



Diet composition & food reformulation to influence satiety

Dr Alexandra Johnstone



Scotland's Food and Health Conflict



'Great food, poor diet'

Obesity is the No. 1 health issue



Food and Drink sector is a major component of the Scottish economy



The challenge: economic growth with health & sustainability as two key policy platforms

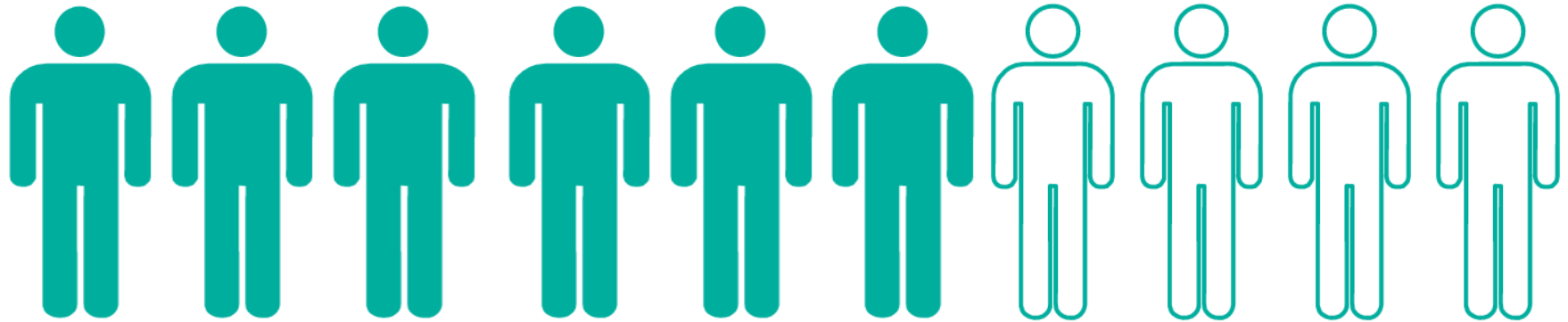


Overweight & Obesity among Adults

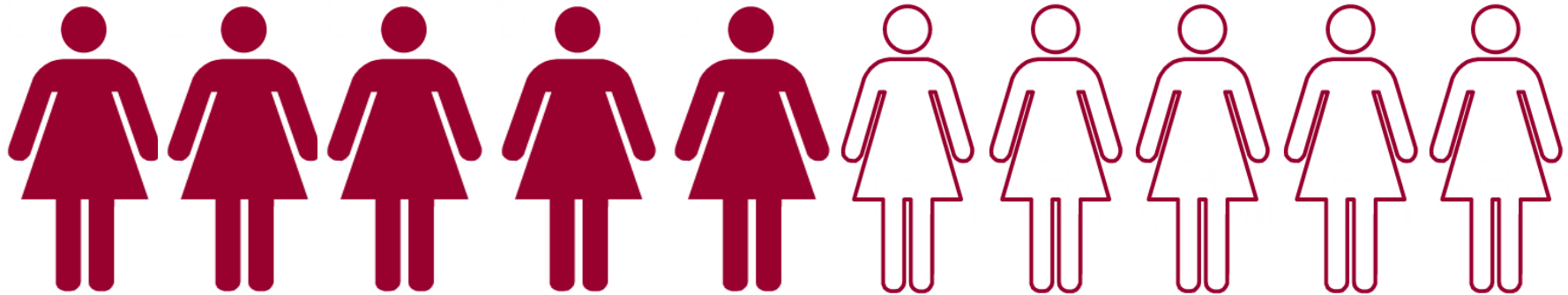
Health Survey for England 2010-2012

Adult (aged 16+) overweight and obesity: BMI \geq 25kg/m²

More than 6 out of 10 **men** are overweight or obese (66.5%)



More than 5 out of 10 **women** are overweight or obese (57.8%)



