

# Obesity

## - developmental perspectives

**Stanley Ulijaszek**

**Unit for Biocultural Variation and Obesity**



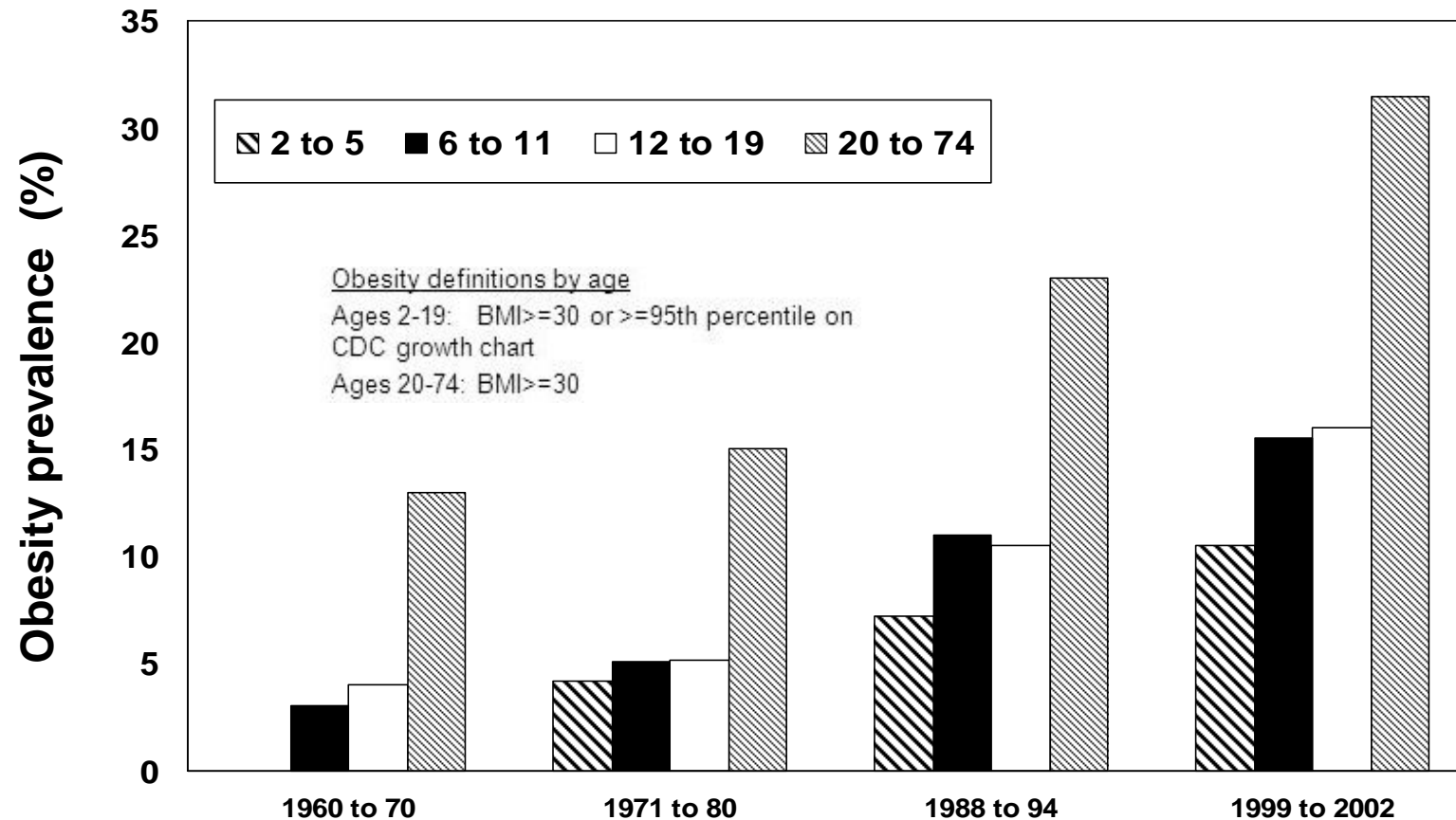
# Complementary views of evolutionary basis for obesity: genetics and development



**Obesity develops**

**Nothing develops  
without behaviour**

# Obesity develops - example from the United States



Data source: National Center for Health Statistics, CDC: National Health Examination Survey (NHES) 1960-1970, National Health and Nutrition Examination Survey (NHANES) 1971-2002.

Homer J, Milstein B, Dietz W, et al. Obesity population dynamics: exploring historical growth and plausible futures in the U.S. *Proc. 24th Int'l System Dynamics Conference*; Nijmegen, The Netherlands; July 2006.



# Nothing develops without behaviour

## THE POWER OF THE FIRST 1,000 DAYS

The right nutrition in the 1,000 days between a woman's pregnancy and her child's second birthday builds the foundation for a child's ability to grow, learn and thrive.

### behaviour

**Pregnancy:** Pre-pregnancy to birth

Babies developing in the womb draw all of their nutrients from their mother. If mom lacks key nutrients, so will her baby, putting the child's future health and development at risk.



### behaviour

**Infancy:** Birth to 6 months

Breast milk is superfood for babies. Not only is it the best nutrition an infant can get, but it also serves as the first immunization against illness and disease.



### behaviour

**Toddlerhood:** 6 months to 2 years

Nutrients from a variety of healthy foods are an essential complement to breast milk to ensure healthy growth and brain development.



The impact of good nutrition early in life can reach far into the future. Children who get the right nutrition in their first 1,000 days:

ARE 10x MORE

likely to overcome the most life-threatening childhood diseases<sup>1</sup>



COMPLETE

4.6 more grades of school<sup>2</sup>

behaviour



Go on to earn behaviour

21% more in wages as adults<sup>3</sup>



behaviour

Are more likely as adults to have healthier families<sup>4</sup>

# The structure

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perspectives

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**Aristotle's 4 causes and Tinbergen's 4 questions**

