

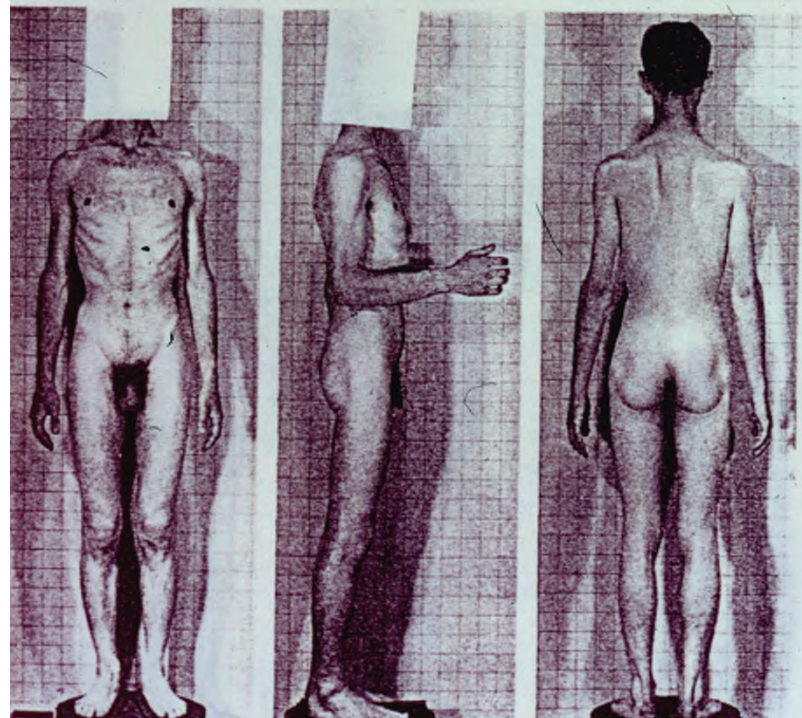
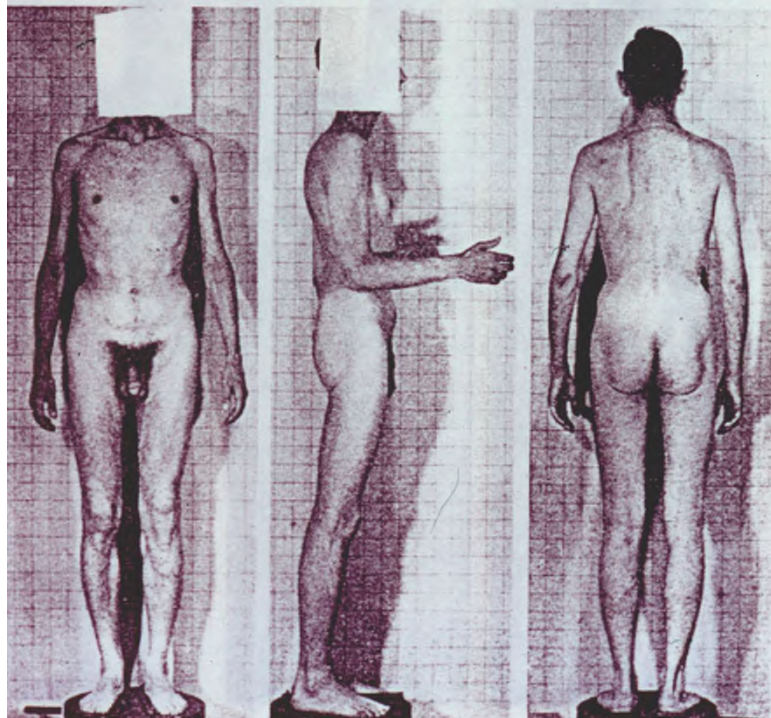
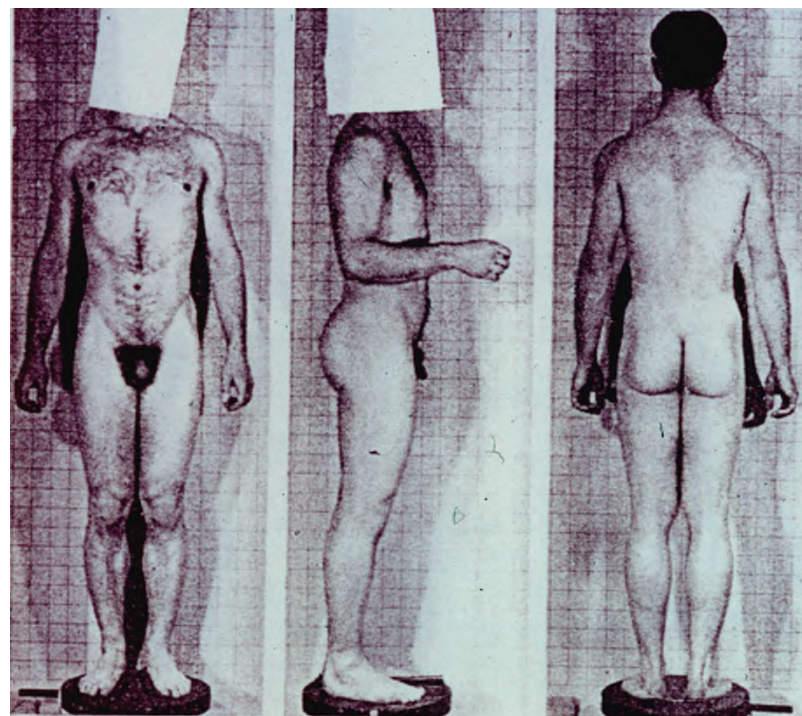
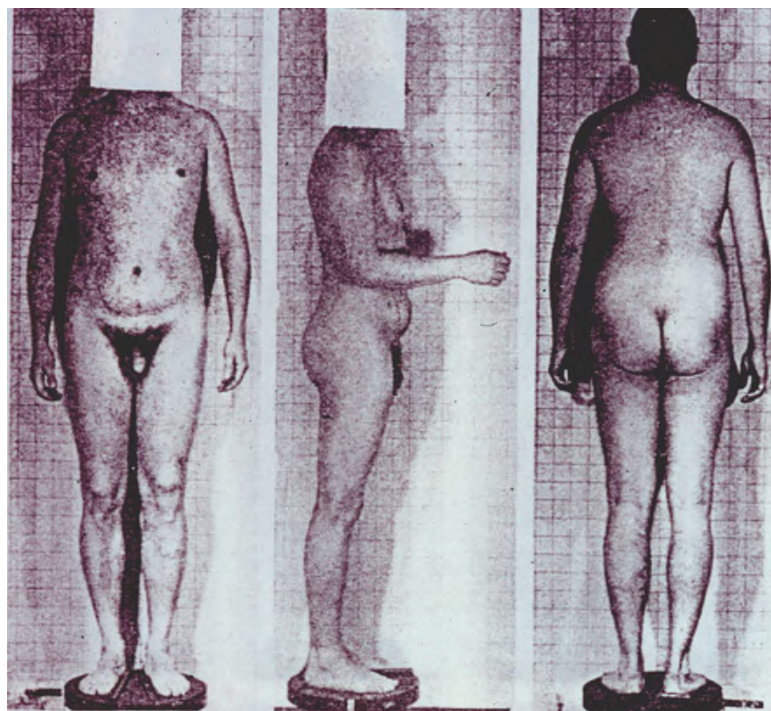
Bioenergetics and cultural physiology