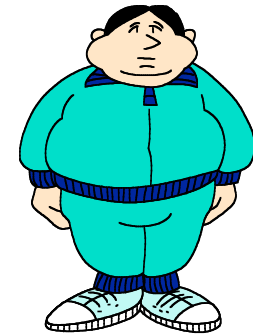
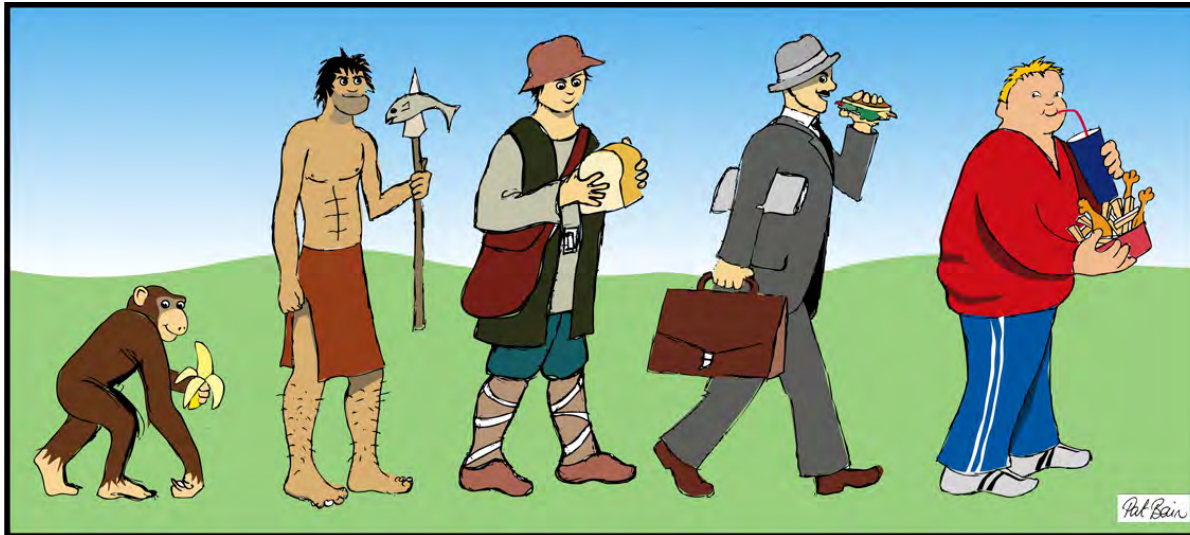
Patterns and trends in adult obesity; The published Health Survey for England data used to produce this graphic are available from:

<http://www.hscic.gov.uk/catalogue/PUB13219>

The word 'diet' comes from the ancient Greek word 'diatia'
– meaning a lifelong regimen for health
BBC iWonder – How we fought fat throughout history



- Our 'obesogenic lifestyle' makes it easy to gain weight
- Eating can be enjoyable with less calories and not feel hungry



- With the ever-increasing obesity problem comes the
- search for effective dietary strategies to:
 - (i) prevent weight gain,
 - (ii) promote weight loss,
 - (iii) maintain a lower body weight

**One diet does not
achieve all of this for
all people!!**

Food approach for improving nutritional intake (emphasis on obesity)

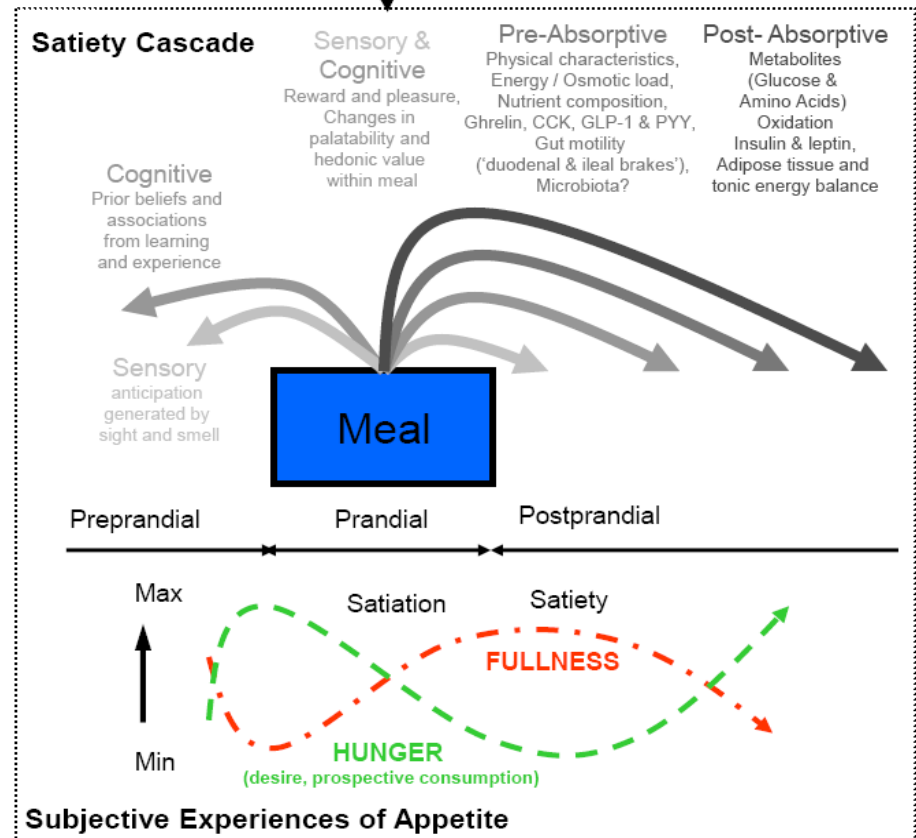
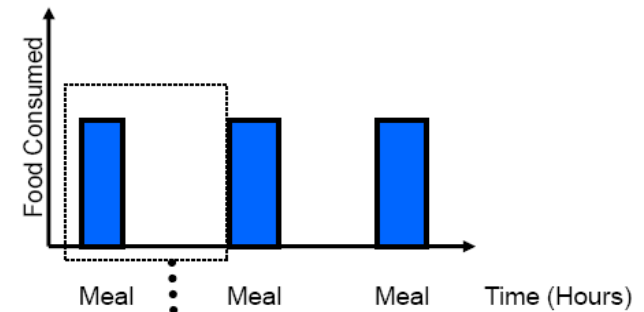
- **Healthy and safe food: Understanding the links between diet and health - optimisation of product formulation through new uses of existing ingredients, novel ingredients and novel formulations**
- Different foods have different effects on appetite systems
- Can effects on short-term appetite regulation be translated into sustained reductions in energy intake and then into long term health benefit?
- Current requirements for a successful EFSA health claim – striking the right balance between protecting the consumer and discouraging innovation in the food sector
- Population level application through behaviour change
- Targeted approaches for different consumer groups