**Fatness and Tinbergen's 4 questions**

**Obesity as proximate developmental outcome of behaviour**

**Fatness and eating**

- ontogeny
- mechanisms



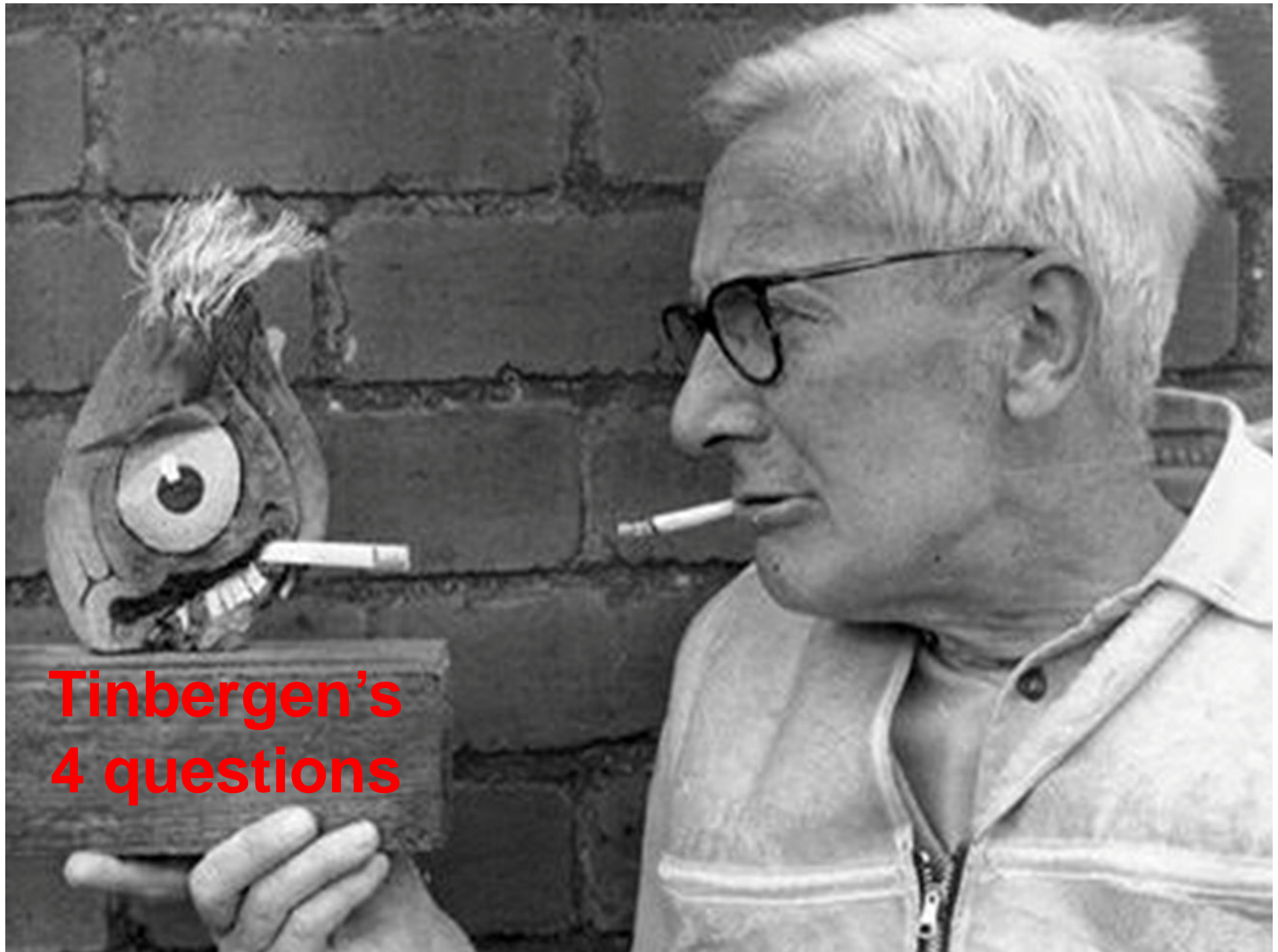


# Aristotle's 'Physics and Metaphysics' and philosophy of substance

**4 causes (or explanations) needed to explain material change in the world**

**A complete explanation will use all four - material, formal, efficient, final**

- Material cause** - what something is made of (human body made up of cells; some cells are adipocytes)
  - general properties of something (human body needs  $O_2$  because its cells need  $O_2$ )
- Formal cause** - what makes a thing one rather than many things (difference between a collection of cells and a human body is that a human body has properties and functions that come from a particular arrangement of the right kind of cells doing the right kind of things)
- Efficient cause** - what does the work (every change is caused by an efficient cause - if a body gains weight, it is because energy enters the body at a rate faster than it dissipates it)
- Final cause** - why efficient causes do what they do; and why formal causes do what they do



**Tinbergen's  
4 questions**



# Who is Niko Tinbergen?

Ethology: The pioneers in the study of animal behavior – 1973 Nobel Prize

Karl von Frisch



Niko Tinbergen



Konrad Lorenz



for discoveries concerning organization and elicitation of individual and social behaviour patterns

**Was Tinbergen an Aristotelian? Comparison of Tinbergen's 4 Why's and Aristotle's 4 Causes  
Hladký & Havlíček (2013)**

## On aims and methods of Ethology

By N. TINBERGEN<sup>1)</sup>



In a famous paper dedicated to Konrad Lorenz on his 60th birthday, Niko Tinbergen (1963) noted that biologists working on behaviour focus on different types of problem

**He identified 4 fundamentally different types of problem are raised in the study of biology - survival value, ontogeny, evolution, causation**

**These can be expressed as 4 questions about any feature of an organism -**

**What is it for?**

**How did it develop during the lifetime of the individual?**

**How did it evolve over the history of the species?**

**How does it work?**

Although Tinbergen was concerned with behaviour, the four questions apply broadly to any characteristic in living systems

4 questions

## Object of study

### Level of question

	<b>Contemporary:</b> An explanation of the current form of a behavior in terms of present-day	<b>Chronicle:</b> An explanation of the current form of the behavior in terms of a sequence
<b>Proximate (how):</b> An explanation in terms of immediate factors, relevant and potentially measurable in current time.	<b>Mechanism</b> (a.k.a. causation) Causal explanations in terms of what the behavior is and how the behavior is constructed. These explanations can include physical morphology, molecular mechanisms, other underlying biological factors, or external stimuli. <i>Aristotle: material cause</i>	<b>Ontogeny</b> (a.k.a. development) Developmental explanations for sequential changes across the lifespan of an individual. Often these explanations are concerned with the degree to which the behavior can be changed through learning. <i>Aristotle: formal cause</i>
<b>Ultimate (why)</b> An explanation in terms of the process and forces of evolution.	<b>Adaptive Value</b> (a.k.a. function) Functional explanations regarding the utility of the current form of the behavior with regard to increasing an organisms lifetime reproductive success. <i>Aristotle: final cause</i>	<b>Phylogeny</b> (a.k.a. evolution) Evolutionary explanations that describe the history of the behavior, such as which ancestor first possessed this trait, what was the antecedent to this behavior, and what selective pressures in the past have shaped this behavior. <i>Aristotle: efficient cause</i>

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**Aristotle's 4 causes and Tinbergen's 4 questions**

**Fatness and Tinbergen's 4 questions**

**Obesity as developmental outcome of behaviour**

**Fatness and eating**

- ontogeny
- mechanisms

# Fitness and the 4 questions

	<b>Current form</b>	<b>Explanation of current form</b>
<b>Proximate (how)</b>	<b>Mechanism - morphology; molecular mechanisms; environmental cues</b>	<b>Ontogeny - developmental explanations</b>
<b>Ultimate (why)</b>	<b>Adaptive value - functional expl of utility in relation to lifetime reproductive success</b>	<b>Phylogeny - evolutionary explanations</b>

# **Fatness and the ultimate questions**

- **Current form - adaptive value**
- **Explanation of current form - evolutionary explanations**

# Current form – adaptive value

- **Insulation: neonates; fat –v- fur**
- **Thermogenesis: brown and beige**
- **Immunology and endocrinology**
- **Energy reserve**
- **Reproduction: women fatten more easily than males**



# **Explanation of current form - evolutionary explanations**

- **Thrifty gene hypothesis (Neil 1962)**
- **Drifty gene hypothesis (predation release and random genetic drift) (Speakman 2008)**
- **Genetics of obesity overwhelmingly related to appetite regulation (Lindgren 2019)**



# Fitness and the 4 questions

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# Mechanism

- **Appetite and palatability (gut brain axis)**
- **Cues from high energy dense foods (metabolic hierarchy)**
- **Obesogenic environments**

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# Development and mechanisms of eating

**Many components:**

- environment
- selection of food
- **mouth, brain and taste**
- gut and microbiota
- digestion and nutrition
- **brain and satiety**