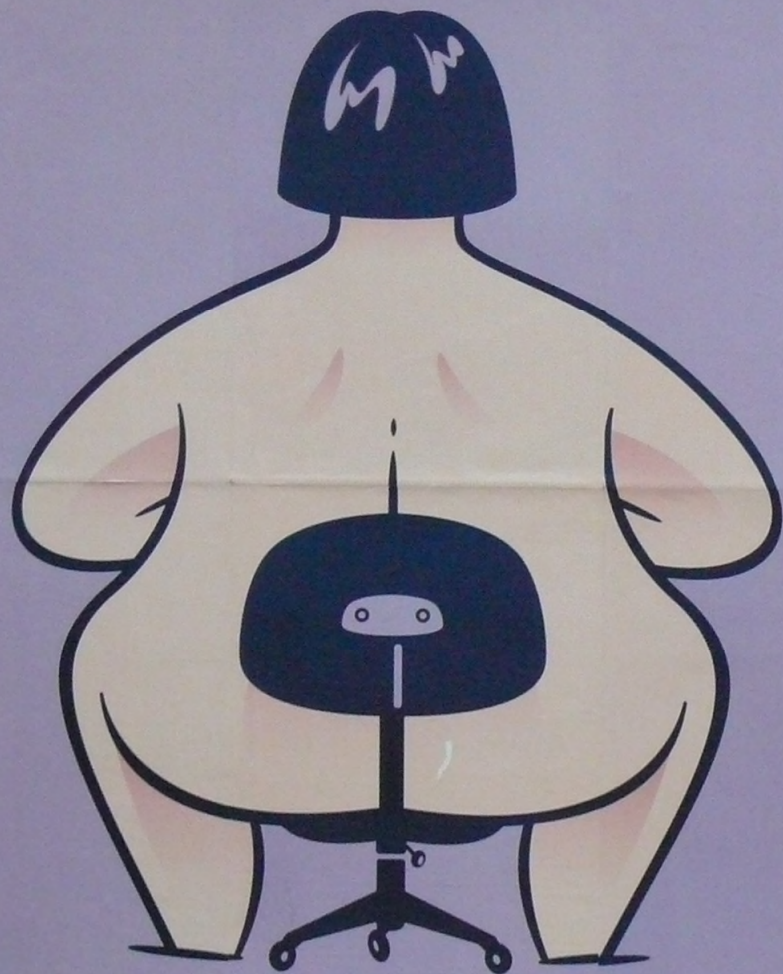
**Departmental Seminar, School of Anthropology and
Museum Ethnography, University of Oxford**

**Stanley Ulijaszek
and
Caroline Potter**

**The use of thermodynamics
in biology has a long history
rich in confusion and is
rampant with attempts to use
equilibrium constructs under
nonequilibrium conditions**

(Morowitz 1992).





