Meat in Human Evolution

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Most modern human foragers eat much more meat than chimpanzees or other nonhuman primates. When did meat first become important?

- Evidence from archaeology
- Evidence from carbon isotopes
- Evidence from tapeworms
- Evidence from apoE

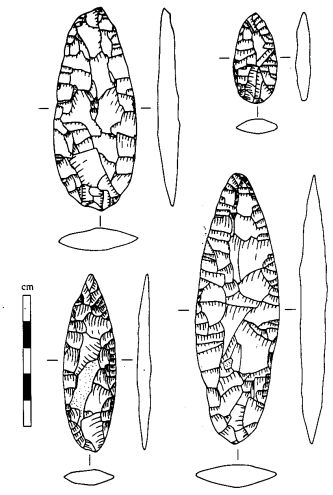
Why care?

- Human nature has been shaped by human history. What did that history consist of?
- Consider heart disease and diabetes. Seem to reflect a mismatch between our diet and our physiology. Presumably, we are well adapted to some diet that we no longer eat. What was that diet?

When did humans become hunters?

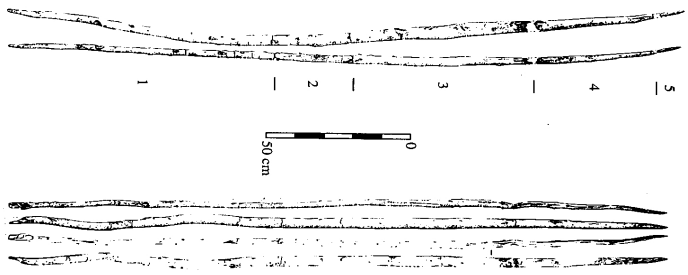
- *Upper Paleolithic: abundant evidence of hunting (spear points, cave paintings, etc)*

It is hard to doubt this evidence



- Good evidence for hunting by Neandertals
- Spear points
- Szeleta Cave, Hungary
- Middle Paleolithic

400 kyr old throwing spears, Schöningen, Germany



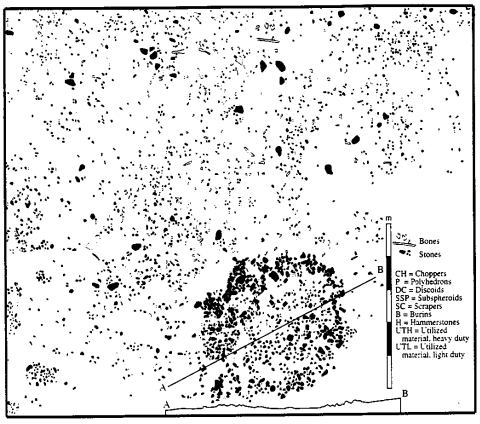
Beginning 2.6 myr ago in E Africa

Archaeological sites with

- stone tools
- bones of medium to large animals
- some with cut marks

We need to evaluate this evidence carefully

Oldowan Tools appear 2.6 myr ago



- Site DK 1, Olduvai Gorge, TZ
- Stone tools
- Animal bones
- Mysterious circle

What should we make of this refuse?

- Not like refuse of modern primates
  - stone tools
  - number of animals deposited at one place
  - large size of animals
- meat and/or marrow apparently more important
- but how much?

How might these sites have been produced?

- Accidental association of tools and bones?
  - aggregated by flowing water?
  - common amenity such as a water hole or a shade tree?
- Passive scavenging?
- Active scavenging?
- Human hunting?

Meat would be important under some hypotheses (hunting, active scavenging) but not others (accidental association, passive scavenging).

FLK Zinj: a site containing stone tools in association with animal bones

1.75 million years old
2,500 Oldowan artifacts
3,500 bones from various kinds of large mammal; at least 40–45 individual animals are represented

Bones and stones were deposited together

- Bones not water-worn
- Bones have cut-marks made by stone tools.

Unlike refuse of any modern primate:

- use of stone tools to butcher carcasses
- many carcasses deposited in the same place
- mostly large and medium-sized animals

Meat was more important to Plio-Pleistocene hominins than it is to any modern ape.

Remaining hypotheses

- Passive scavenging hominins ate what was left
- Active scavenging chased the lions away
- Hunting

Overlapping tooth- and cut-marks

Sometimes cut-marks and tooth-marks overlap. If humans ate first, then tooth-marks should usually overlie cut-marks. If humans ate last, then cut-marks should usually overlie tooth-marks.
Data:

	Cases
Cut-mark over tooth-mark	5
Tooth-mark over cut-mark	8

Humans ate first, at least some of the time[1].