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# Fatness and feeding

- **Ontogeny**  
–development



- **Mechanisms**  
–morphology, physiology,  
environmental cues

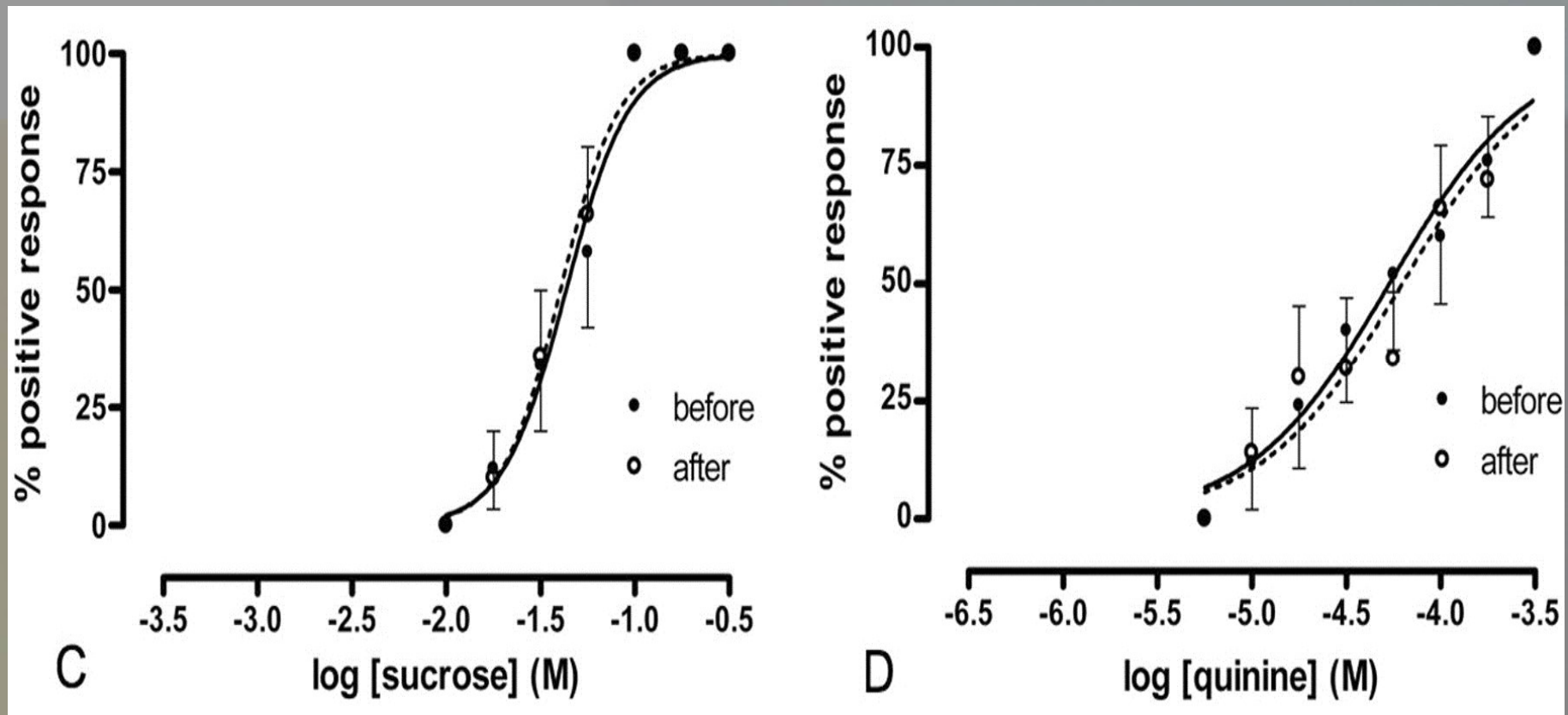
# Innate human taste preferences vary

MSG (umami)



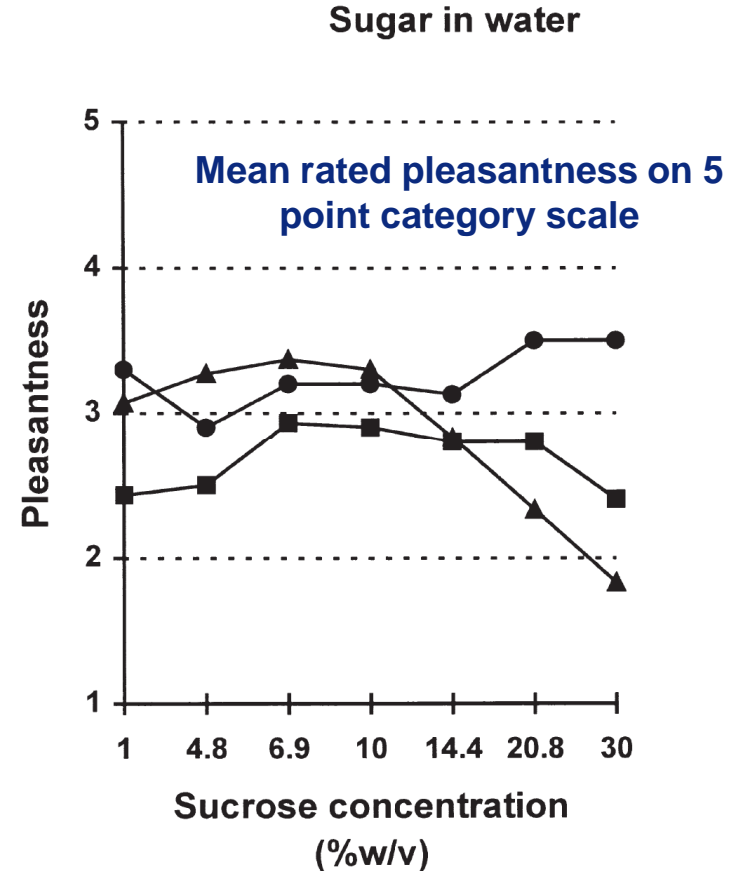
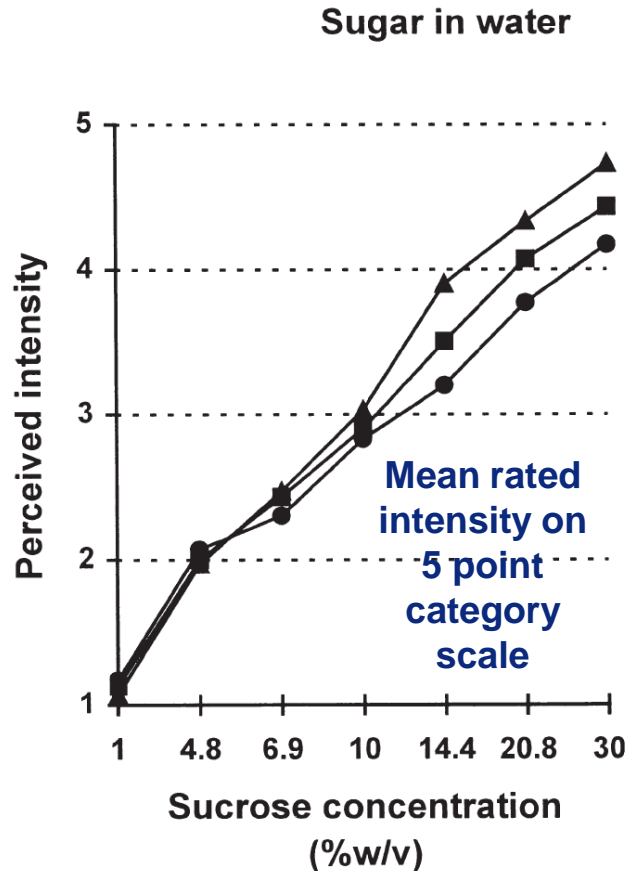
# And in adult life

sweet and bitter taste sensitivities vary  
20 UK subjects before and after placebo (Heath et al 2006)





# Children prefer sweeter tasting foods than adolescents; than do adults

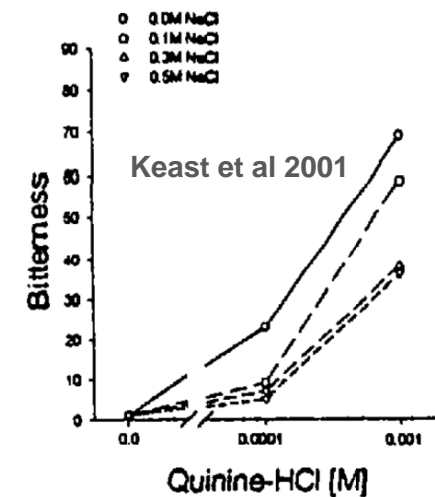


Reflects energy needs per unit of body size?

Graaf and Zandstra 1999

## Sweetness and bitterness of childhood: insights from basic research on taste preferences (Mennella and Bobowski 2015)

- Children's liking of sweet and dislike of bitter reflect their basic biology
- Preferences for sweets and sensitivity to bitter change during adolescence
- Sodium salts are more likely to block bitter tastes in adults than children
- For children, sugars are a better blocker of some bitter tastes than salts



# Energy intake of children

## Influenced by:

**innate taste variation (genetics)**

**infant feeding (appetite regulation - lower satiety response in children with history of rapid weight gain from infancy through childhood; higher food responsiveness related to history of rapid growth (de Santis et al 2011))**

**parental influence (including instrumental consumption)**

**experiential learning**

# Development of feeding behaviours in infancy & childhood (Ramsey 2004)



- developmental skill that matures over time
- reliant on hunger/satiety cues and experiential learning
- feeding skills well-established by 2 years of age
- hunger/satiety cues shift from primarily internal to external (family, school and societal) control by about 4-5 years
- 
- ‘problematic’ feeding behaviours (turning head, arching or crying)
  - initially reactions to internal cues (absence of hunger, poor sucking ability)
  - later increasingly conditioned by association to external and societal cues (coaxing parents, television commercials)

