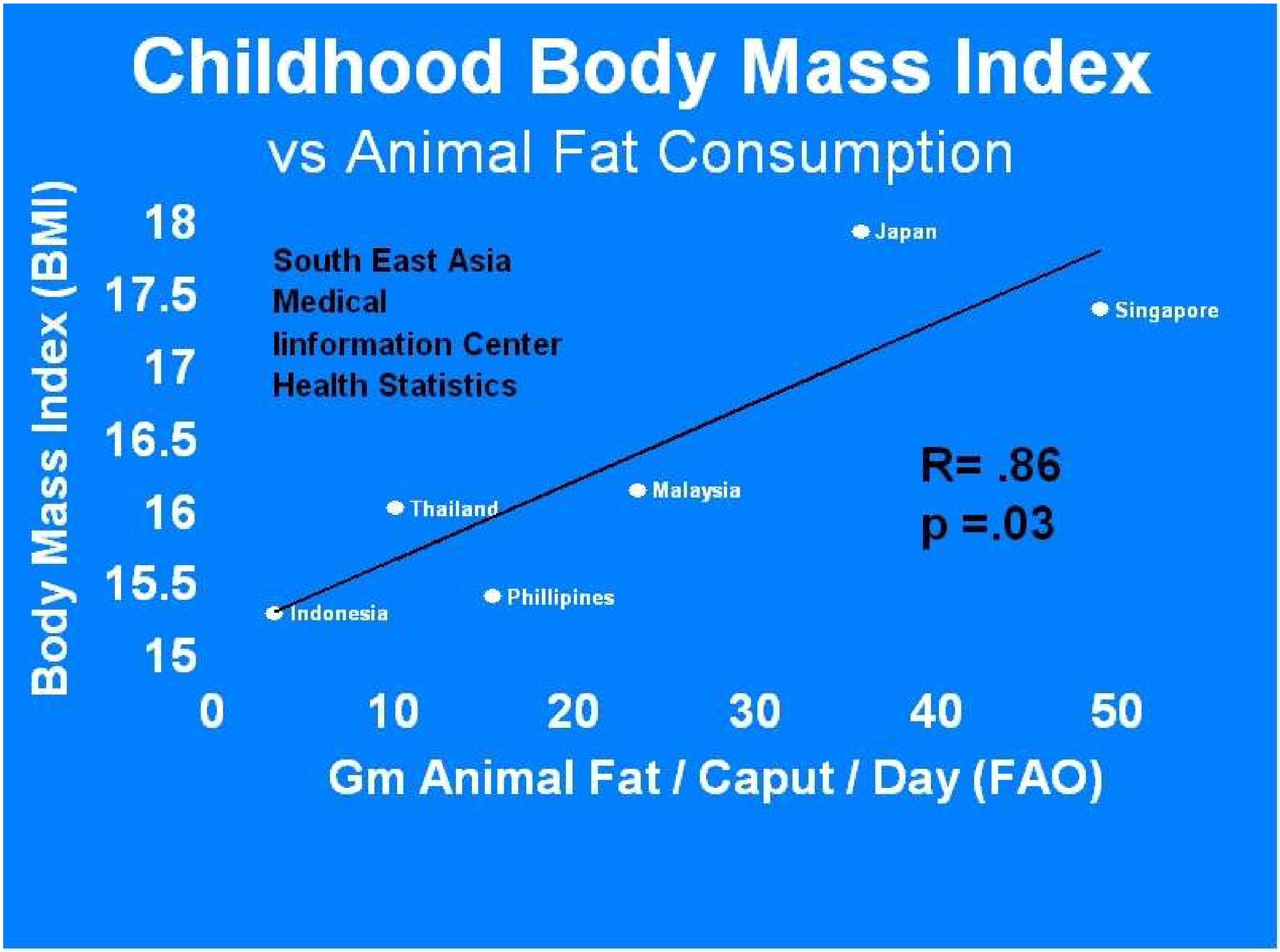
[10] Borland International. *Quattro Pro for Windows* v5.0. (A Graphic Spreadsheet). Scotts Valley, CA 1993.