Work naked

Mobile broadband and email

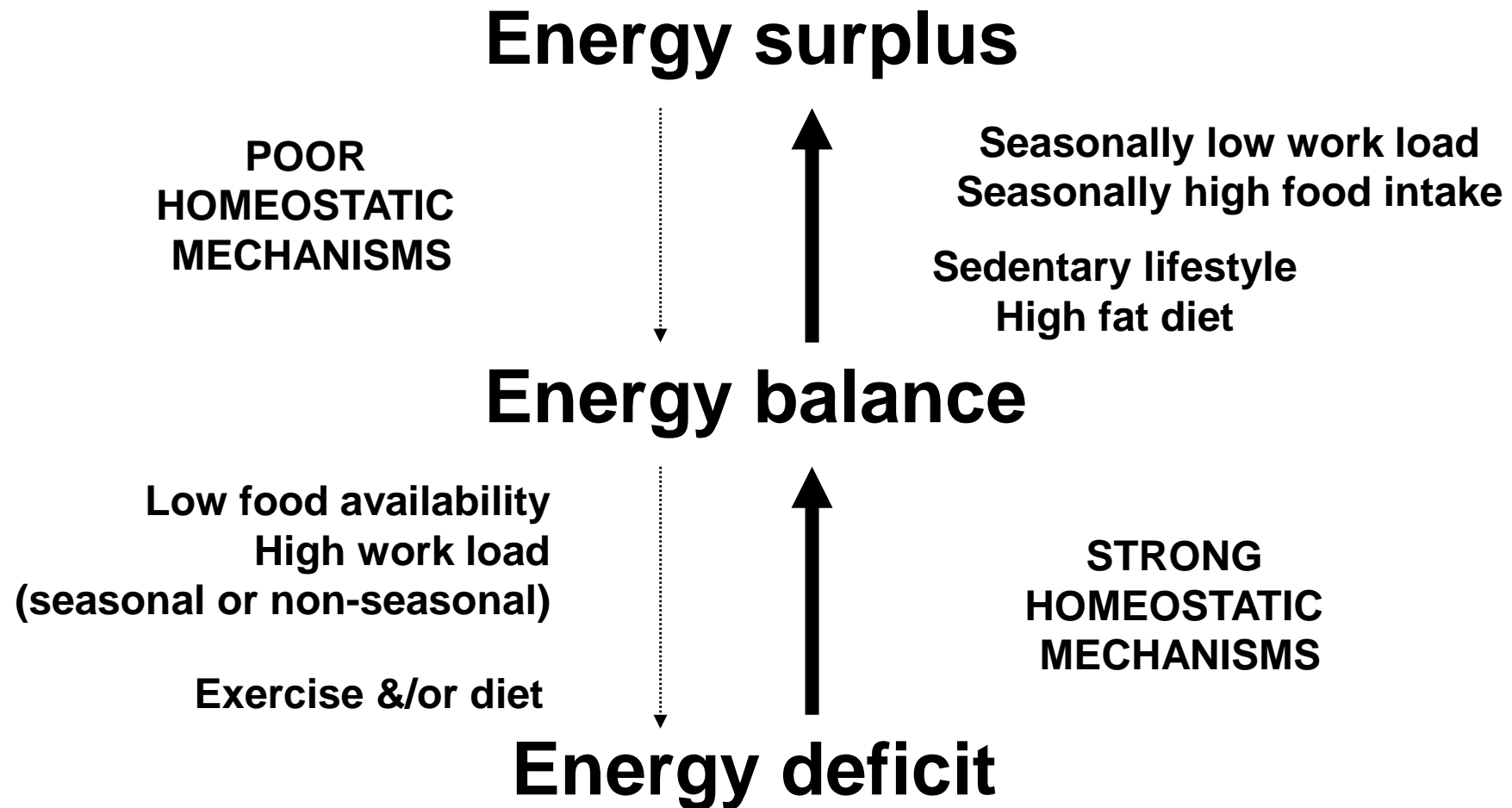
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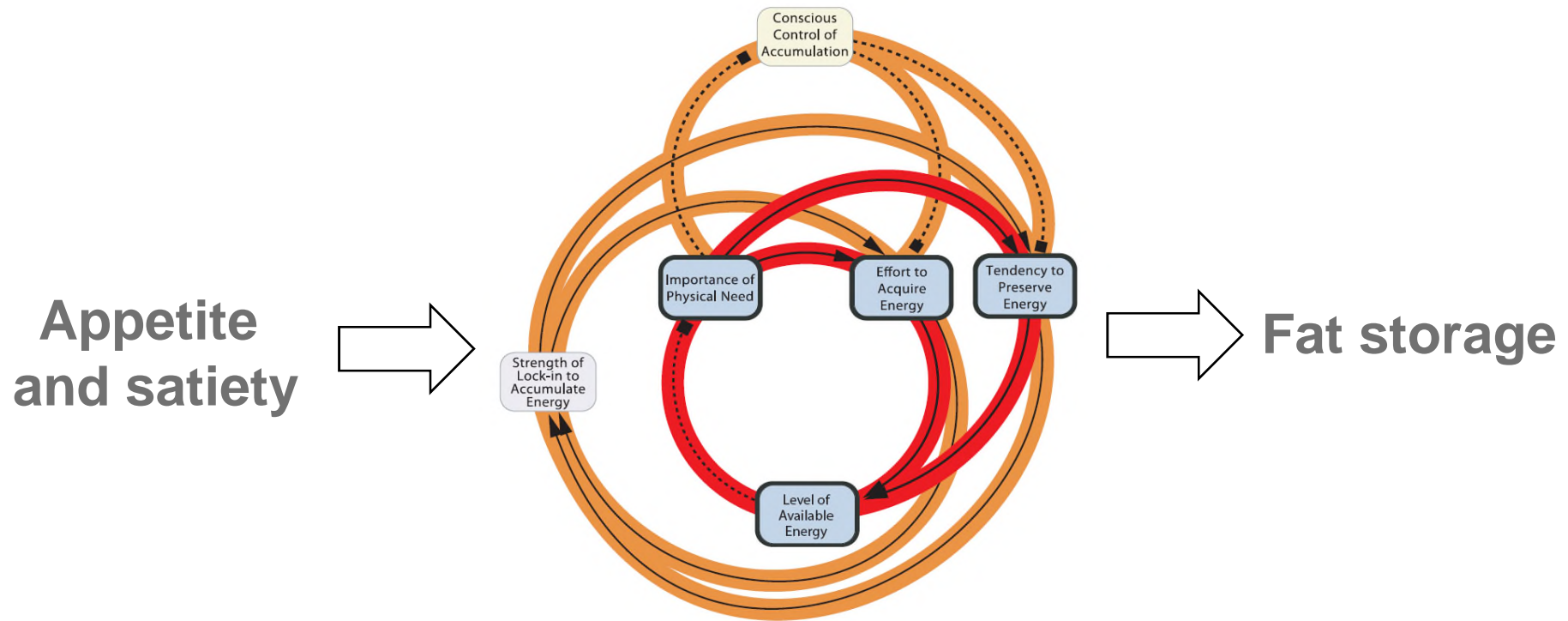
Body weight regulation (amended from Moore, 2000)