# Fatness and feeding

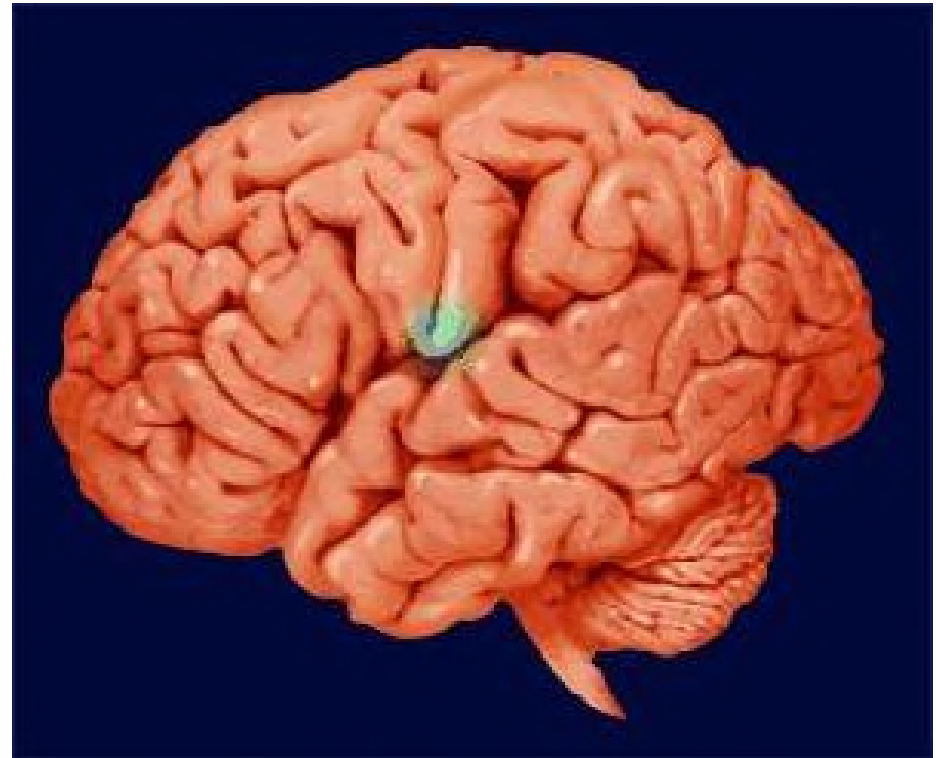
- **Ontogeny**
  - development



- **Mechanisms**
  - morphology, physiology, environmental cues

# The brain is the most important organ of taste and satiety

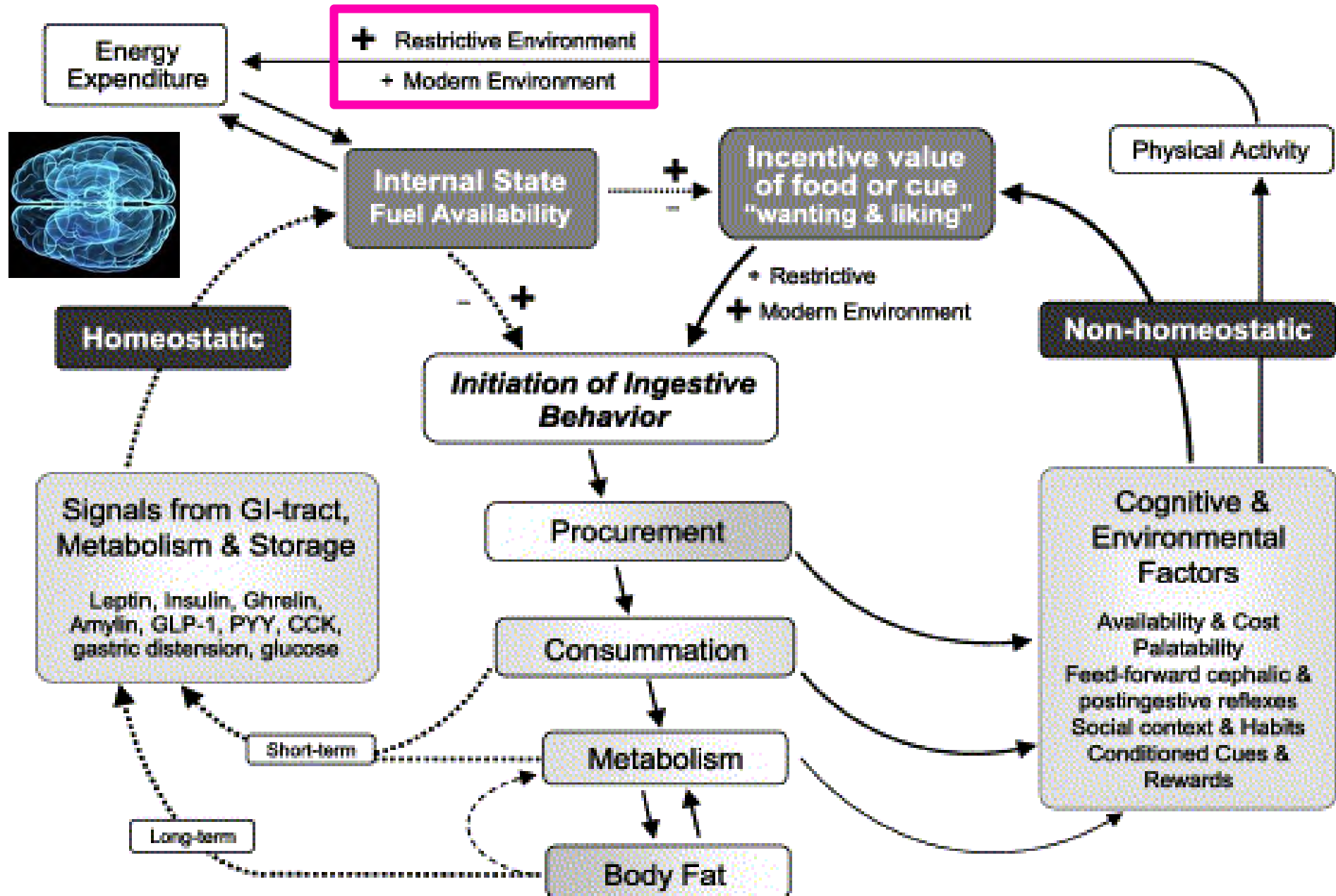
Taste is biocultural – biology which can be shaped by social learning



Laland, K. et al. (2010). How culture shaped the human genome: bringing genetics and the human sciences together. *Nature Reviews Genetics* 11: 137

