Evolution and human diet: What can we learn from the past?

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Thoughts of a pioneer !

“We are the heirs of inherited characteristics accrued over millions of years, the vast majority of our biochemistry and physiology are tuned to life conditions that existed prior to the advent of agriculture some 10,000 years ago.

Genetically our bodies are virtually the same as they were at the end of Paleolithic some 20,000 years ago.

The appearance of agriculture and domestication of animals some 10,000 years ago and the Industrial Revolution some 200 years ago introduced new dietary pressures for which no adaptation has been possible in such a short time span.

Thus an inevitable discordance exists between our dietary intake and that which our genes are suited to”.

Eaton SB , Eaton SB III and Konner MJ. Paleolithic nutrition revisited: A twelve year retrospective on its nature and implications. Eur J Clin Nutr, 1997; 51:207-216.

Hypothesis :

The diets of Paleolithic and recent hunter-gatherers may represent a reference standard for modern human nutrition and a model for defense against several western lifestyle diseases.

Or at least give us insights into what aspects of modern foods could be involved in metabolic conditions evident in diseases of modern western lifestyle.

This is exactly what an international group of nutritionists, health experts, anthropologists and food scientists set about to investigate.

Origins and evolution of the western diet: Health implications for the 21st century

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Am J Clin Nutr (2005); 81; 341-354.

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What did our ancestors eat ?

What time period are we talking about?

How do we know?

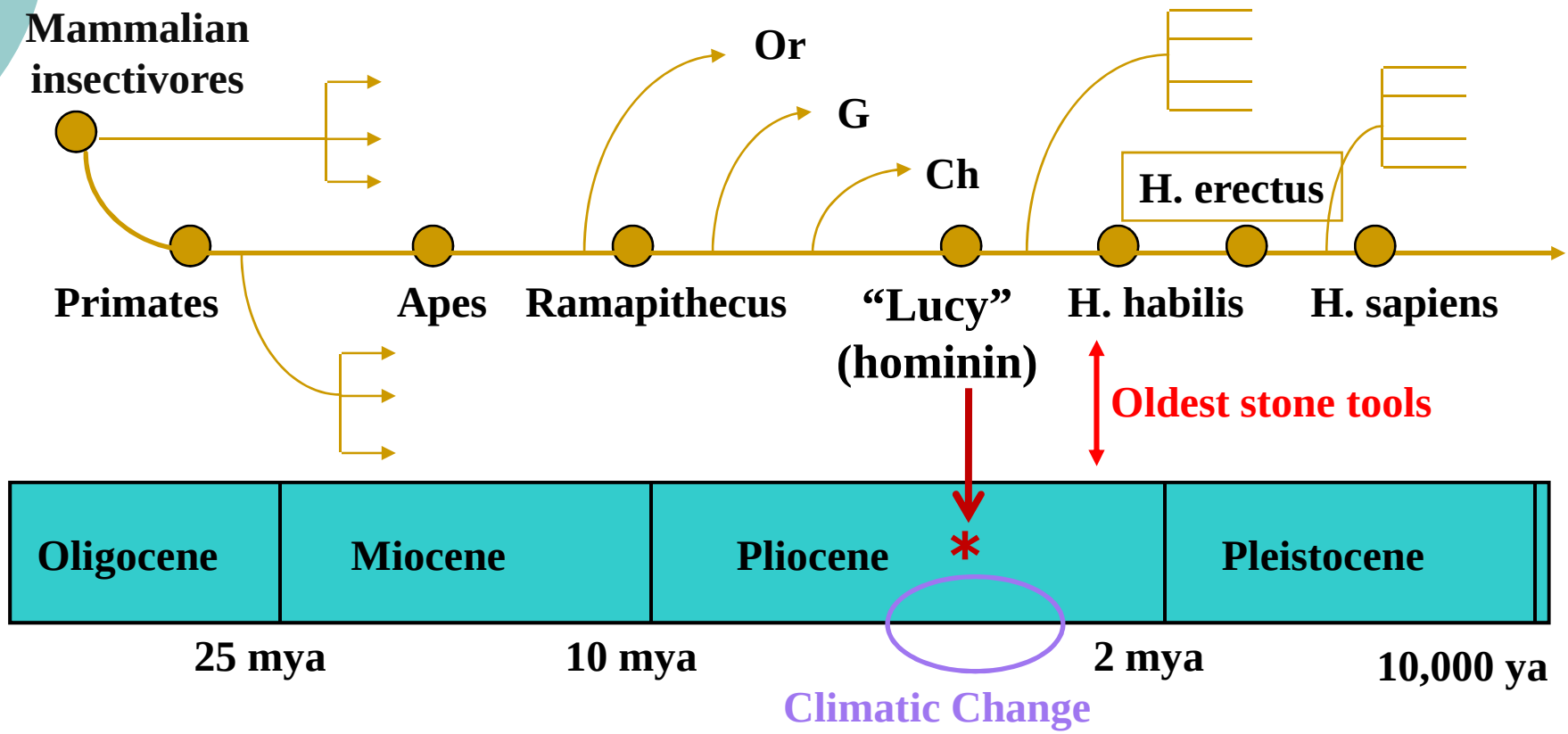
What evolutionary adaptations to diet occurred?