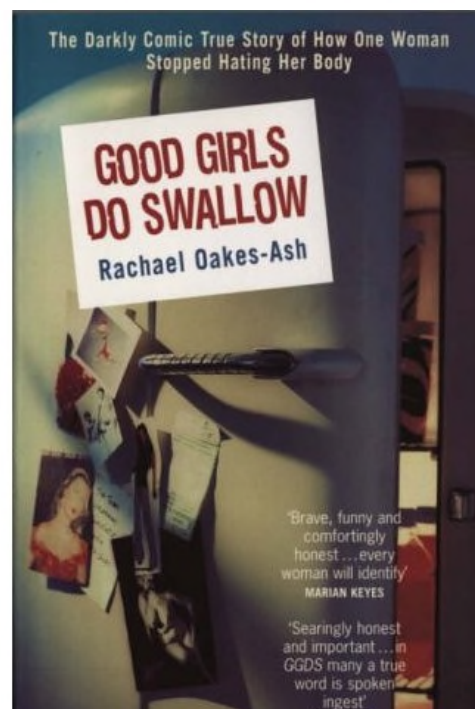
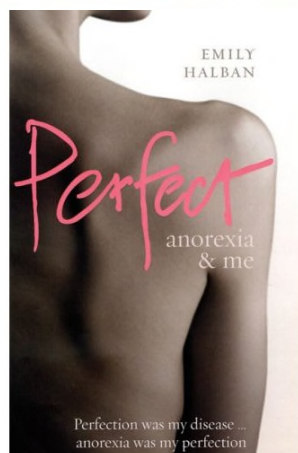
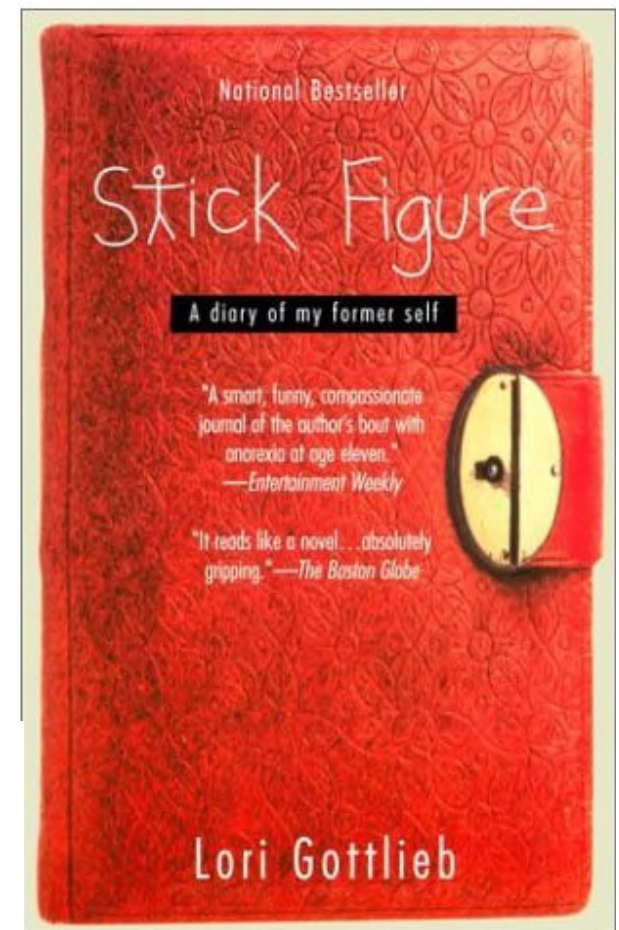
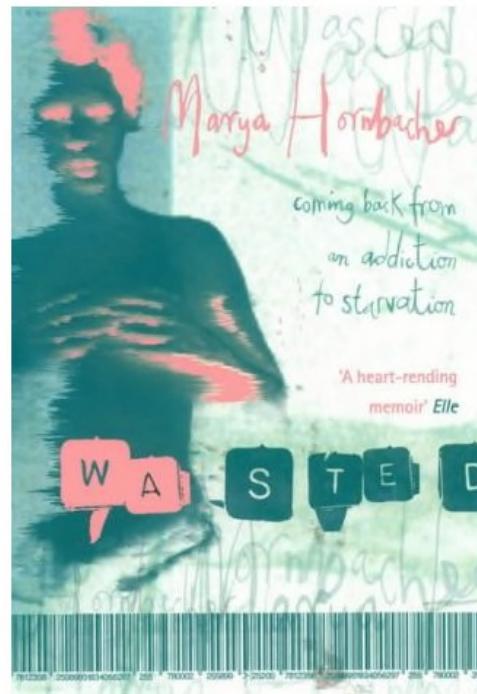
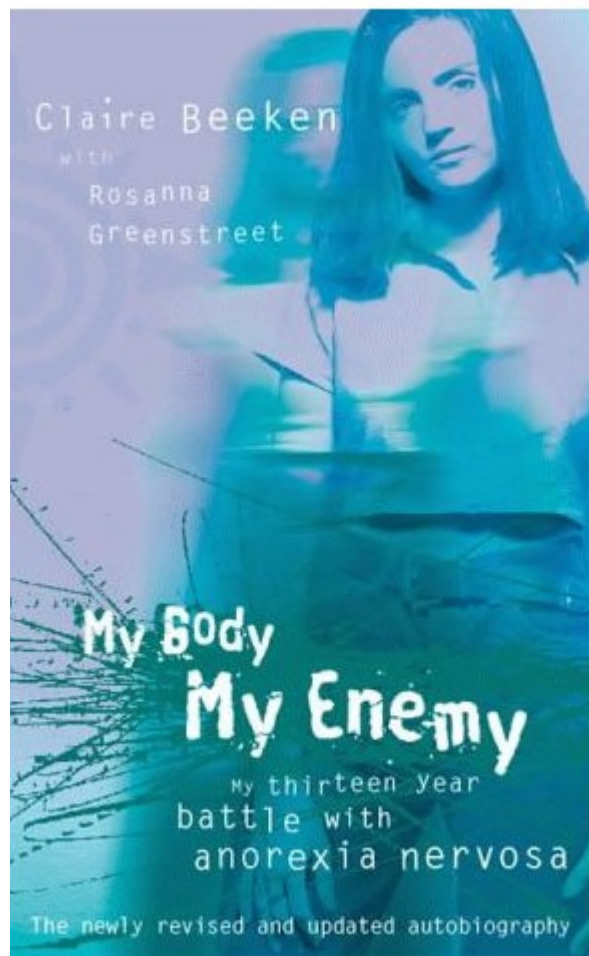
Three contexts of
food availability:
low; seasonal; high