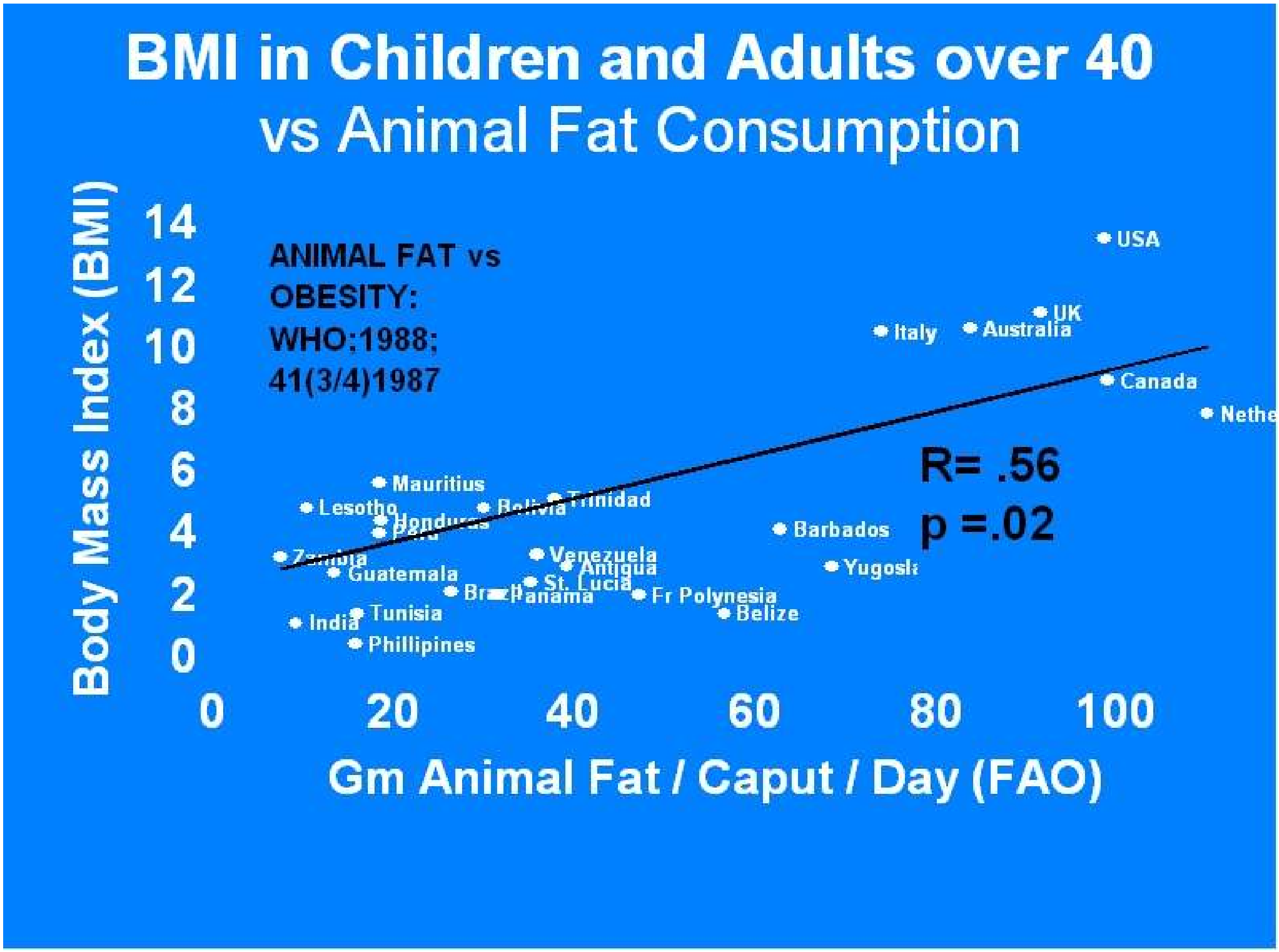
[11] Food and Agriculture Organization of the United Nations. *FAO Production Yearbook*. Rome, 1987. (All subsequent graphs utilize this source for X axis data).

Unfortunately there's not much epidemiological data on obesity. The following is from six Asian countries which keep median weight and height figures for their children. Body Mass Index (BMI) is defined as weight (kgs) divided by the square of the height (meters)[12]. A BMI of 30 or more signifies "a high degree of fatness." Since these six countries are not big time fat eaters to begin with the graph does not suggest obesity but perhaps a tendency in that direction in the countries using the most animal fat.