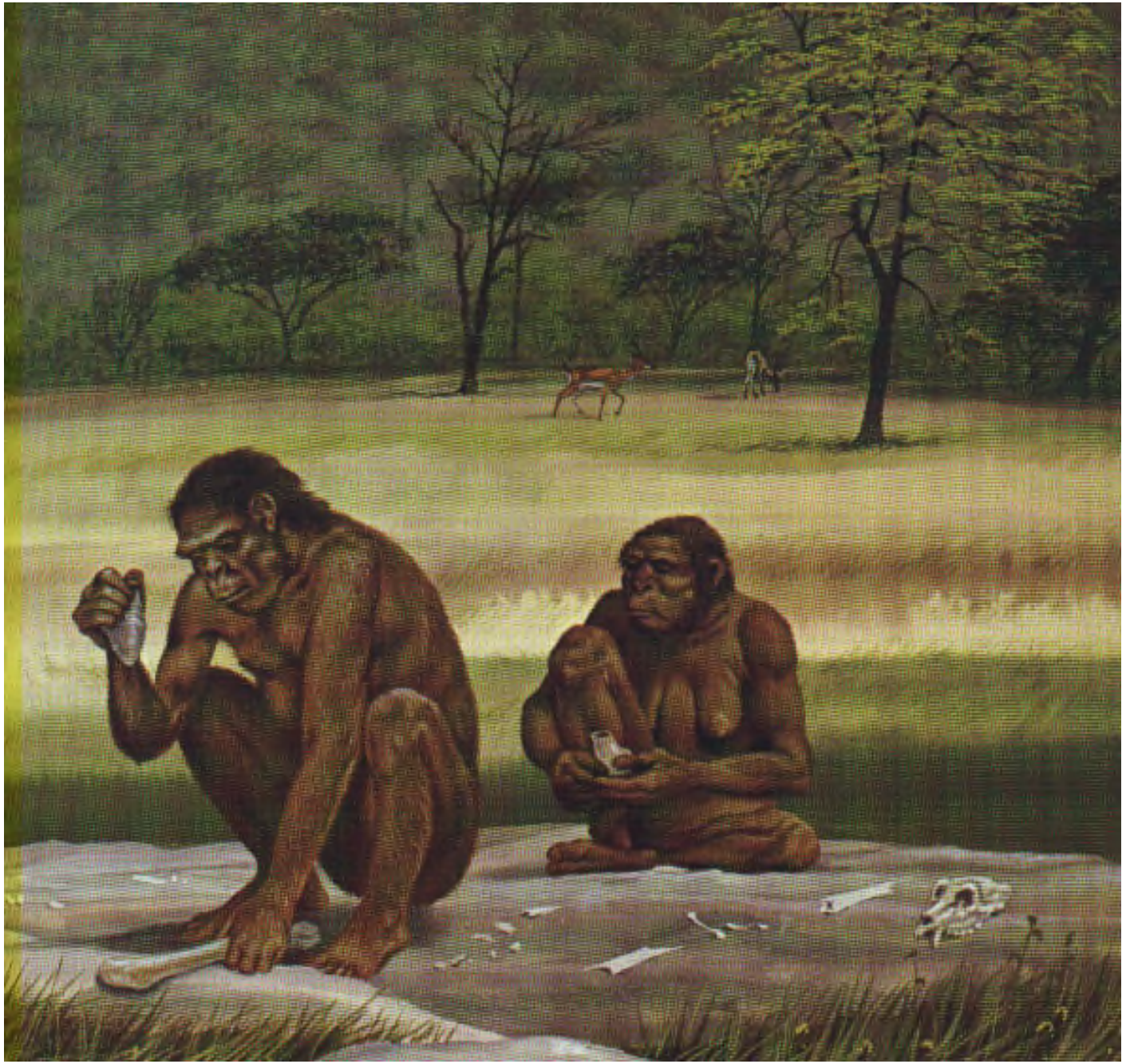
How does modern food differ to ancestral foods?

Does it matter?

Evolution and Diet

Evolution in a geological context





Approximately 3.5 million years ago following global climate change

Australopithecus Aferensis

Evolution and diet - Fields of study

- **Cranio-dental features**
- **Bone C13/C12 isotope ratios**
  (Indicator of foliage type) **(Lee-Thorp et al, J Arch Sci, 1989)**
- **Bone Sr/Ca ratio**
- **(indicator of animal:plant intake)**
  (Sillen et al, J Hum Evol, 1995)
- **Remains of hunted game, tools and weapons**
- **Forensic paleobiology**
  eg. teeth micro-wear patterns
- **Dietary modeling - based on OFT**

In fact: Anthropology literature is extensive and contains much information on food intake habits of our ancestral homminins.

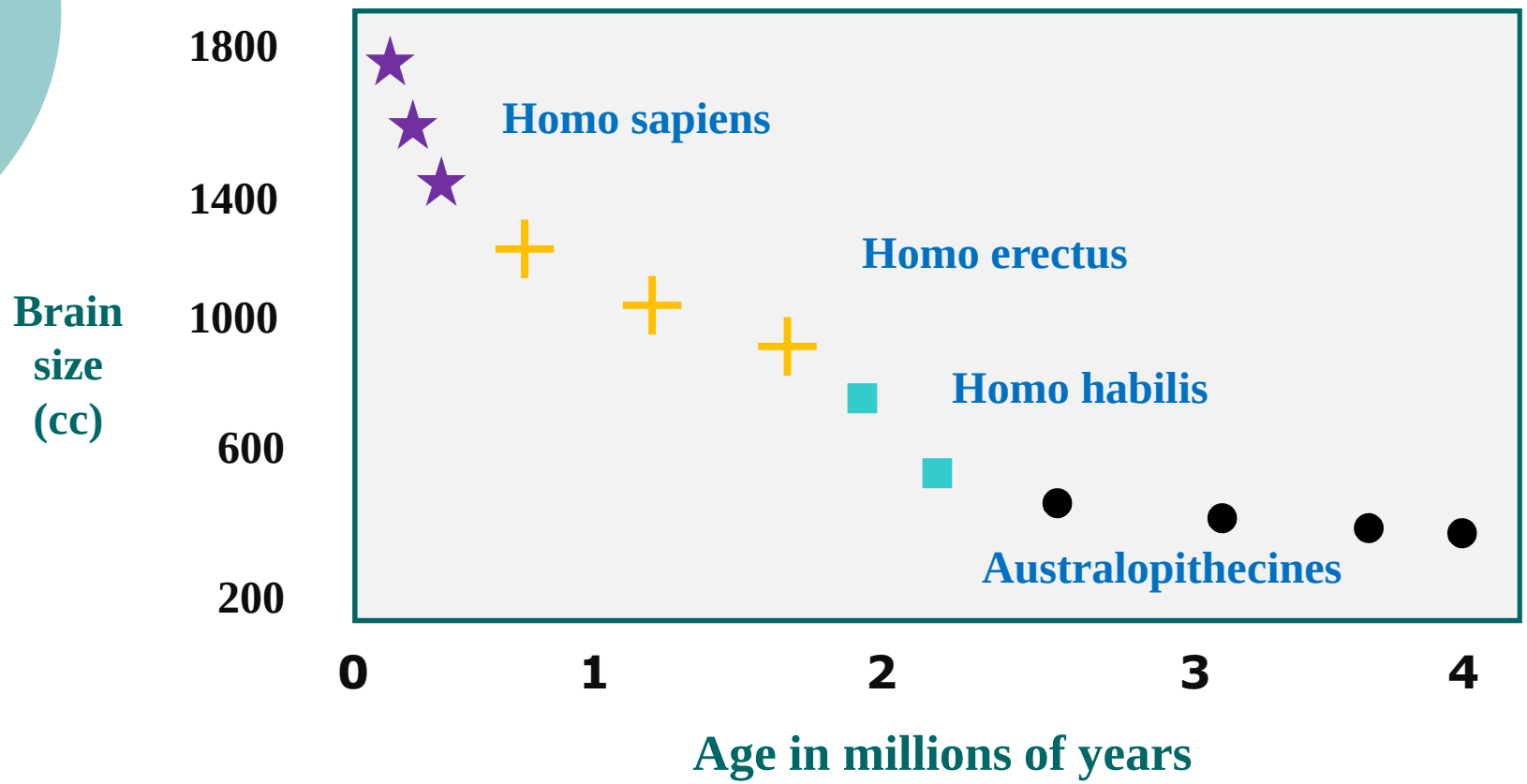
Optimal Foraging Theory

- **Pre-agriculture we were hunter-gatherers**
- **Day-to-day survival depended on daily energy intake being adequate**
- **Body energy use = Basal metabolism + activity**
- **Best choices were foods with the greatest energy return**

  (ie. energy content - energy expenditure for collection and preparation)
- **High energy dense foods became critical**

The diet was by necessity very broad, hence delivered a wealth of micronutrients, most of which were or did become "essential".