[1] Bunn & Kroll 1986

Summary of archaeological evidence

- we knew most of this by mid 1990s
- concensus: early *Homo* ate more meat than living primates
- many still doubted that meat was important in early hominin diet

Outline

- Evidence from archaeology
- Evidence from carbon isotopes
- Evidence from tapeworms
- Evidence from apoE
- Evidence from MYH16

Stable isotopes of carbon

^{12}C (pronounced "Carbon 12") constitutes 99% of carbon atoms on earth.

^{13}C (pronounced "Carbon 13") constitutes 1% of carbon atoms on earth.

During photosynthesis, plants incorporate carbon atoms of both types.

Types of photosynthesis

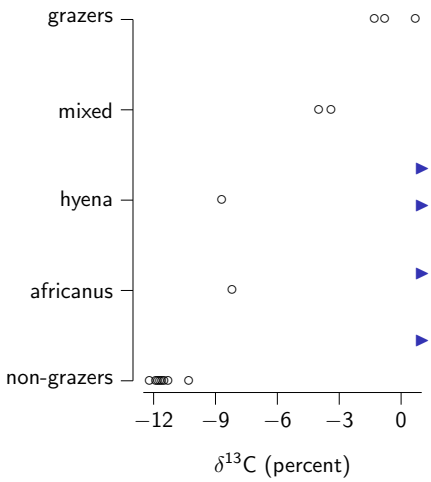
C3 plants (most plants) incorporate less ^{13}C. In their tissues, the ratio $^{13}C/^{12}C$ is relatively low.

C4 plants: (warm-season grasses) incorporate more ^{13}C. In them, $^{13}C/^{12}C$ is higher.

Carbon isotopes of herbivores reflect their food.

Those of carnovores reflect their prey.

Carbon Isotopes at Makapansgat, a cave in S Africa



- Grazers: high $\delta^{13}C$
- Non-grazing herbivores: low $\delta^{13}C$
- Carnivores: $\delta^{13}C$ like their prey
- africanus $\delta^{13}C$ like hyena

Did africanus eat meat?

- No one can quite believe it.
- Big jaws and teeth
- Thick enamel w/ heavy pitting
- Eating nuts?
- Crushing bone?

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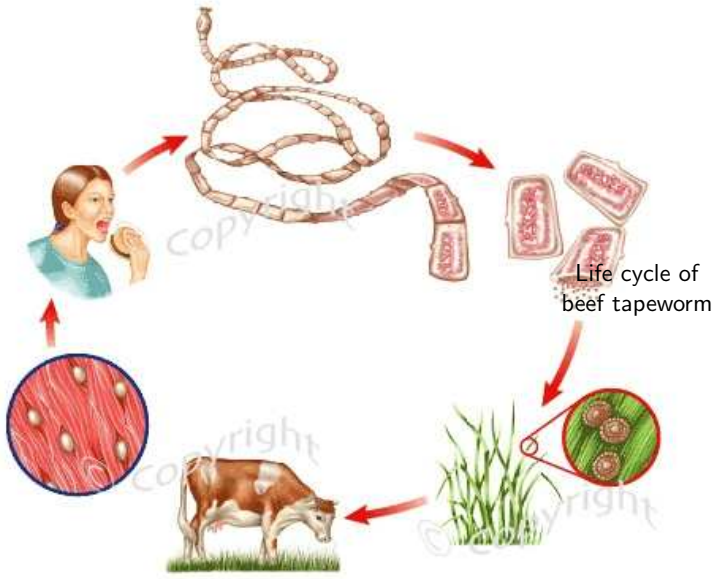
Tapeworms of genus *Taenia*

- Adult lives in gut of carnivore
- Sheds eggs
- Ingested by herbivore
- Larvae burrow into muscle
- Ingested by carnivore

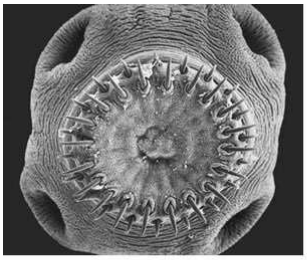


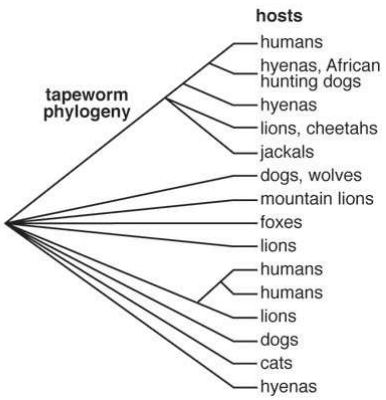
Human tapeworms

- Three species
- Where did we get them?
  - domestic animals?
  - prey species in Eurasia?
  - prey species in Africa?