Obesity: energy in exceeds energy out

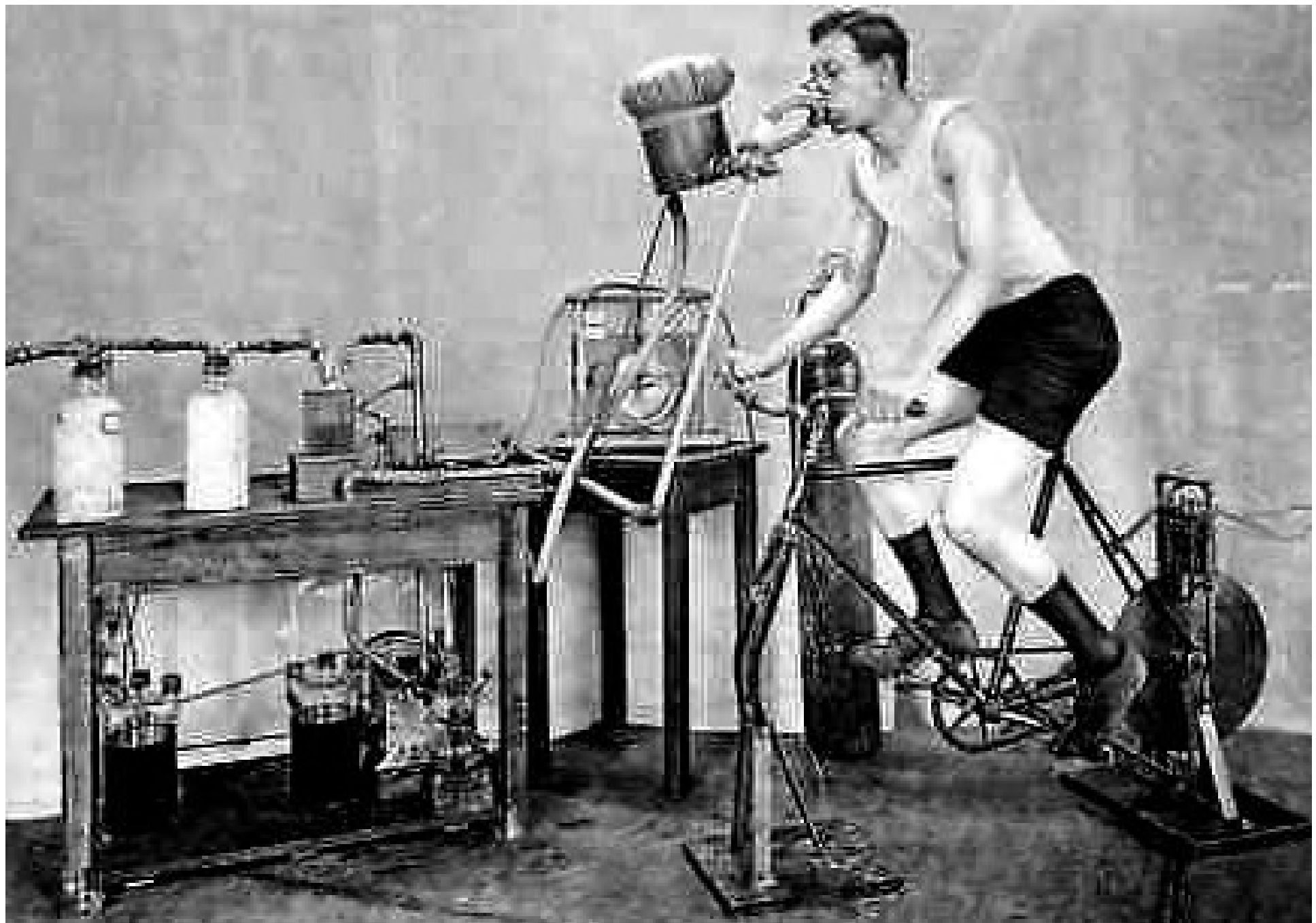
Energy metabolism



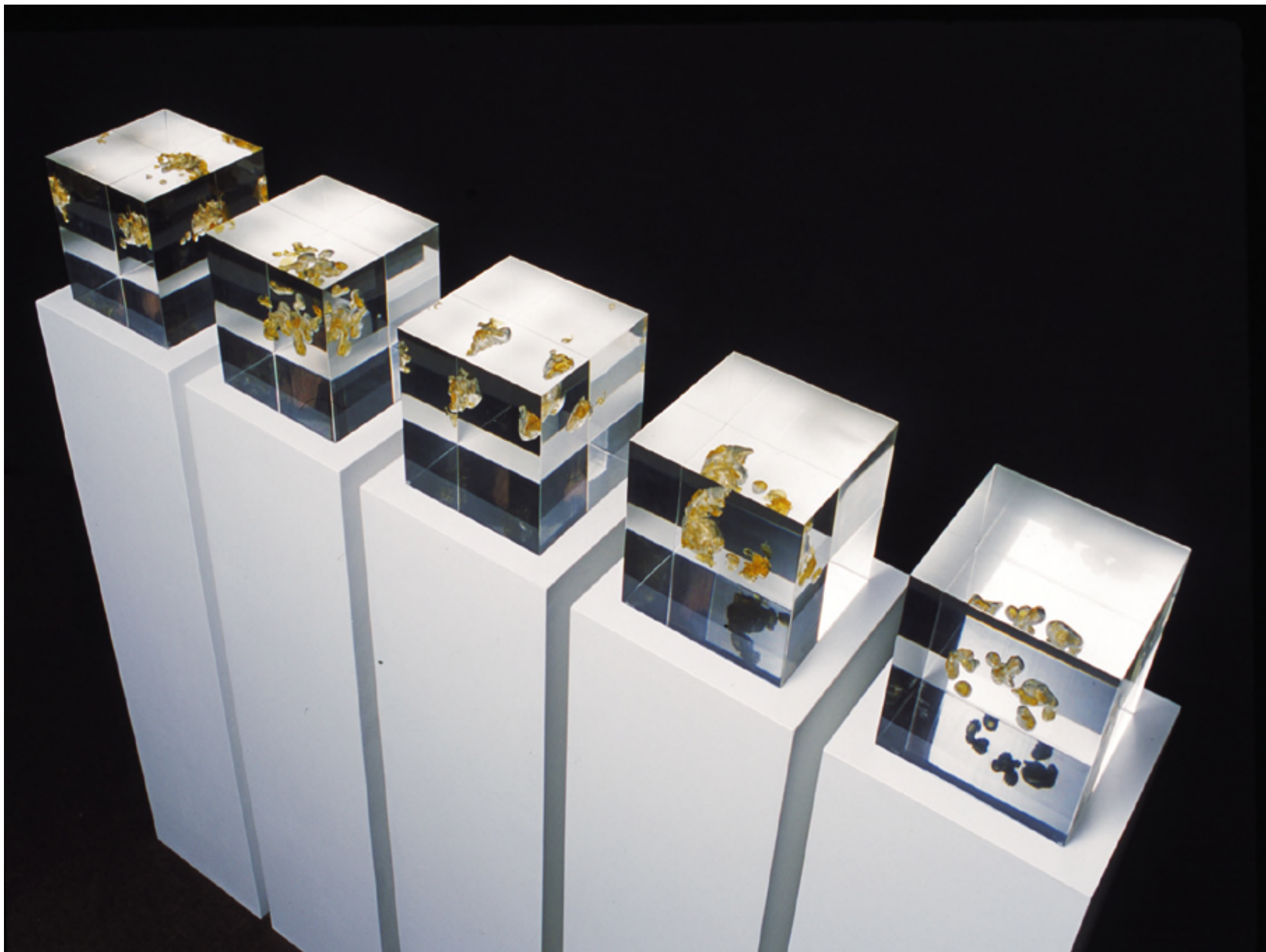


Landmarks in bioenergetics

- **Energieia (Aristotle 350BC): being at work**
- **Lavoisier: Elementary Treatise on Chemistry (1789): respiration and chemistry of life**
- **Kelvin: kinetic theory of the dissipation of energy (1874)**
- **Atwater (1893): metabolic interchangeability of macronutrients, intake and expenditure**
- **Walker (1978): molecular bioenergetics**
- **Schull and many others (1987): genetics of molecular bioenergetics**