[12] Committee on Health Statistics. *SEAMIC Health Statistics*. Southeast Asia Medical Information Center. International Medical Foundation of Japan 1988.

Recent work indicates that increased fat intake is the only distinct difference in eating behavior between obese and lean adults[13]. On the next page is a evidence from the World Health Organization on the correlation between animal fat consumption and obesity[14]. Children under five and adults over forty who have had longer exposure to high fat diets seem to be primarily affected.



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[13] Miller WC, Lindeman AK, Wallace J, Niederpruem M. *Diet composition, energy intake, and exercise in relation to body fat in men and women.* Am J Clin Nutr. Sept 1990;52(3):426-30.

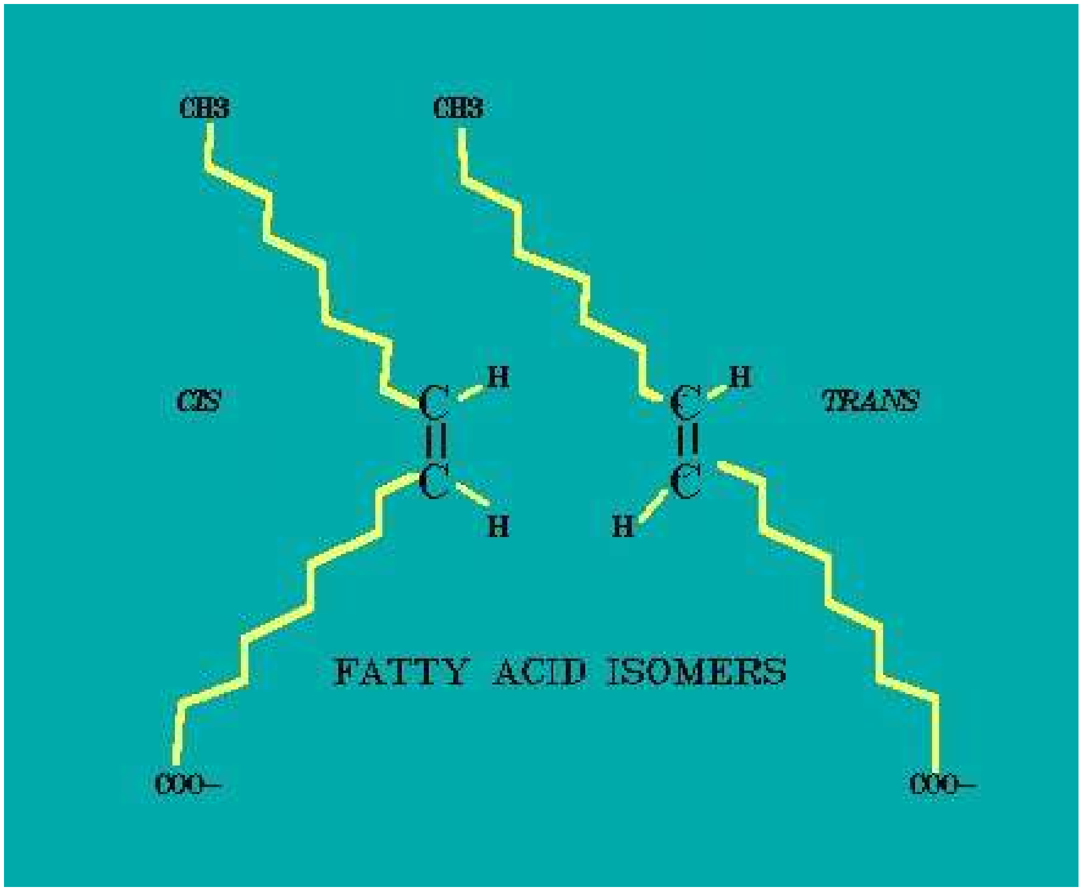
[14] Gurney M, and Gorstein J. *The Global Prevalence of Obesity-An Initial Overview of Available Data.* World Health Statistics Quarterly. 1988;41(3/4):251-254.

There are at least 1800 weight-loss diet books in print. The checkout stand tabloids and the ladies mags feature a new diet every month but few of them say the dreaded "V" word (vegan) although there are almost no obese vegans. It's part of addictive behavior to look for answers in every spot but the right one.