Human Brain Size



(Aiello & Wheeler: The Expensive Tissue Hypothesis: 1995)

Human Brain Size

Mammalian brain size closely follows :

$$\log E = 0.76 \log P + 1.77$$

(Martin 1983)

E = brain mass (mg)
P = body mass (g)

Human encephalization quotient = 4.6 !

Brain - Gut Trade Off

Tissue	Mass (kg) Observed	Expected	Metabolic increment (W)	% body BMR
Brain	1.30	0.45	+ 9.5	16.1
Heart	0.30	0.32	- 0.6	10.7
Kidney	0.30	0.24	+ 1.4	7.7
Liver	1.40	1.56	- 2.0	18.9
GI tract	1.10	1.88	- 9.5	14.8

(Aiello & Wheeler: The expensive tissue hypothesis, 1995)

Brain - Gut Trade Off

- **Gut size (and complexity) can only decrease as diet quality increases**

  ie. Overall small gut, high proportion as small intestine and a simple stomach

  (Stevens & Hume, Comparative physiology of the vertebrate digestive system, Cambridge Univ Press, 2001)

- **Requires a low bulk, high energy, easily digested diet**

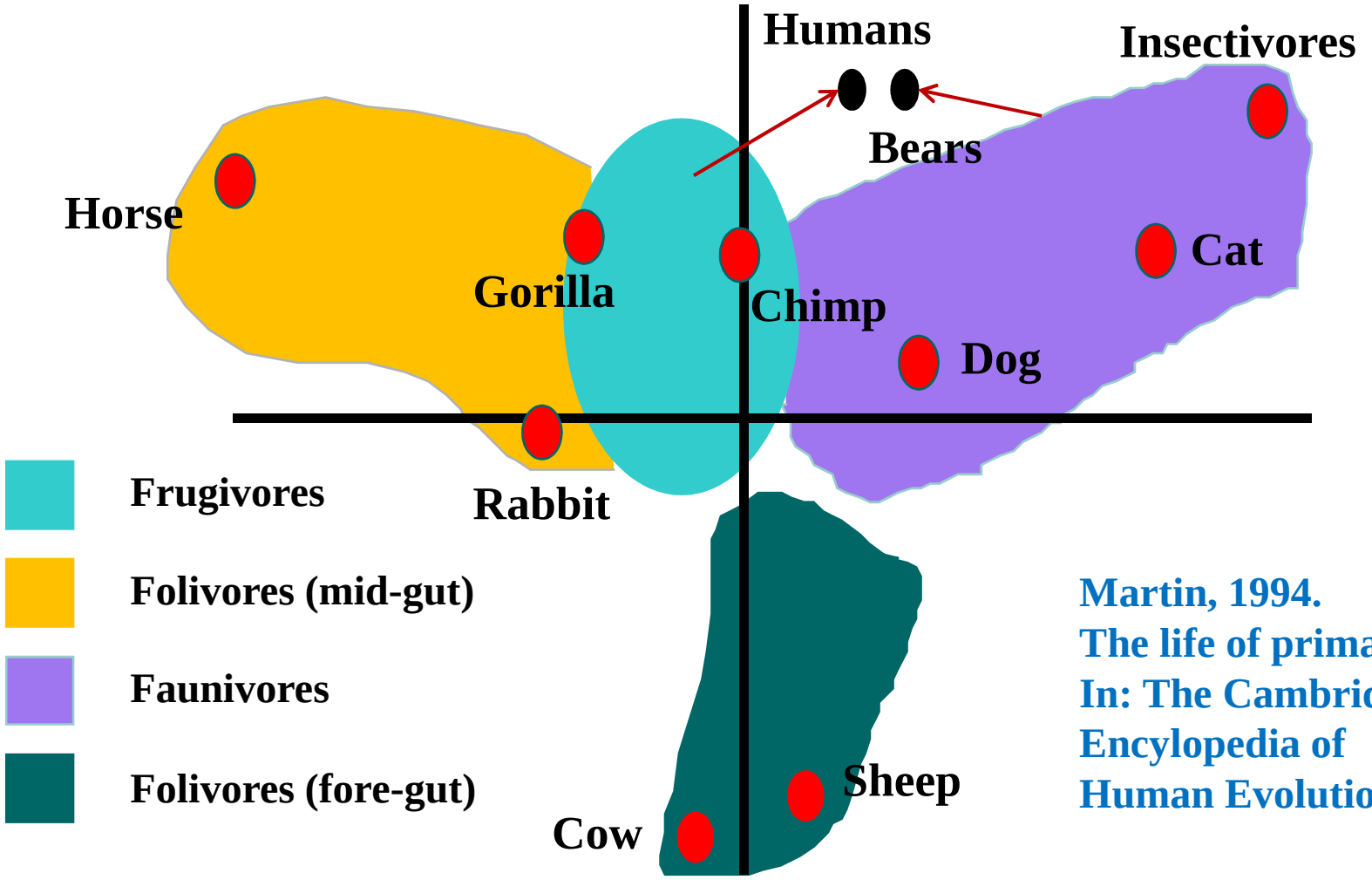
  (Chivers & Hladik 1980)

- **Mainly achieved by increasing the proportion of animal foods in the diet (in most locations)**

  (Speth 1989)

- **Wild plant foods generally low energy per unit weight**
- **Increased animal food intake at most latitudes**

Gut morphology and diet



Martin, 1994.
The life of primates.
In: The Cambridge Encylopedia of Human Evolution