- **Saks (2009): networked (relational) bioenergetics**



Energetics of cycling using the respirometer of Atwater, US Department of Agriculture, 1895-1907



Bioenergetics

Molecular: energy involved in making and breaking of chemical bonds in molecules of biological organisms

Ecological: food and energy as key interface between organisms (humans) and their environments

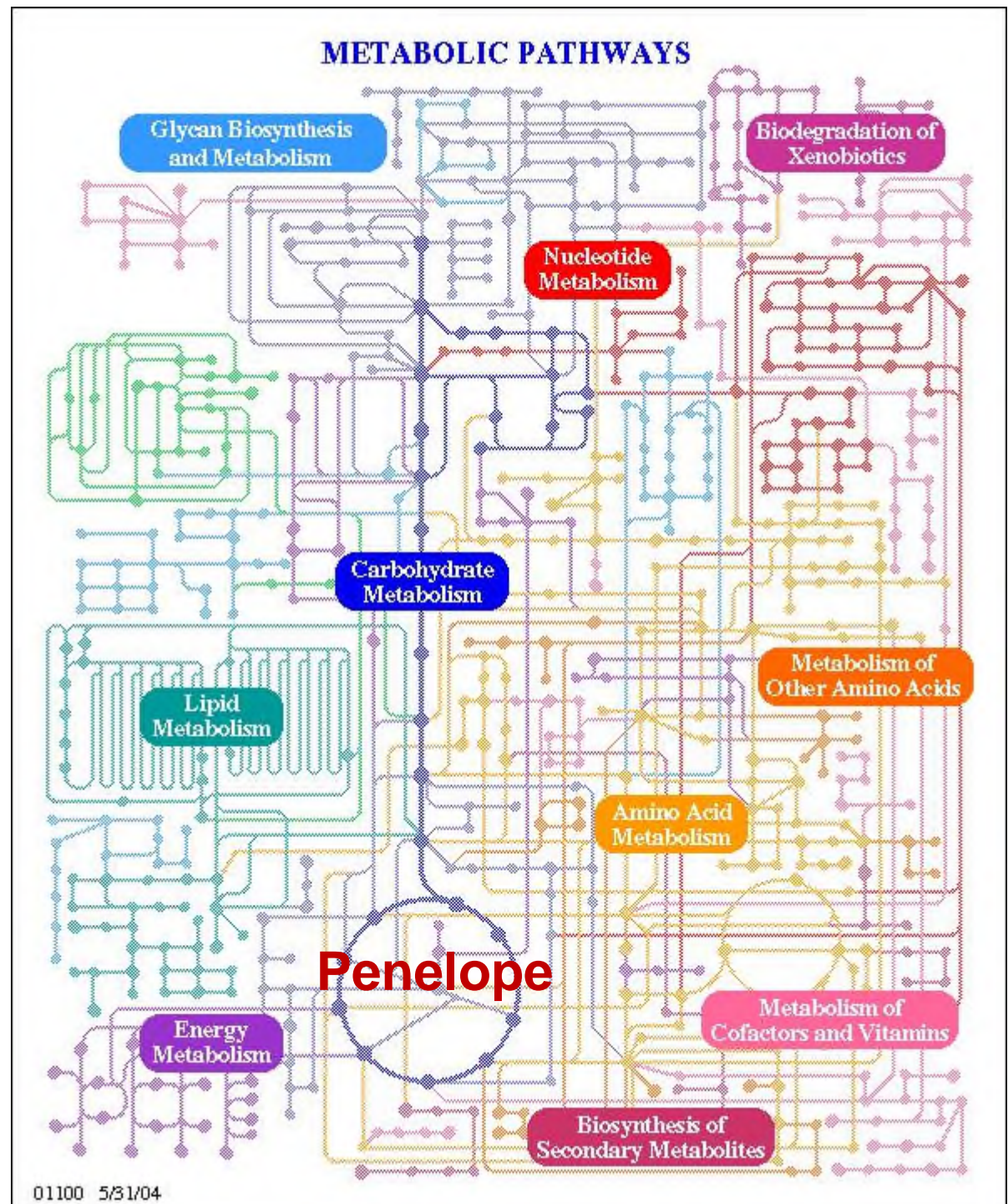
Evolutionary: energy budgets associated with reproduction, development, and foraging behaviour that lead to survivorship

How is molecular bioenergetics changing?