Animal fat is a bad dietary idea but refined vegetable fat is no bargain either. Since the turn of the century the degenerative disease rates in the US have gone up in parallel with fat consumption but the animal food folks are fond of pointing out that animal fat consumption has actually gone down[15] which means that our use of vegetable oils has gone up.

Aside from using the stuff in the first place there are a few other marginal things you can do to vegetable oil *before* you eat it.

First off you can hydrogenate it by heating it in the presence of nickel and hydrogen[16], thus removing some of the double bonds and making it thicker. This technique is favored by commercial peanut butter and chip/dip manufacturers but the problem is that in this non-enzymatic hydrogenation process as some of the double bonds are being converted to single bonds others are going from *cis* to *trans*.



Some bacteria synthesize *trans* fatty acids but higher animals only synthesize *cis* fatty acids. Not all the returns are in yet in but it appears that *trans* fatty acids raise cholesterol and LDL (Low Density Lipoprotein) levels[17], while lowering HDL (High Density Lipoproteins). They can be used for fuel but they accumulate in the phospholipids of cell membranes[18] with unknown results.

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[15] See note 23, p 132

[16] See note 6, Vol.14 p 530.

[17] Mensink RP, Katan MB. *Effect of dietary trans fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects.* New England Journal of Medicine. Aug 16 1990:323(7):439-45.

[18] See note 2, p47.

We can speculate on those results however. A normal cell membrane bilayer made up mostly of kinky and folded *cis* fatty acids may be like two strips of Velcro, held firmly to each other. Add trans fatty acids and the kinks start to disappear and the layers start to slide around. Membrane permeability is almost certainly affected. It may not be a coincidence that as the food industry has increasingly bombarded the market with hydrogenated fat the incidence of certain viral diseases such Herpes simplex has gone up. Unlike bacterial infections viruses have to get inside the host cell; it's not likely that *trans* fatty acids do much to keep them out.

Prehistoric humans did not have refined oils. The Egyptians by 2500 BC appear to have used vegetable oils for food and for painting materials[19]. The Mediterranean peoples found out about pressing olives, an apparently benign discovery since as yet no one has pinned the rap on mono-unsaturated olive oil. There does seem to be a problem with poly-unsaturated vegetable oils which lower the risk of Coronary Heart Disease (CHD) but raise the risk of bowel cancer.

One of the true culinary catastrophes, the frying of food in hot oil first appears in English references around 1290 AD[20]. Whose bad idea it was in the first place is difficult to determine.

Raw fooders object to baking, boiling, and steaming. Possibly they're right but these processes simply predigest food by hydrolyzing it (breaking chemical bonds with hot water). Proteins, fats, and carbohydrates are broken down in the GI tract by the same process using enzymes instead of heat[21].

Frying is a whole different ballgame. 100 grams of raw potato in the skin carries 76 Calories of food energy. Boiled, it still has 76 Calories. Baked, it has 93 Calories since it dehydrates slightly. Stripped and deep fried, it's now French fries and 274 Calories. Thin sliced and fried, it becomes 568 Calories of potato chips[22]. In addition to a lowered nutrient/Calorie ratio it also has an outer layer of fat which has been subjected to oxygen and heat. Conventional wisdom[23] holds that frying temperatures are not high enough to degrade fat but there is evidence that if fat is reboiled and recycled often enough it will contain peroxides, epoxides, aldehydes, ketones, cyclic monomers, dimers, and polycyclic hydrocarbons[24]. These substances interfere with normal metabolism and some are carcinogenic.

On balance it appears that vegetable fat in any amount above that found in unprocessed vegetables is a poor idea. Animal fat is worse since it's more likely to be saturated and accompanied by cholesterol. As for cooking with oil, an anonymous author observed: "God sends the food, the devil sends the cook". The cook usually brings his frying pan.

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[19] See note 6, p 523.

[20] *Oxford English Dictionary*. Oxford University Press. Oxford 1989. ISBN 0-19-861186-2. Vol VI p 236.

[21] See note 7, p 43.

[22] United States Department of Agriculture. *Composition of Foods*. Agriculture Handbook No. 8. U.S. Government Printing Office. Washington, DC 20402, 1963.

[23] See note 6, p 527.

[24] See note 23, pp 185-209. Alexander JC. *Heated and Oxidized Fats*.