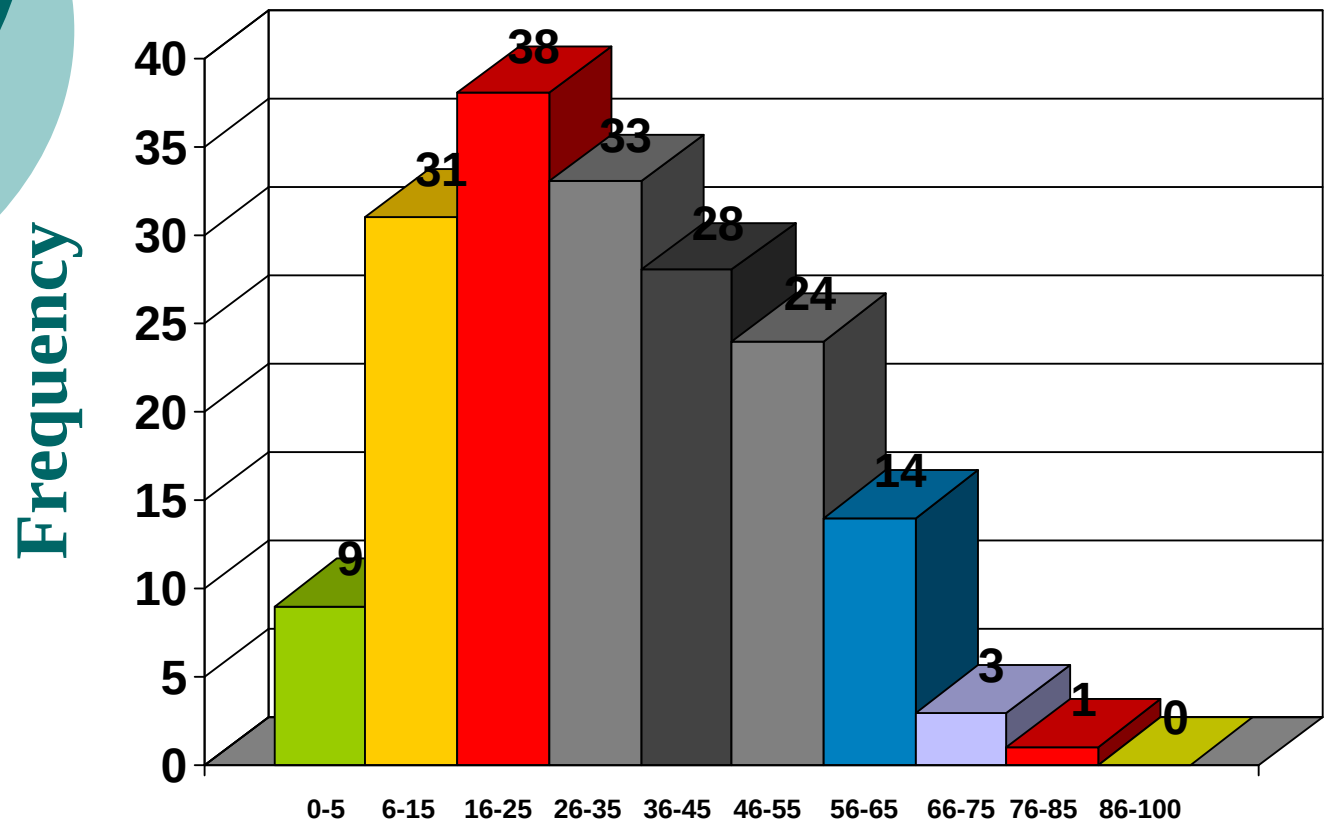
Hunter-Gatherers in Recent Time

- **Dietary data on 181 HG societies recorded in: "Ethnographic Atlas"** (Murdoch 1967)
- **Animal:Plant subsistence ratio: 65:35**

  (Cordain, Brand-Miller, Eaton, Mann & Speth, Am J Clin Nutr, 2000)
- **No complete vegetarian society !**
- **Eskimos and !Kung apparent extremes**
- **Food selection follows OFT**

Frequency Distribution of Subsistence

Dependence upon Gathered Plant Foods in World Wide Hunter Gathers Societies (n=181)



(Cordain, Brand-Miller, Eaton, Mann, Holt & Speth (2000), Am J Clin Nutr, 71; 682-692)

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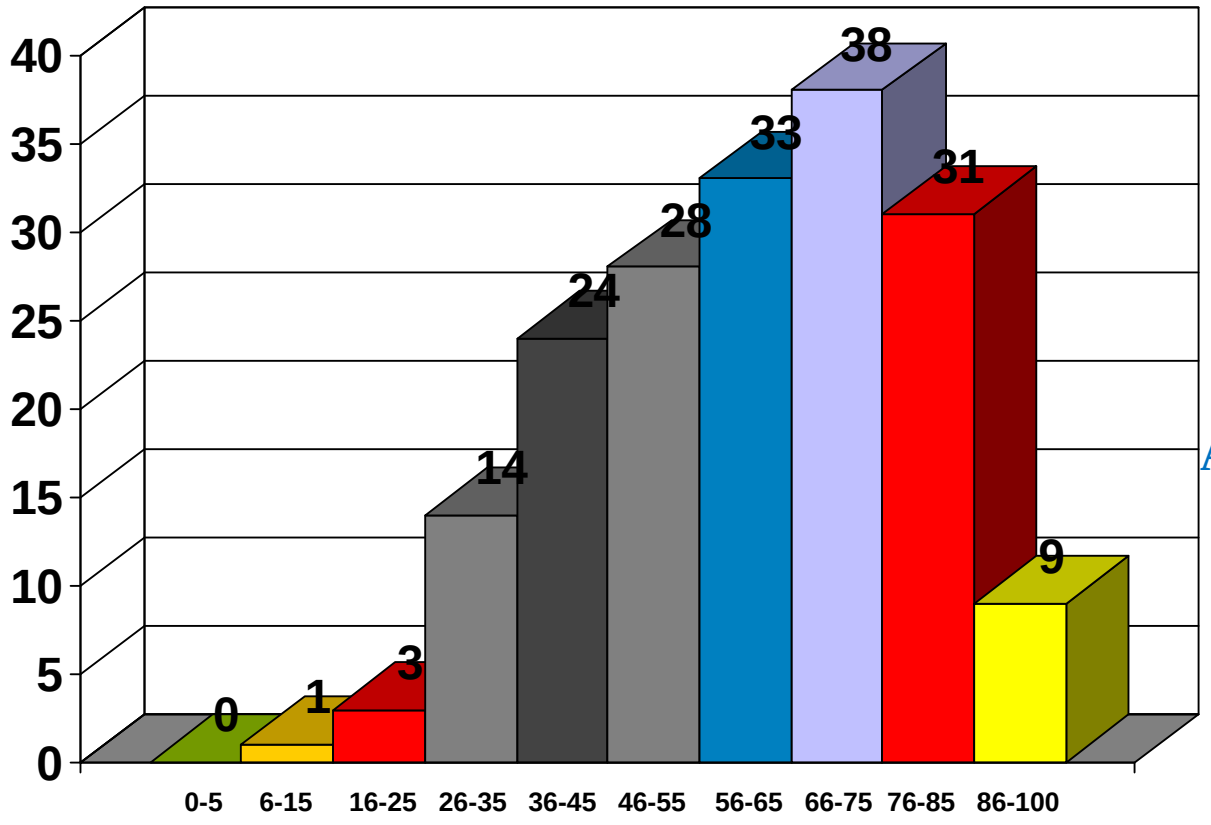