According to Saks et al (2009):

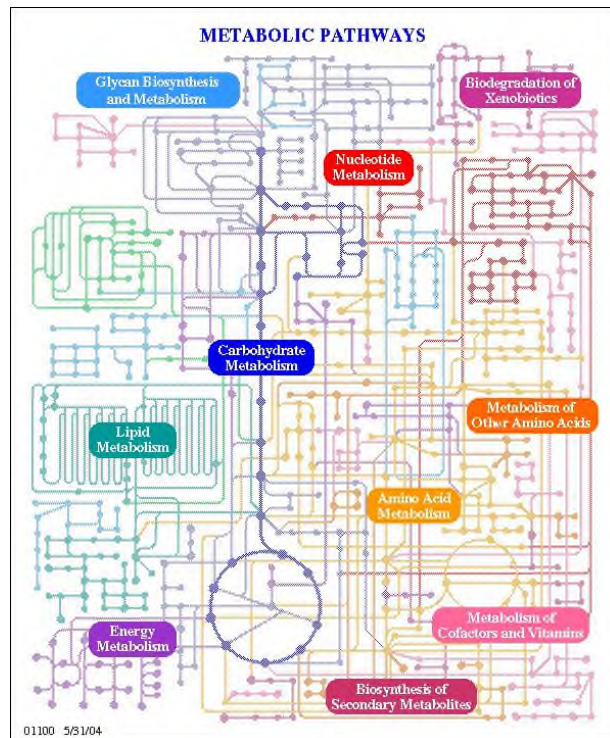
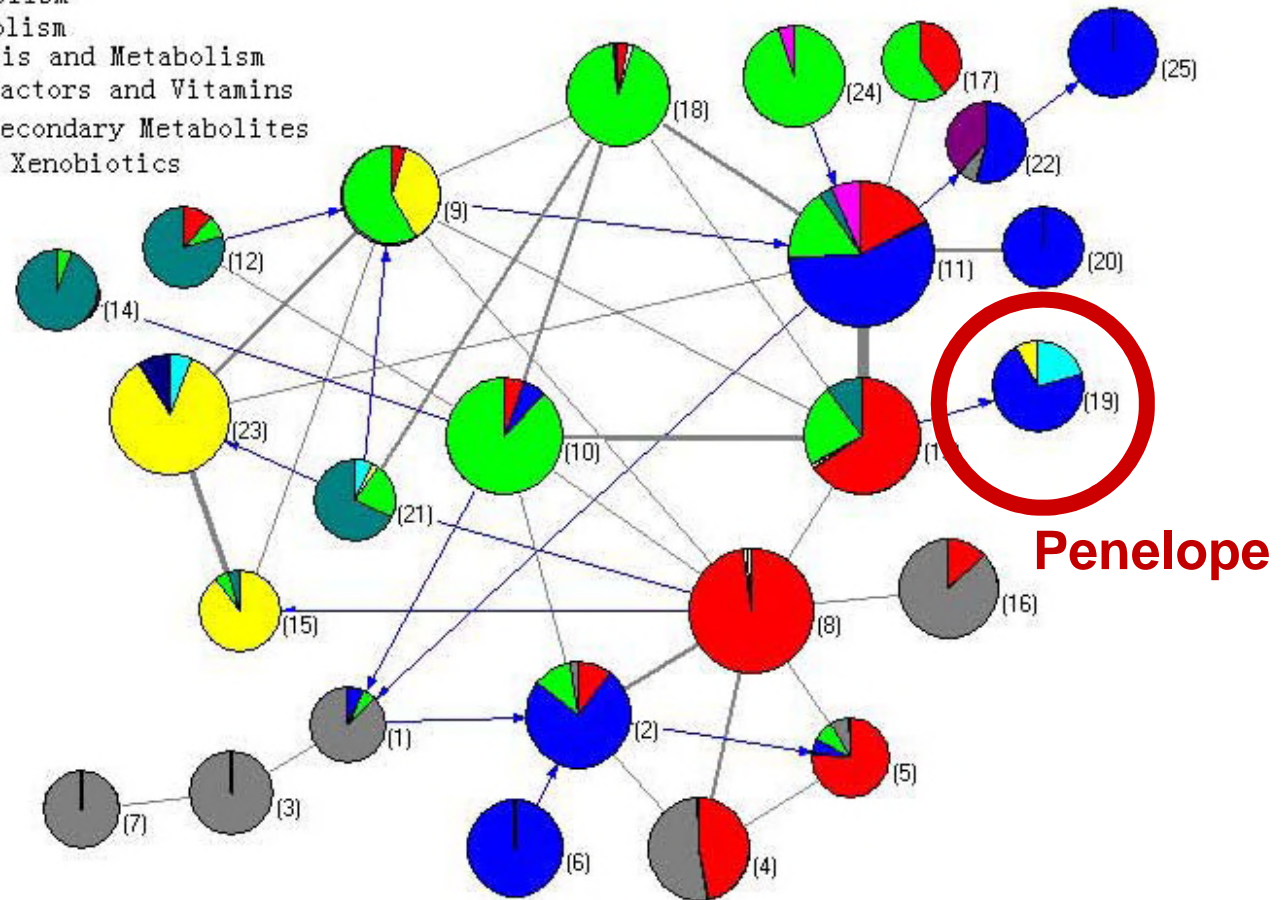
- **Within last decade, biological sciences have witnessed a radical change of paradigms**
- **Reductionism, which used to be a philosophical basis of biochemistry and molecular biology when everything – from genes to proteins and organelles – were studied in their isolated state is giving way to Systems Biology, which favours the study of integrated systems at all levels: molecular, cellular, organ, organism, and population**

- Classical dynamic view of metabolism,
- or how bodies get built and maintained
- House-building (cells) and chemical engineering (substances needed to build and maintain them) is the model
- Problem: the building blocks 'talk' with each other, as do the genes that code for their production, while building and maintenance happen



Metabolic network, based on genetic relationships that code for its components (Zhao et al 2007)

- I. Carbohydrate Metabolism
- II. Energy Metabolism
- III. Lipid Metabolism
- IV. Nucleotide Metabolism
- V. Amino Acid Metabolism
- VI. Glycan Biosynthesis and Metabolism
- VII. Metabolism of Cofactors and Vitamins
- VIII. Biosynthesis of Secondary Metabolites
- IX. Biodegradation of Xenobiotics



Each circle represents a module and is coloured according to the Kyoto Encyclopedia of Genes and Genomes pathway classification of the reactions belonging to it, while the arcs reflect the connection between clusters. The area of each colour in one circle is proportional to the number of reactions that belong to the corresponding metabolism. The width of an arc is proportional to the number of reactions between the two corresponding modules. For simplicity, bi-directed arcs are presented by grey edges.