# morphology, physiology

# environmental cues



# **Nutrition transition (Popkin 2000)**

**From hunting and gathering**

**To traditional agriculture, food  
processing and storage**

**To modern agriculture, food  
processing, storage and  
distribution**



# To obesogenic environments

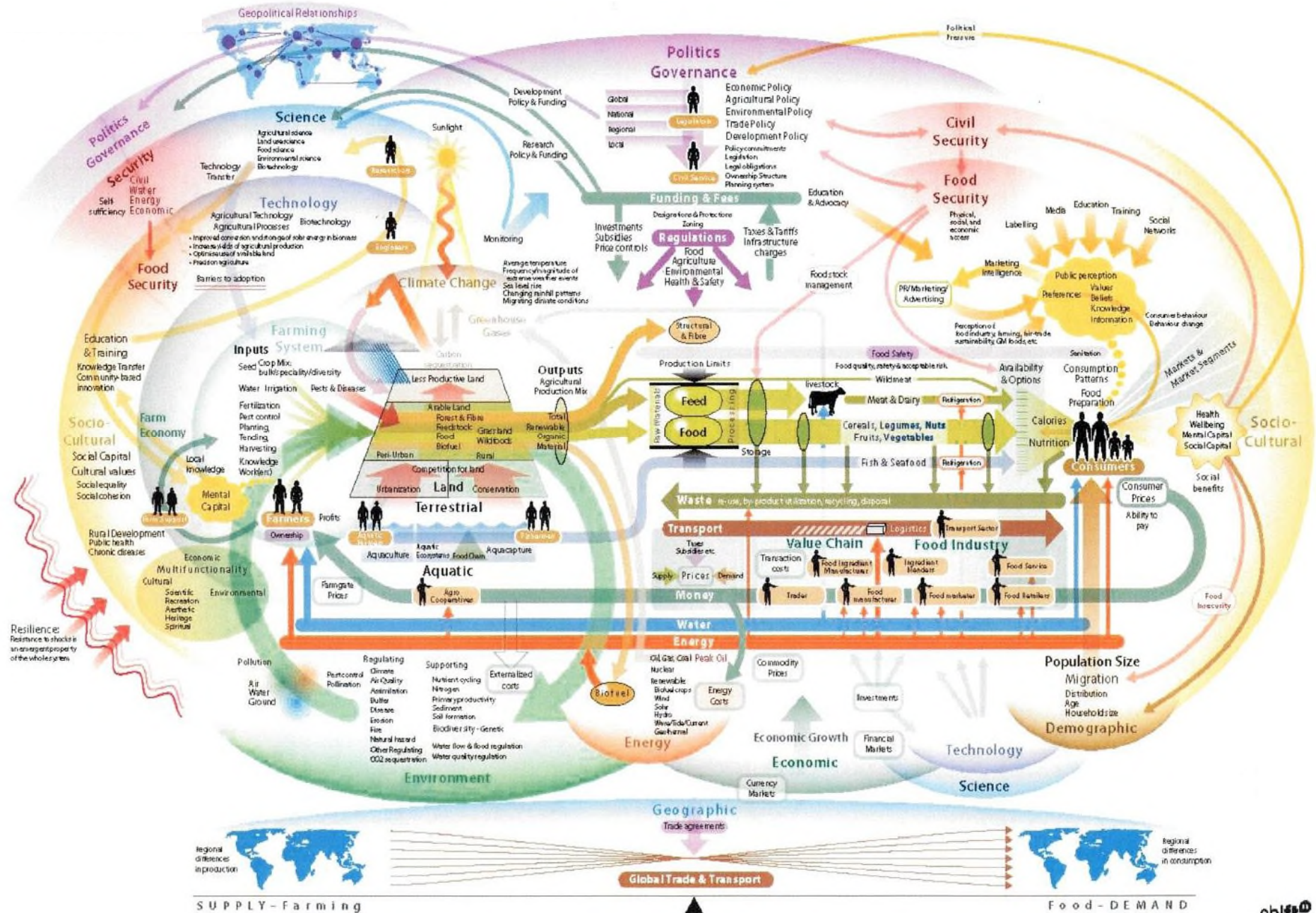
- **Types of food eaten**
  - high fat, palatable and fast foods, food industry
- **Decline in physical activity**
  - cars, work, leisure, computers (everywhere)
- **Interactions**
  - modern lives, little time, television