(Cordain, Brand-Miller, Eaton, Mann, Holt & Speth (2000), Am J Clin Nutr, 71; 682-692)

Agriculture:
The beginning of dietary change

- **Grain cultivation approximately 10,000 ya**
- **Less meat/wild vegetation, narrow cereal based diet**
- **Evidence of malnutrition (Harris Lines)**

  (Diamond 1993, The Third Chimpanzee)
- **Reduced: stature and life span.**
- **Increased: dental caries, osteomalacia, iron deficiency, infectious diseases, infant mortality. Famine!**

  (Cohen et al. 1987, Food & Evolution)
- **Higher carbohydrate, lower protein diet, with reduced food variety and subsequent micro-nutrient intake**

Stages of Dietary Change

- **Primitive** (~4.5 million of years) (~80,000 generations)
- **Agriculture** (max 10,000 years) (~400 generations)
- **Industrial revolution** (approx 200 years)
- **Fast/processed food revolution** (approx 60 years)

Changes in food type and composition at each stage ?

Significance of the dietary changes?

- **Prior to the development of agriculture our diet was minimally processed wild plant and animal foods**
- **With the advent of agriculture, novel foods were introduced as staples for which the hominin genome had little evolutionary experience.**
- **Food-processing procedures (milling, refining etc) were then developed, which allowed for quantitative and qualitative food and nutrient combinations that had not previously been encountered over the course of hominin evolution.**

What are these new nutritional patterns?

- **Cereals, refined sugars, refined vegetable oils and margarines, dairy products and alcohol now comprise 72.1 % of the total daily energy consumed in the USA**
- **These foods would have contributed little or none of the energy in the typical pre-agricultural hominid diet**
- **Mixtures of these ingredients comprise the ubiquitous processed foods that dominate the typical Western diet :**

  biscuits, cakes, bakery foods, breakfast cereals, bagels, rolls, muffins, crackers, chips, snack foods, pizza, soft drinks, candy, ice cream, condiments, salad dressings, etc.

  Along with the never ending list of fast food alternatives high in fat, sugar and readily digestible starch.

Food and food types found in western diets generally unavailable to pre-agricultural hominins.

Food	% diet energy	Food	% diet energy
Dairy products		**Refined sugars**	
whole milk	1.6	sucrose	8.0
low fat milks	2.1	hf corn syrup	7.8
cheese	3.2	glucose	2.6
butter	1.1	syrups	0.1
other	2.6	other	0.1
total	*10.6 %*	*total*	*18.6 %*
Cereal grains		**Refined vegetable oils**	
whole grains	3.5	salad, cooking oils	8.8
refined grains	20.4	shortening	6.6
total	*23.9 %*	margarine	2.2
		total	*17.6 %*

Food composition and structural changes

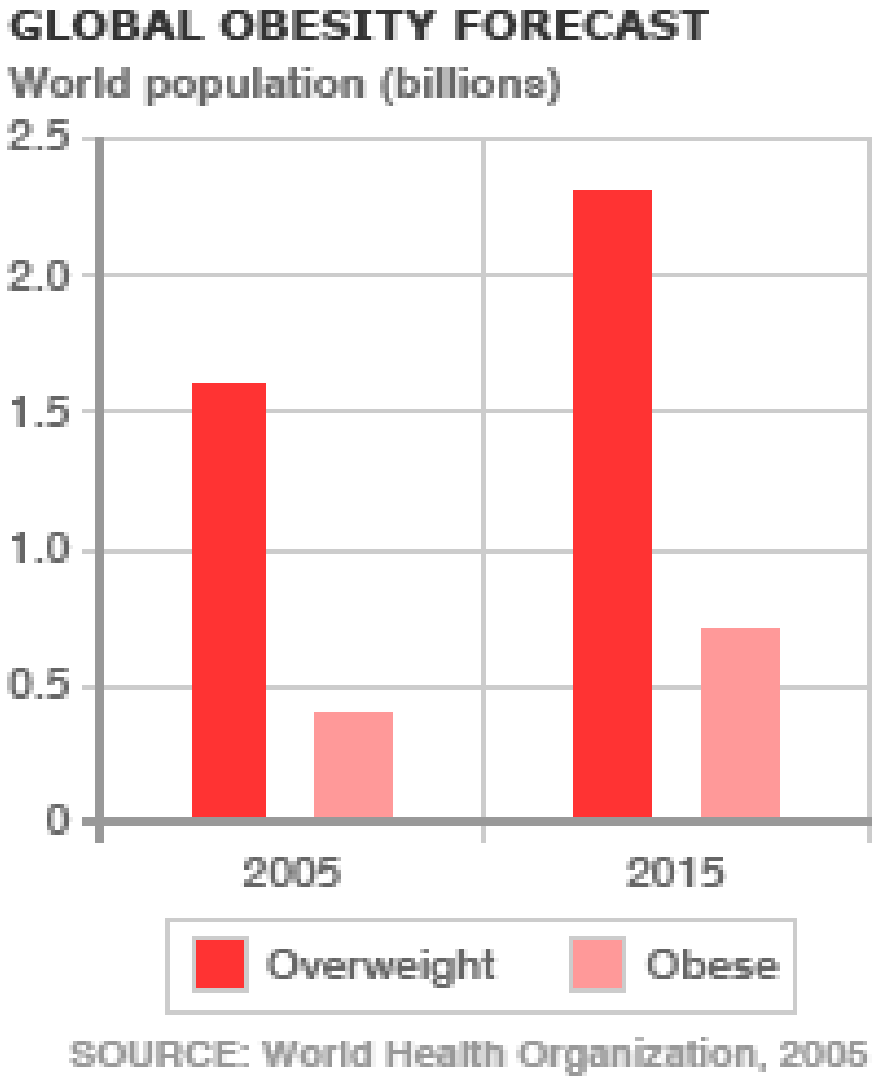
What are the crucial nutritional characteristics of the ancestral hominin diet, altered by changing food staples and food processing procedures introduced during the Neolithic and Industrial era :

Energy density of foods !

- **glycaemic load**
- **fatty acid balance**
- **macro-nutrient balance**
- **trace nutrient density**
- **acid/base balance**
- **sodium/potassium balance**
- **fibre content**

Energy density of food and obesity is there a connection?

The World Health Organization predicts there will be 2.3 billion overweight adults in the world by 2015 and more than 700 million of them will be obese.