Study of Hoberg et al (2001)

- used morphology to infer phylogenetic tree
- used DNA to estimate dates





What the tapeworms tell us

- we got our tapeworms by eating African antelope
- at least twice
- more than (roughly) 1 myr ago
- *H. ergaster* ate a lot of meat

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Diets of wild hominoids

- Gorillas eat no meat
- Chimpanzees almost none
- Neither eats much saturated fat
- We eat a lot

Hominoids in zoos

- Some diets contain saturated fats
- Elevated blood cholesterol
- Vascular disease
- Heart attacks and death
- Saturated fat worse for them than for us

How did our ancestors handle the shift to meat?

Apolipoprotein E (apoE)

- helps transport cholesterol
- two alleles: E3 (common) and E4
- E4 carriers sensitive to saturated fat.

Response of apoE alleles to saturated fat

- initially on low-fat diet
- added 2 egg-yolks per day
- results: serum cholesterol increased 4$\times$ more in E4/E4 individuals than in E3/E3.
- E4 is bad for you

Which allele is ancestral?

- Most deleterious alleles are recent mutations.
- Yet apoE4 is ancestral.
- Our ancestors could not deal with saturated fat.

ApoE and meat

- Early meat-eating hominins had heart attacks.
- Allele E3 makes meat diet possible.
- When did it evolve?
- Best estimate: 226,000 years ago
- Much meat in diet at least since then.

Outline

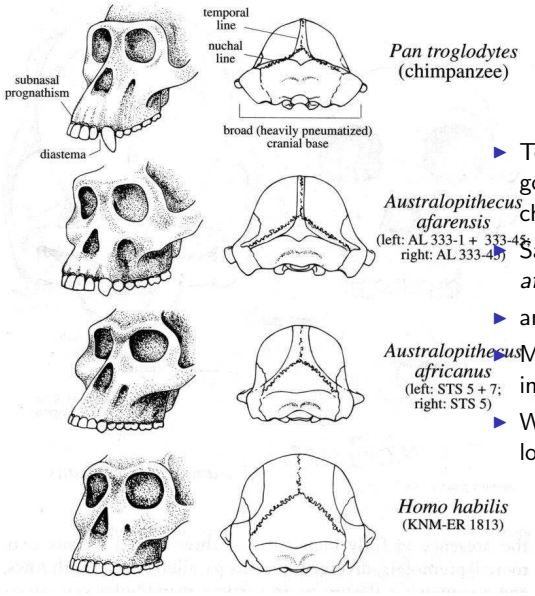
- Evidence from archaeology
- Evidence from carbon isotopes
- Evidence from tapeworms
- Evidence from apoE
- Evidence from MYH16
- Summary and conclusions

MYH16: a protein in jaw muscle

- Useful for brief, powerful bite.
- Present in carnivores.
- Lost in some herbivores.
- Present in chimps and gorillas.
- Lost in humans within past 4 my.

Effect of losing MYH16

- Evidence: knockout experiments with similar proteins in mice.
- Loss of gene causes 50% reduction in muscle mass.
- Is there evidence of such a reduction in hominin fossils?



- Temporalis muscle goes to top of head in chimp.
- Same true of *A afarensis*,
- and of *A africanus*.
- Muscle much smaller in *Homo habilis*.
- Was this when we lost MYH16?

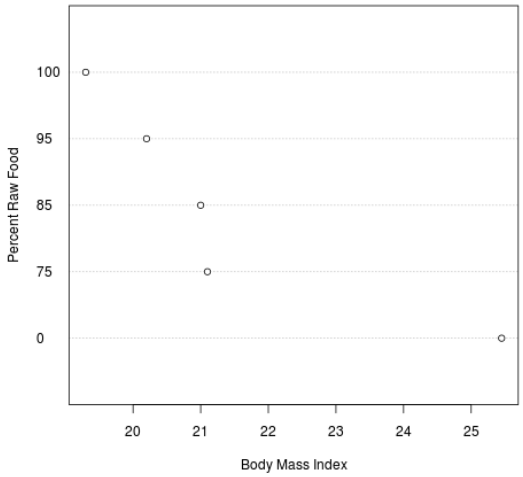
Implications of MYH16

- *Homo habilis* was the first hominin to use stone tools.
- It appears that jaw muscles were reduced at the same time.
- Having tools, there was less need for the brief powerful bite.

Summary

- Hunting weapons since 400 kya.
- Aggregations of stone tools and animal bone with cut marks since 2.5 mya.
- Evidence for meat in australopithecine diet
- Tapeworms since at least 1 mya.
- Adaptation for meat diet (apoE) since 226 kya

Raw Food is Hard to Digest



Conclusions

- Pliocene hominins ate more meat than modern chimps.
- Pleistocene hominins ate a lot of meat.
- Either hunting or active scavenging.