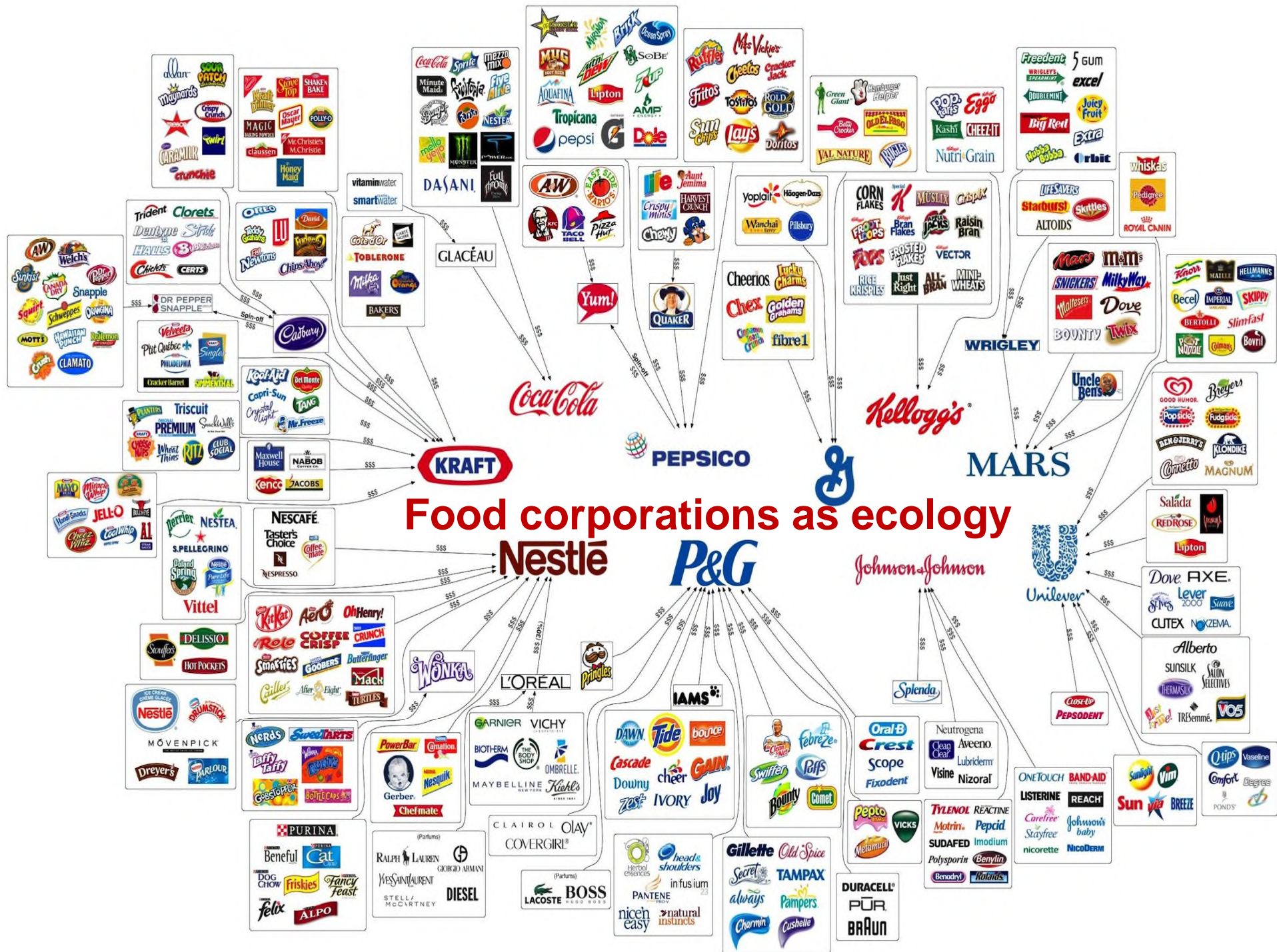


**from nutrition transition  
to expert systems  
and ultraprocessed foods**

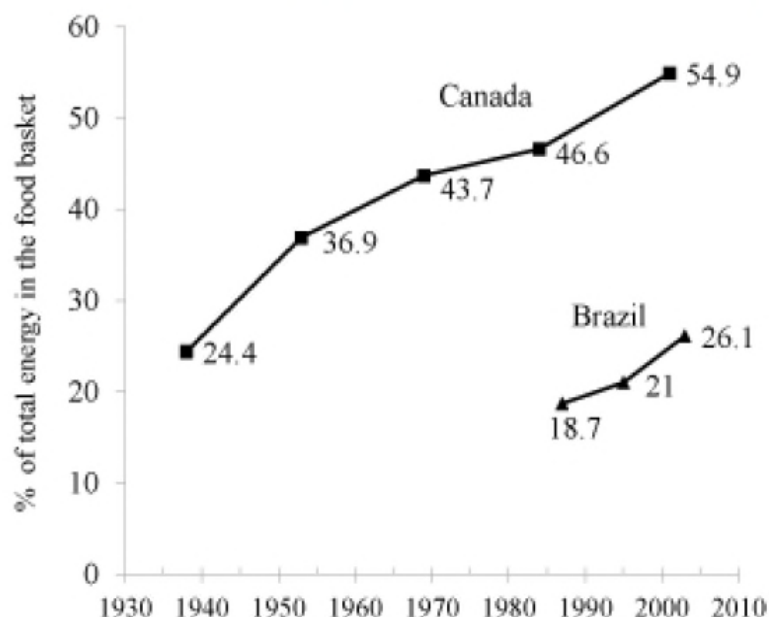


# An expert system: global food system





# Ultra-processed products go global



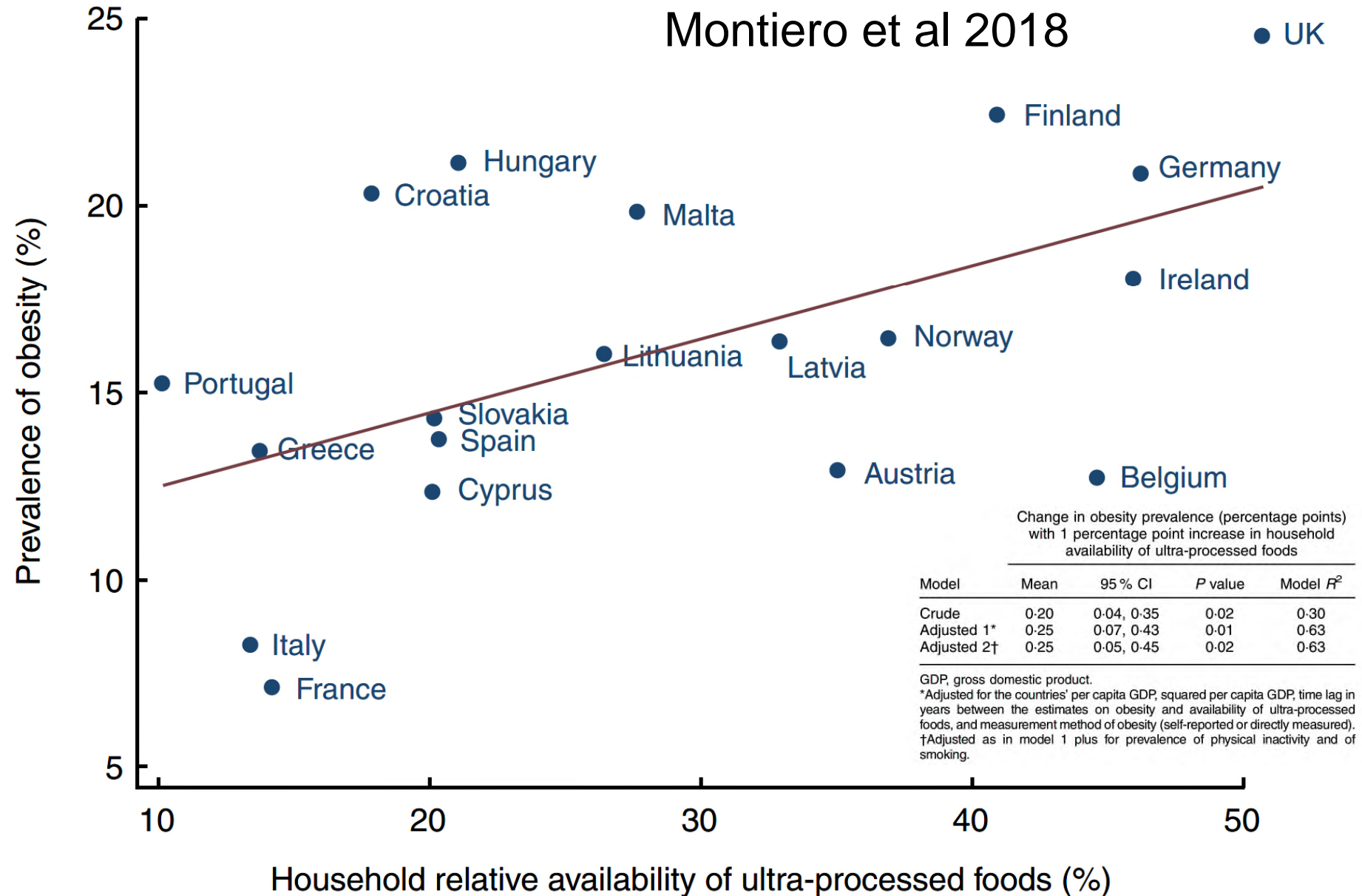
## Ultra-processed products:

- Ubiquitous; Palatable
- Refined
- Ready to consume & durable
- energy dense;
- high glycaemic load;
- low in dietary fibre, micronutrients, and phytochemicals;
- high in unhealthy types of dietary fat, free sugars, and sodium



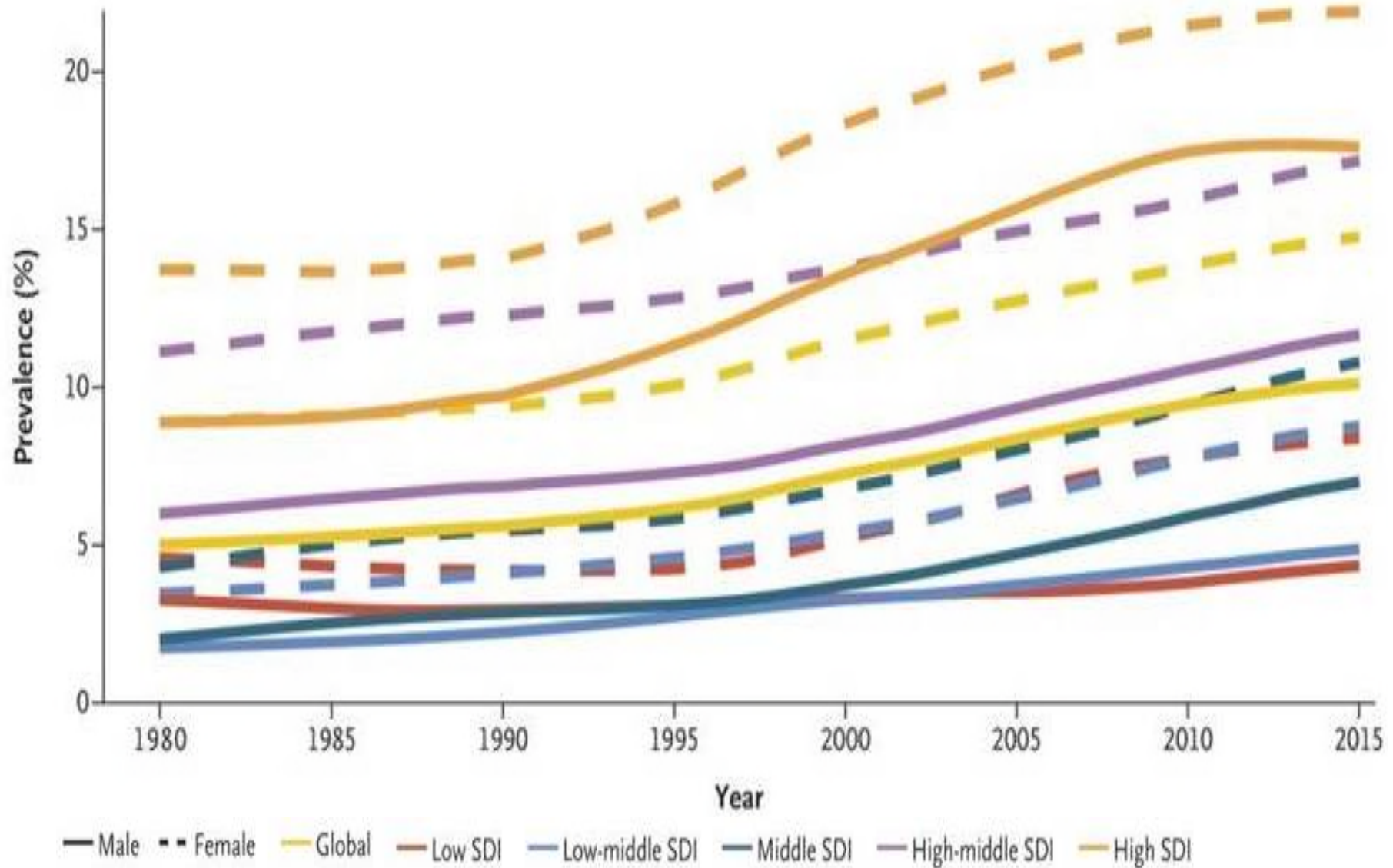
▲ Upper-middle-income countries; ■ Lower-middle-income countries.