Australian statistics:

National Health Survey (NHS 2005) showed that:

- **Overall 32.6% of adults were reported as overweight in 2004–05**
  (40.5% of males and 24.9% of females were overweight)
- **Overall 16.4% of adults were reported as obese in 2004–05**
  (17.8% of males and 15.1% of females were obese)
- **Higher rates of overweight or obesity in older age groups**
  (55–64 age group had the highest combined rates of overweight and obesity; 72% of males and 58% of females)

The prevalence of overweight and obesity increased markedly between 1995 and 2004–05

(29.5% to 32.6% and 11.1% to 16.4% respectively)

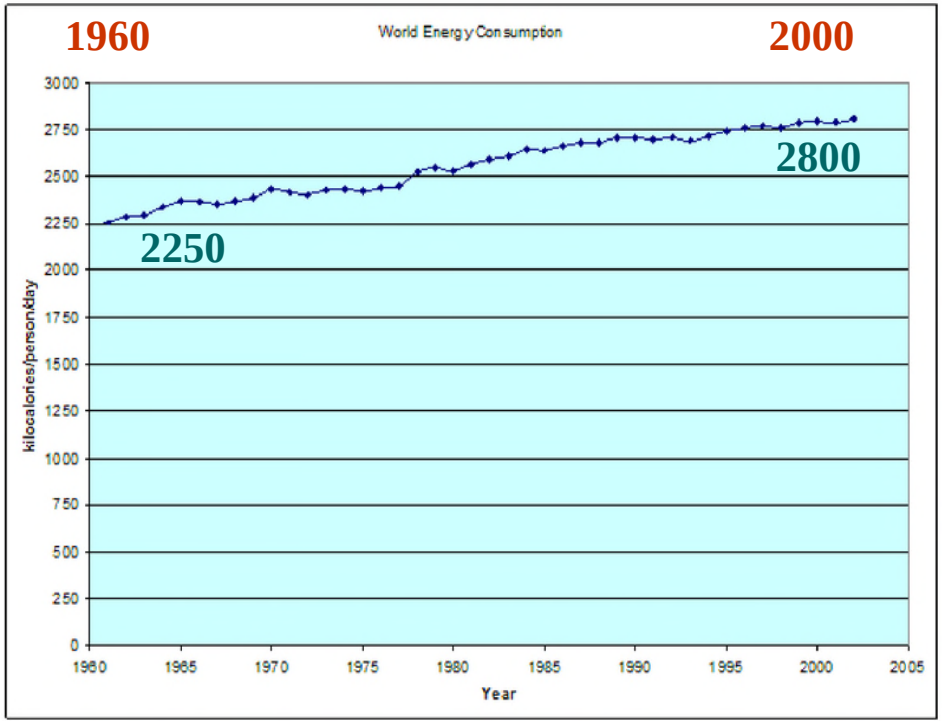
In 2007, the WHO found that 67.4% of Australian adults were overweight, ranking 21st in the world.

Obesity and the food supply

Agricultural policy and techniques mainly in the USA and Europe have led to lower food prices.

In the USA, subsidization of corn, soy, wheat, and rice (mainstays of processed energy dense food) through the "U.S. Farm Bill" has made the main sources of high energy processed food cheap compared to fruits and vegetables (low energy density, high water, micro-nutrient and fibre content).

Daily energy consumption (world mean, kcal/day)



Eating behaviour and food energy density: a possible connection ?

“Passive Over-eating a possible explanation for the obesity epidemic”

Reference

Prentice, A. M., Diaz, E., Goldberg, G. R., Jebb, S. A., Coward, W. A., Whitehead, R. G.
Famine and Refeeding: adaptations in energy metabolism.
Anderson, GH Kennedy, SH eds. *The Biology of Feast and Famine: Relevance to Eating Disorders* 245–267. Academic Press San Diego, CA

Active Vs passive overeating

Active overeating can be induced by a number of conditions:

- **A cognate drive to consume above one's natural appetite (driven by either internal or external cues),**
- **A constitutional defect in appetite regulation (as occurs in many of the rare monogenic forms of human obesity),**
- **An inappropriate psychological response to stress,**
- **A physical or pharmacological disruption of the hypothalamic satiety center.**

Passive overeating is a separate phenomenon, reliant on two scenarios which usually overlap:

- **Consumption of amounts of food that would be appropriate against a background of normal physical activity.**
- **Consumption of foods that are processed and contain minimal water/fibre but high levels of macronutrients (ie energy dense).**

Altered energy density of foods

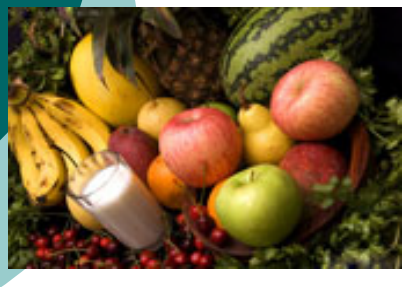
- **Weight (fat) gain is a matter of energy imbalance (input versus output)**
- **In modern society <u>reduced</u> physical activity is common and impacts on weight gain through altering the balance in favour of input**
- **However excess energy intake alters the balance more significantly because the energy density of food has <u>increased</u> more than exercise has decreased**

eg The energy content of a "Mars bar" is equivalent to several kilograms of wild plant foods or a very large piece of lean game meat and would require almost 1 hour of moderate - high level aerobic exercise to "burn".

In 100g of mars bar:
Fat = 17g
Carb = 70g
Energy = 1910 kJ

In 100g of vegetables:
Water = 94g
Fibre = 4g
Fat = 0.5g
Carb = 1g
Energy = 20 kJ

Further examples of passive overeating …



Fruits
~ 150 kj/100g
(> 90% water)

Lean meat
~ 450 kj/100g
(~2-5 % fat)

Fish
~ 640 kj/100g
(2-10% fat, much as omega-3)

Deep fried Mars bar
~ 2100 kj/100g

Sausage roll
~ 1600 kj/100g

Apple pie
~ 1400 kj/100g

1. The Glycaemic Load

- **Modern refined grain and sugar products have high GI & GL compared with wild carbohydrate containing foods**
- **High GL diets are linked with metabolic changes that promote insulin resistance**

Diseases of insulin resistance are frequently referred to as "diseases of civilization" and include:

- **obesity, CHD, type 2 diabetes, hypertension, and dyslipidemia**

and may also include:

- **myopia, acne, gout, PCOS, breast, colon, and prostate cancers**

Glycaemic indices (GI) and glycaemic loads (GL) of various food groups.