Evolution of metabolic modules found in humans (Zhao et al 2007)

- I. Carbohydrate Metabolism
- II. Energy Metabolism
- III. Lipid Metabolism
- IV. Nucleotide Metabolism
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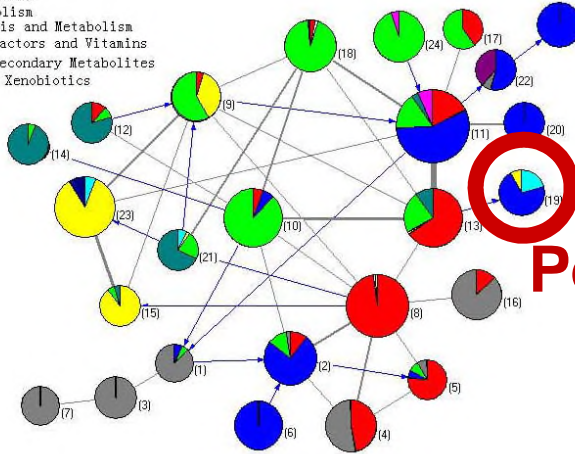


Table 2: Evolutionary ages of topological modules for *H. sapiens* network

Evolutionary age	Module	Percentage of enzymes in this age	P-value	Inter-module degree
6	3	82.35 %	9.26×10^{-8}	4
6	6	68.75 %	2.46×10^{-4}	1
6	7	71.42 %	6.19×10^{-3}	2
6	19	63.16 %	3.02×10^{-4}	1
6	25	85.71 %	1.58×10^{-6}	1
4	24	30.00 %	2.22×10^{-3}	1
3	20	40.00 %	4.18×10^{-3}	5
2	22	33.33 %	2.34×10^{-3}	2
2	1	36.84 %	1.89×10^{-3}	5
2	5	40.00 %	6.82×10^{-3}	5
1	8	69.09 %	4.27×10^{-5}	22
1	9	84.38 %	3.5×10^{-6}	17
1	12	65.22 %	2.53×10^{-3}	4
1	13	65.31 %	6.48×10^{-4}	25
1	15	64.00 %	2.65×10^{-3}	11
1	18	68.57 %	1.61×10^{-3}	17

Evolutionary age is defined as: 1. Prokaryota; 2. Protists; 3. Fungi; 4. Nematodes; 5. Arthropods; 6. Mammalian; 7. Human. See Method part for the detailed definition.

Ecological bioenergetics

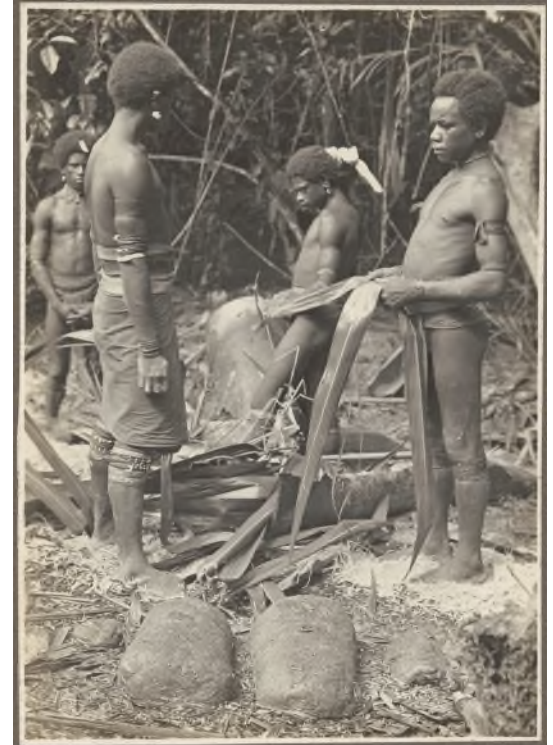
- **Energy is a force (as is money)**
- **Many aspects of human activity involve energy transfer of one sort or another**
- **A form of biological economics**
- **Tradability of human physical energy for animal and technological force**
- **Tradability of food energy with fossil fuels (and other)**
- **Ecological sustainability**
- **But doesn't consider non-economic energy transactions**

Sago making



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Triangulation of the three bioenergetics

New scientific synthesis, under negotiation

Recent developments in genetics, physiology, medical imaging and network theory offer ways in which human action can be examined anew, linking energies of body and mind

Popular engagement with ideas that have bioenergetics at their core – obesity, starvation, sustainability, environmental degradation – suggest that this emerging synthesis carries great resonance which can be tapped to explore the human condition in a new way



Toward a cultural physiology

- **Bioenergetics cannot adequately measure energy flows between individual and social bodies**
- **Limited ability to explain intra-societal differences in how individuals mobilize energy resources while under particular cultural constraints**
- **Potentially informative social theory (eg. Bourdieu's 'habitus' (cultural predisposition towards repeating certain thoughts and actions)) absent from bioenergetics discourse**
- **Energized human bodies do not behave as predictably or mechanistically as a physiological understanding of energy flows might suggest.**
- **Bodies as creative agents in responding to and changing societal structures and behavioural conventions**
- **A measure of social energy exchanges needed**

What has dance to do with obesity?



Caroline's turn

LABAN

↑
main entrance
♿ parking

←
private car park
deliveries

CREEKSIDE SE8

↑
entrance
drop off point A
←
parking A
—
no bicycles
beyond this point
guide dogs only













Stanley's turn

Other ways forward: fat flows

- Annie Catrell

Other ways forward: fat flows

- Andrew Carnie

Toward a cultural physiology: summary