# Household availability of ultra-processed foods and obesity in nineteen European countries



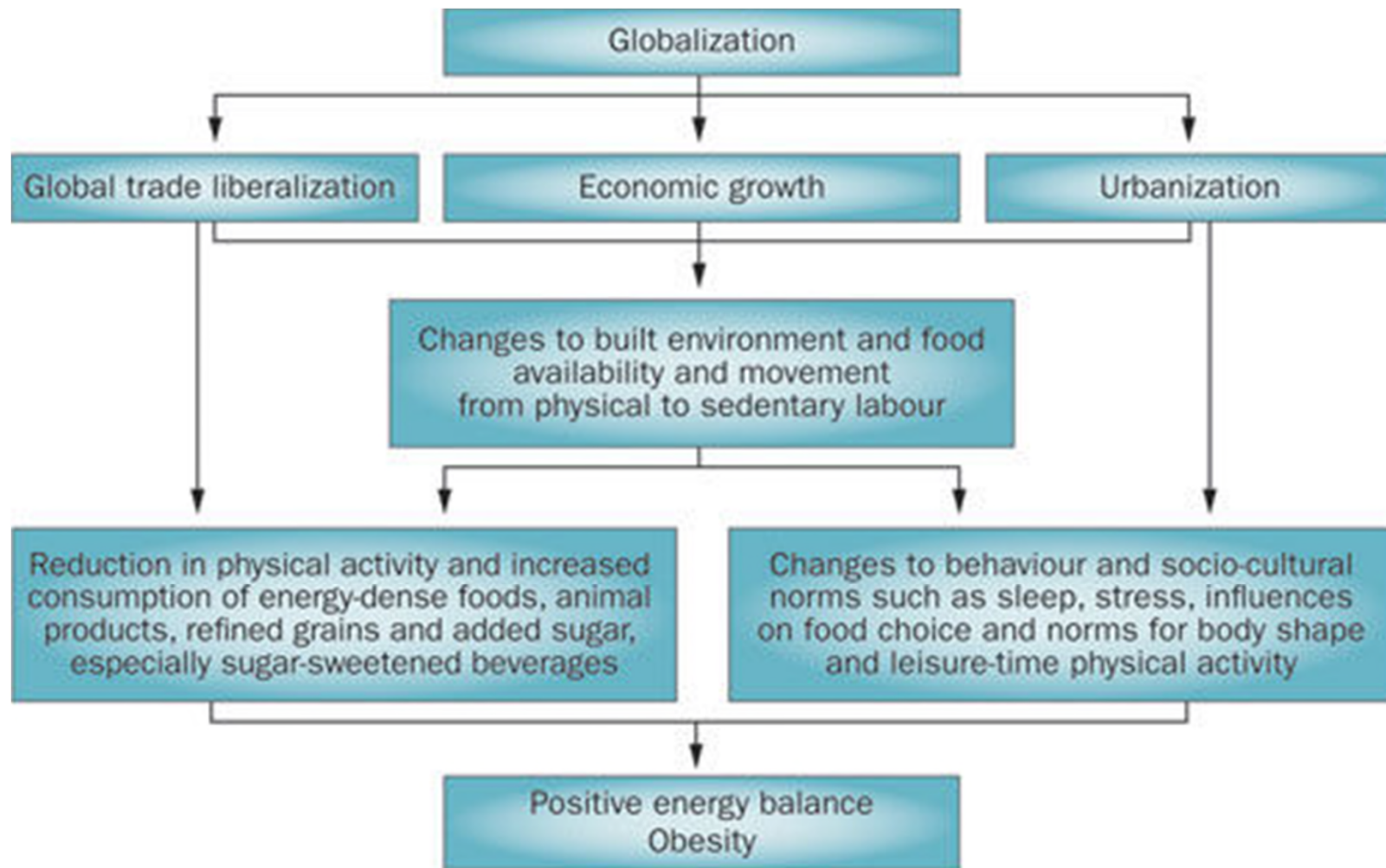
# Prevalence of Obesity at the Global Level, by Sociodemographic Index

(Global Burden of Disease 2015 Obesity Collaborators 2017)



# Globalization, human environmental change & obesity

(Malik et al 2013; Ulijaszek 2017)

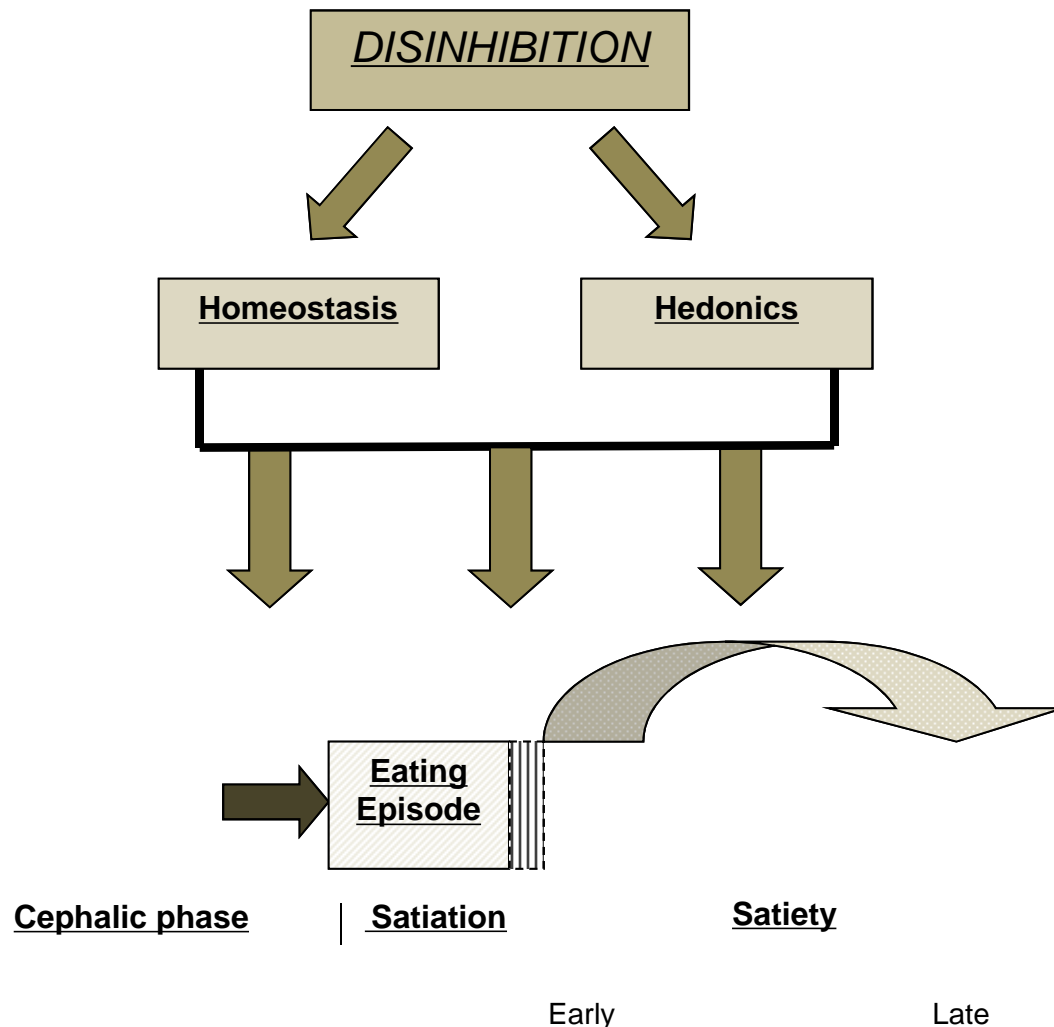




# **Insecurity feeding - evolutionary explanations**

- **Uncertainty**
- **Seasonality**
- **Hibernation**
- **Subordination**
- **Binge eating**
- **Stress relief**

# Binge eating, Disinhibition and obesity (Ulijaszek and Bryant 2016)



Binge eating & Disinhibition - evolved mechanisms for dealing with one of the most fundamental of insecurities, of food, especially in seasonal and unpredictable environments

In recent times, with improved food security in industrialized nations and emergence of obesity at the population level, they have become deleterious for health

Binge-eating and disinhibition no longer responses to uncertainty in food availability, but uncertainty and insecurity in everyday life in present-day society likely to lead to Disinhibition, binge-eating and obesity, through linked physiology of stress and appetite

# Psychobiology of comfort eating (Gibson 2012)

- **Comfort eaters vulnerable to depression, emotional dysregulation and need to escape negative affect**
- **During negative affect, preferentially consume sweet, fatty, energy-dense food - confers protection against stress, by suppression of hypothalamic-pituitary-adrenal (HPA) axis response**
- **Activation of HPA may further drive appetite for these palatable foods**