Food	GI	GL	Food	GI	GL
Grain Products			**Vegetables**		
Rice cereal	88	77.3	Baked Potato	85	21.4
Cornflakes	84	72.7	Sweet potato	54	13.1
Rice cakes	82	66.9	Yam	51	11.5
Rye crisp bread	65	53.4	Carrots	71	7.2
Corn chips	73	46.3	**Fruits**		
White bread	70	34.7	Banana	53	12.1
All bran cereal	42	32.5	Apple	39	6.0
Whole wheat bread	69	31.8	Orange	43	5.1
Dairy foods			**Sugar, sweets**		
Ice cream	61	14.4	Jelly beans	80	74.5
Whole Milk	27	1.3	Mars bar	68	42.2

Glycaemic index and glycaemic load

- **At least 39 % of the total energy in the typical Western diet is supplied by foods that may promote the four proximate causes of insulin resistance , chronic and substantial elevations in:**
  - **plasma glucose,**
  - **insulin,**
  - **very low density lipoproteins (VLDL) and**
  - **free fatty acid concentrations**
- **These high GL foods were rarely or never consumed by average citizens as recently as 200 years ago.**
- **Diseases of insulin resistance are rare or absent in hunter-gatherer and other less westernized societies living and eating in their traditional manner**

Glycaemic index and glycaemic load

- **Overconsumption of diets with a high overall glycaemic load adds to the risk of raised plasma triglycerides. There is also an interaction with obesity such that the effect of glycaemic load is much stronger in overweight women who are already prone to insulin resistance**

Liu, S., Manson, J. E., Stampfer, M. J., et al. (2001) Dietary glycemic load assessed by food-frequency questionnaire in relation to plasma high-density-lipoprotein cholesterol and fasting plasma triacylglycerols in postmenopausal women. *Am J Clin Nutr* 73: 560–566

- **A series of other studies have shown adverse effects of high glycaemic load in relation to CVD and type 2 diabetes:**

Liu, S., Willett, W. C., Stampfer, M. J., et al. (2000) A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. *Am J Clin Nutr* 71: 1455–1461.

Salmeron, J., Ascherio, A., Rimm, E. B., et al. (1997) Dietary fiber, glycemic load, and risk of NIDDM in men. *Diabetes Care* 20: 545–550.

Salmeron, J., Manson, J. E., Stampfer, M. J., Colditz, G. A., Wing, A. L., Willett, W. C. (1997) Dietary fiber, glycemic load, and risk of non-insulin-dependent diabetes mellitus in women. *J Am Med Assoc* 12;277: 472–7.

2. The Fatty Acid Balance

- **Wild game meat is low in total fat (little storage fat), relatively rich in long chain PUFA (structural), particularly omega-3 fatty acids**
  - **Mean fat level in 11 wild ungulates - 3.6%**
  - **Compare with US grain fed beef - 33-40% fat**

    (Speth 1983, J Anthrop Arch)

- **Current Western diet high in total fat, sat fat (fast foods), n-6 PUFA (high cereal and seed oil intake) and trans fats (partially hydrogenated vegetable oils), low in n-3 PUFA**

  (Crawford et al. 1986, Prog Lipid Res)

- **n-6/n-3 intake ratio has increased significantly from Paleolithic times**

Fats in the Diet

- **Current Western diet is high in total fat, saturated fat, and low in omega-3 fats**

  (Crawford et al. 1986, Prog Lipid Res)

- **Omega-6/omega-3 intake increased from HG profile**
- **Margarines, cooking oils high in omega-6 fats**
- **Aquatic and wild game meats high in omega-3 fats**
- **Domesticated meats can be high fat and saturated fat or lean and have moderate levels of omega-3 fatty acids if pasture fed**

  (Mann (2005), Lipid Technology 17(4): 79-83)

- **Fast foods tend to be high in total fat and saturated fats**

Animal sources of fatty acids in the diet

Food	Fat	Sat	MUFA	PUFA	AA	LC n-3PUFA
	g/100g	%	%	%	mg/100g	
Beef	2.7	46	43	11	32	60
Lamb	4.1	44	45	11	45	108
Pork	2.0	37	37	26	56	35
Chicken	2.3	33	41	26	43	40
Kangaroo	1.9	32	37	31	62	98
Salmon	9.8	24	37	39	100	2500
Liver	6.2	42	21	37	294	610
Egg	32.0	34	50	16	390	381

Mann et al. (1995). *J Nutr*; Vol 125: 2528-2535

The Fatty Acid Balance (contd)

	18:2 n-6	n-6/n-3	AA/LC n-3
Western diet	12.3 g/d	12:1	3.3:1*
Hunter-gatherer	3.3 g/d	2.4:1	1:1

(Sinclair & O'Dea 1990, Fats in Human Diets Through History)

*(Eaton, Eaton, Cordain, Sinclair & Mann 1998, World Rev Nutr Diet)

The increased intake of:

total fat, saturated fat, trans fat and n-6 : n-3 ratio

have been associated with:

obesity, atherosclerosis, dyslipidaemia, thrombosis, CVD, inflammatory conditions and cancers

3. The Macronutrient Balance

Predicted macronutrient intake balance from Paleolithic dietary modeling and contemporary hunter-gather food intake data from the "Ethnographic Atlas" compared with current USA and Australian trends:

		USA	Australia
Protein	**19 - 35%**	**(15.5%)**	**(17.0%)**
Carbohydrate	**22 - 40%**	**(49.0%)**	**(45.1%)**
Fat	**28 - 47%**	**(34.0%)**	**(32.4%)**

Note: Intake of digestible carbohydrate was substantially lower due to lack of availability in wild plants compared with modern agricultural crops

Recent isotopic data from Upper Paleolithic European skeletons support the notion that protein consumption may have been substantially higher than current values

(Richards, Hedges (2000), J Arch Sci, 27: 1-3)

An increasing body of evidence also indicates that higher protein diets may :

- **improve blood lipid profiles**
- **improve metabolic control in type 2 diabetes patients**
- **improve insulin sensitivity and prevent muscle loss in obese women compared with high carbohydrate diets**
- **be inversely related to CVD in women (cohort of 80,082)**
- **be associated with lower blood pressure**
- **be inversely related to stroke mortality**
- **be more effective than calorie restricted high carbohydrate diets in promoting weight loss**

4. The Trace Nutrient Density

- **The range of food types consumed narrowed, with particular loss of many nutrient dense, wild plants from the diet**
- **The introduced cereal and milk products have lower nutrient density rankings than fruits, vegetables, lean meats and seafood**
- **The Neolithic introduction of cereal grains and dairy foods as staples in place of wild plant and animal foods caused the average trace nutrient content of the diet to decline**
- **This situation worsened as cereal milling techniques, developed in the Industrial era, allowed for the production of flour devoid of the more nutrient dense bran and germ**

Nutrient density for various foods groups
(mg/418 kJ samples, ignores bioavailability)

	Cereals	Dairy	Fruits	Veg	Sea Food	Lean Meats	Nuts/Seeds
Vitamin B12	0.00[4]	0.58[5]	0.00[4]	0.00[4]	7.42[7]	0.63[6]	0.00[4]
Vitamin B3	1.12[4]	0.14[1]	0.89[3]	2.73[5]	3.19[6]	4.73[7]	0.35[2]
Vitamin B2	0.05[2]	0.26[6]	0.09[3]	0.33[7]	0.09[4]	0.14[5]	0.04[1]
Vitamin B1	0.12[5]	0.06[1]	0.11[3]	0.26[7]	0.08[2]	0.18[6]	0.12[4]
Folate	10.3[4]	8.1[2]	25.0[6]	208.3[7]	10.8[3]	3.8[1]	11.0[5]
Vitamin C	1.53[3]	74.2[5]	221.3[7]	93.6[6]	1.9[4]	0.1[1]	0.4[2]
Iron	0.90[4]	0.08[1]	0.69[2]	2.59[7]	2.07[6]	1.10[5]	0.86[3]
Magnesium	32.6[4]	21.9[2]	24.6[3]	54.5[7]	36.1[6]	18.0[1]	35.8[5]
Calcium	7.6[2]	194.3[7]	43.0[4]	116.8[6]	43.1[5]	6.1[1]	17.5[3]
Zinc	0.67[4]	0.62[3]	0.25[1]	1.04[5]	7.6[7]	1.9[6]	0.6[2]
Sum Rank Score	**44**	**44**	**48**	**81**	**65**	**50**	**38**

Food group superscripts represent relative ranking (7 = highest, 1 = lowest).

Dietary Comparison: Then and Now

Nutrient	Paleolithic	Modern	Nutrient	Paleolithic	Modern
%Protein	37	12	Vit A (RE)	2870	1300
% Carb.	41	48	Vit E	32.8	8.0
% Fat	22	40	Minerals mg/d		
P:S	1.4	0.4	Iron	87	10
Fibre g/d	104	15	Zinc	43	10
Vitamins mg/d			Calcium	1956	750
Riboflavin	6.5	1.7	Sodium	768	4000
Thaimin	3.9	1.4	Potassium	10500	2500
Folate	0.4	0.2			

(Eaton & Konner 1997, Eur J Clin Nutr)

5. Acid/Base Balance

- **After digestion, absorption and metabolism, nearly all foods release either acid or base into the circulation**
- **The typical western diet yields a net acid load estimated to be approx + 50 meq/day**
- **Adults consuming the standard western type diet sustain a chronic, low-grade pathogenic metabolic acidosis**
- **Cereals and energy dense - nutrient poor foods introduced during the Neolithic and Industrial eras are acid forming and displaced base yielding fruits and vegetables**

Acid/Base Balance (contd)

- **Consequently, a net base producing diet was the norm throughout most of hominid evolution**
- **The known health benefits of a net base yielding diet include preventing and treating:**

  osteoporosis
  age related muscle wasting
  calcium kidney stones
  hypertension
  exercise induced asthma

- **Interestingly, over 80% of the acid/base effect of food is explained by the protein : potassium ratio**

(Lehman; (1999), Nephron 81 (Suppl 1): 18-25)

Potential net acid (or base) loads

	n	Net Acid Load (meq/418 kJ)	Net Acid Load (meq/10,460 kJ)	Potassium (meq/418 kJ)	Protein (g/418 kJ)	Protein g/100 meq Potassium
Acid Foods						
Fish	**8**	**+14.6**	**+398**	**8.1**	**16.8**	**207**
Meat	**3**	**+12.4**	**+342**	**7.6**	**18.4**	**242**
Poultry	**2**	**+7.8**	**+227**	**4.7**	**13.4**	**287**
Egg	**1**	**+7.3**	**+215**	**2.4**	**8.3**	**339**
Shellfish	**3**	**+7.3**	**+215**	**18.4**	**18.0**	**159**
Cheese	**9**	**+3.3**	**+115**	**0.8**	**7.1**	**982**
Milk	**4**	**+1.3**	**+64**	**6.4**	**5.7**	**90**
Cereals	**7**	**+1.1**	**+60**	**2.6**	**3.2**	**153**

Potential net acid (or base) loads (contd)

	n	Net Acid Load (meq/418 kJ)	Net Acid Load (meq/10,460 kJ)	Potassium (meq/418 kJ)	Protein (g/418 kJ)	Protein g/100 meq Potassium
Base Foods						
Nut	6	-1.1	-6	3.8	2.5	86
Fruit	11	-5.2	–98	9.4	1.6	16
Tuber	2	-5.4	–102	11.8	2.2	18
Mushroom	1	-11.2	–247	62.3	25.7	41
Vegetables						
Fruit	1	-17.5	–404	35.5	5.6	15
Greens	6	-23.4	–553	43.5	10.0	24
Stalks	1	-24.9	–590	54.8	4.6	8

6. Sodium/Potassium Balance

- **Changes in food type and composition during the Neolithic & Industrial periods, caused a four fold decline in the potassium intake while initiating a four fold increase in sodium ingestion**

	Paleolithic mg/day	Modern mg/day
Sodium	768	4000
Potassium	10500	2500

- **Two dietary factors are primarily responsible for the shift in dietary Na/K ratio:**

1. **Consumption of processed foods rich in sodium**
2. **Displacement of potassium rich vegetables and fruits by potassium poor grains, dairy, oils and sugar products**

Sodium/Potassium Balance *(contd)*

Diets low in potassium and high in sodium may partially or directly underlie or exacerbate a variety of chronic illnesses including:

- **hypertension, stroke, kidney stones,**
- **osteoporosis, gastrointestinal tract cancers,**
- **asthma, insomnia,**
- **airsickness, high altitude sickness and**
- **Meniere's Syndrome (ear ringing)**

7. The Fibre Content

- **Fibre rich plants have been replaced by dietary staples, introduced during the Neolithic and refined since the beginning of the Industrial period**
- **The fibre content of the typical Western diet is much lower than paleolithic estimates**

  (approx 15g/day versus 100g/day)
- **Refined sugars, oils, dairy products & alcohol are devoid of fibre and comprise 48.2 % of the energy in the U.S. diet**
- **Fibre-depleted, refined grains represent 85 % of the grains consumed in the U.S. and make up 20.4% of the energy intake**

Concluding Remarks

- **The diet related chronic diseases of modern times are the single largest cause of death in Western society**
- **These diseases are rare or absent in hunter-gatherers and other societies consuming minimally processed foods**
- **The discordance that now exists between our genome and diet could be the underlying primary factor**
- **Return to hunter-gatherer practices or elimination of core food groups such as cereals and dairy is not possible or advisable**
- **Greater attention to processed food composition and position in the diet would be the logical alternative**
- **Government incentives or pressure on food processors may need to be considered as an alternative if current health expenditure on treatment of chronic western lifestyle diseases continues to escalate.**