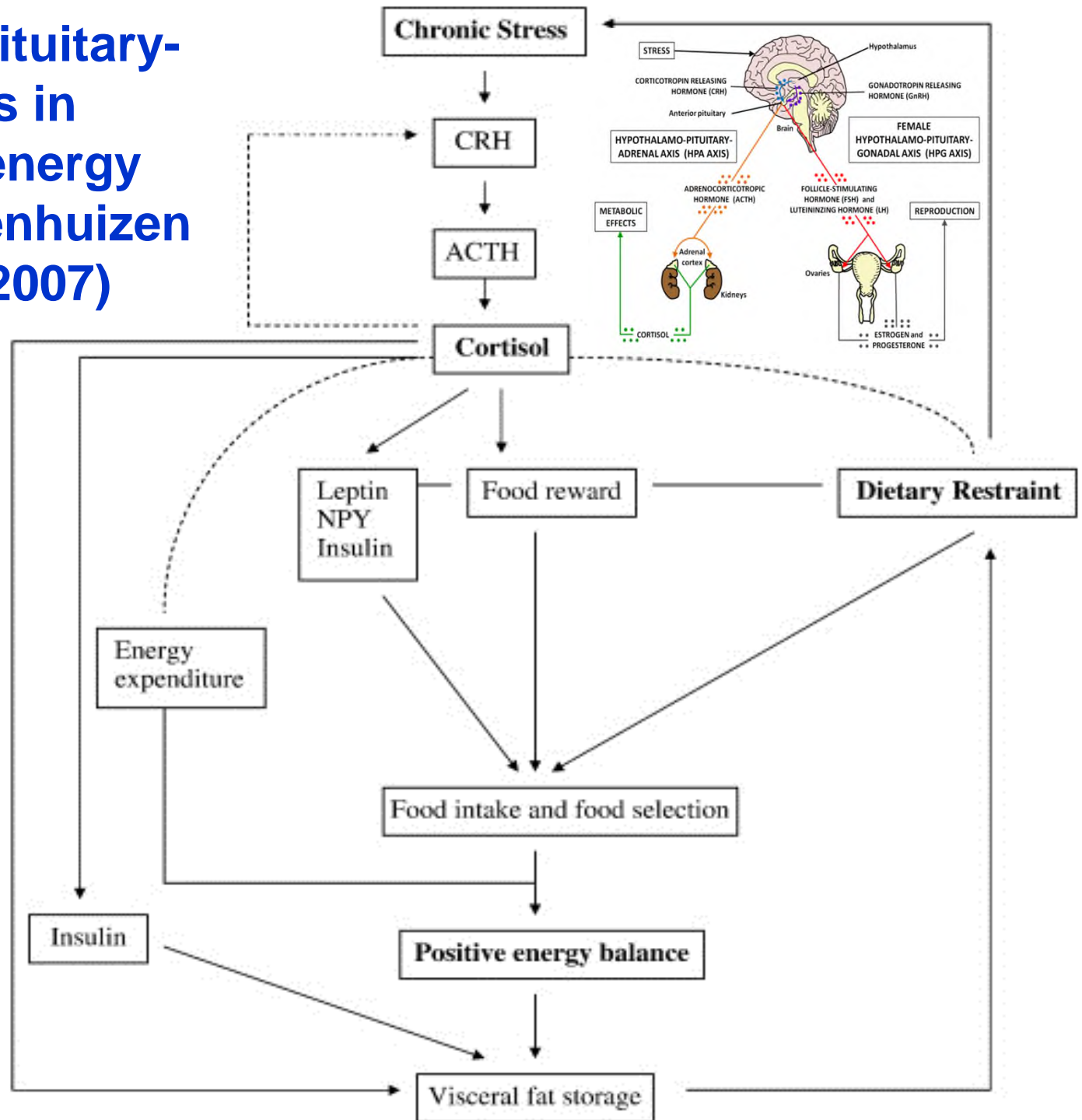
- **Resulting in weight gain**

# Hypothalamic-pituitary-adrenal-axis in regulation of energy balance (Nieuwenhuizen and Rutters 2007)



HPA axis controls reactions to stress and regulates digestion, immune system, mood, emotions, sexuality, energy storage and expenditure

Common mediating mechanism for neuro-endocrine response to stress and adaptation to it



# Conclusions - Fitness & Tinbergen's 4 questions

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## Conclusions – Fatness & Tinbergen's 4 questions

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Approach offers proximate causes of body fatness to be investigated from a biological (what is it for? how does it develop across the lifecourse?) rather than medical perspective (how can it be fixed?)

Does not preclude using biological understanding to identify fixes, but does not privilege medicine

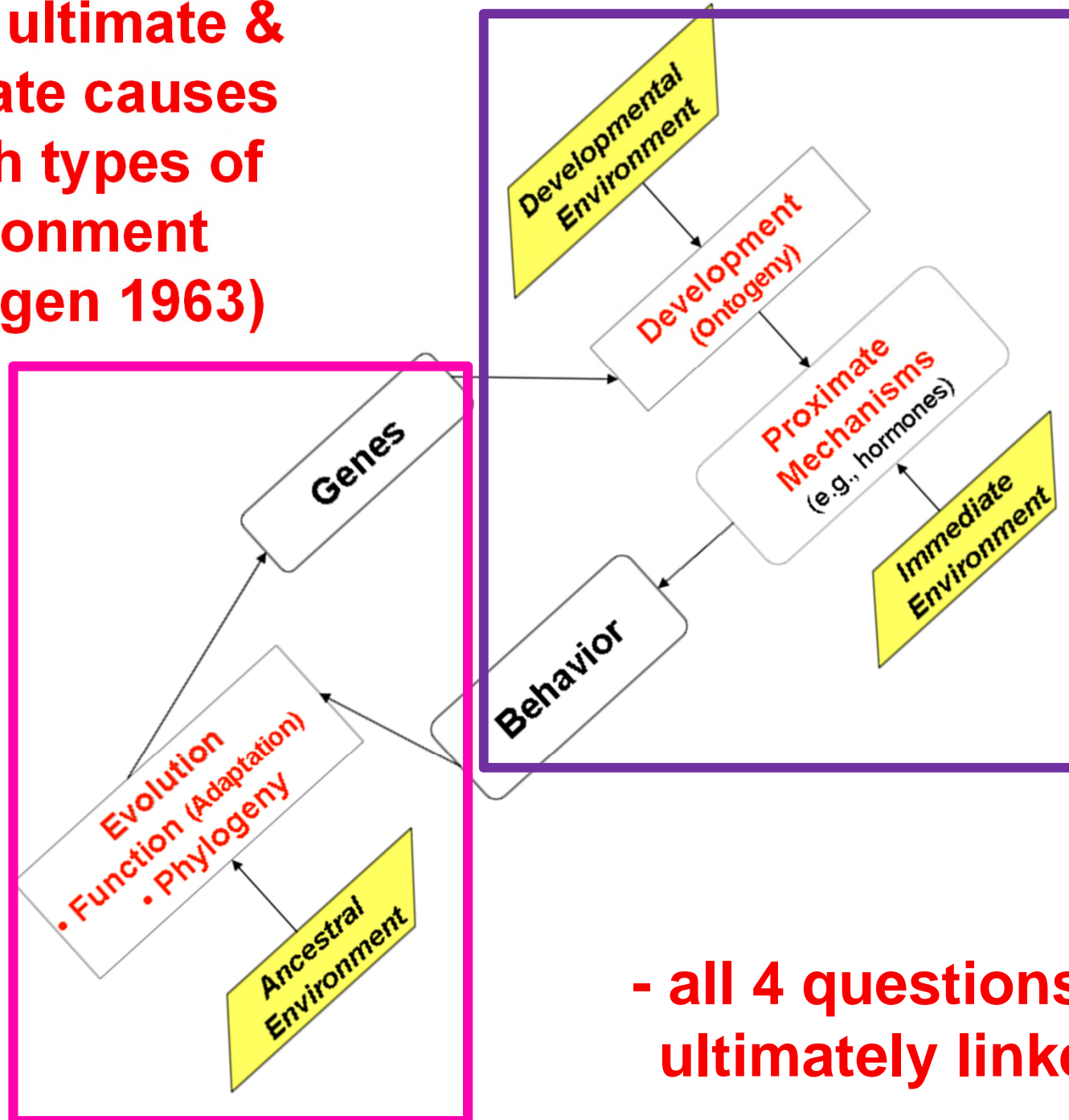
- **Feeding behaviour explanation doesn't exclude other developmental explanations**

- Fetal development
- Predictive adaptive response
- Epigenetics
- Infant feeding
- Physical activity
- Metabolic adaptations

**Obesity as  
behavioural  
and  
physical  
development**

- **All have behavioural components**

# Linking ultimate & proximate causes through types of environment (Tinbergen 1963)



- all 4 questions are ultimately linked -

# And in the end...



- **Obesity develops**
- **Obesity and Tinbergen's proximate causes**
- **Focus on eating - developmental**
- **Environmental cues – from local biology to global systems**



**Thank you!**