Improving nutritional intake to tackle obesity

- A strategy? – a range of products which address different parts of the satiety cascade, and different food ‘occasions’
- Benefits to the consumer of enhanced satiety beyond weight loss or weight maintenance – e.g. satisfaction post-meal, managing eating behaviour across the day (coping with hunger), self-control and
- Self-efficacy, success in compliance with weight management
- Energy density, food matrix, fibre, protein, plant products
- Better controlled/standardized trials; mechanism of action
- Reassessment of current EFSA guidelines to provide some likelihood of a health claim around satiety being granted

- suppress further consumption
- strategies for limiting over-consumption of calories (WL) or sustaining appropriate levels of intake (WM)
- foods that target satiation during a meal (accelerate) and satiety after a meal (enhance) provide a plausible approach to weight management
- can these effects be translated into a health benefit?

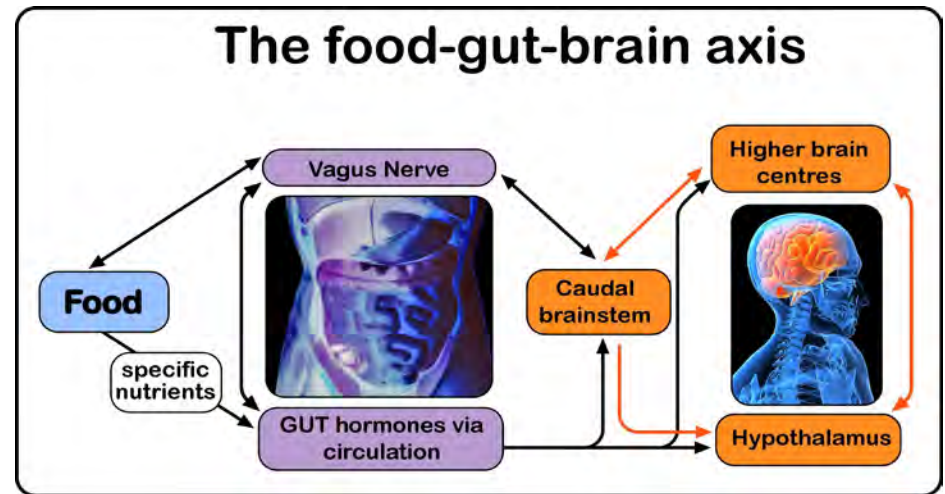
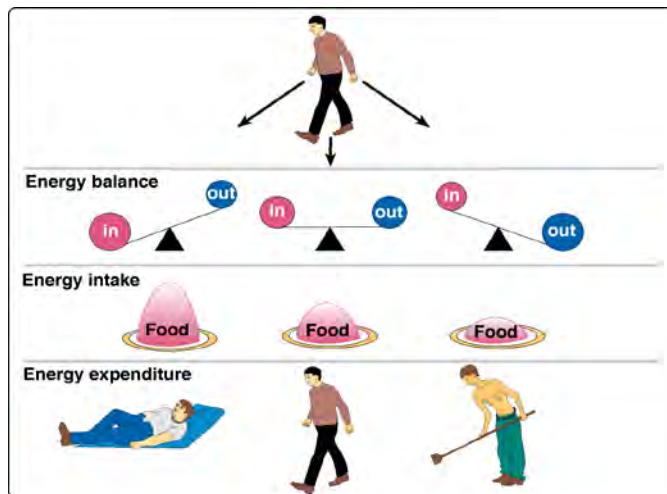
Daily Pattern of Eating Behaviour



From J Halford , adapted from J Blundell, 'Satiety Cascade'

Satiety cascade as a target for reformulation

- Processes that initiate, sustain and terminate a meal, and that suppress further consumption
- Strategies for limiting over-consumption of calories or sustaining appropriate levels of intake
- Foods that target satiation during a meal (accelerate) and satiety after a meal (enhance) provide a plausible approach to weight management
- Can these effects be translated into a health benefit?



Improving nutritional intake - bioactives and bioavailability

Satiety – efficacy of macronutrients/metabolites

- *protein*
- *fibre*
- *SCFAs*



Sustainability of ingredients

- *maintaining the healthiness of foods*
- *trade-offs between healthiness and GHG emissions*



Natural products and health

- *blaeberrries and glycaemic control*
- *wholegrains and blood pressure*



Consumer (food) choice, barriers to change

- *socioeconomic, psychological, educational*
- *demographics, inequalities*



Effects of dietary fibre on appetite, energy intake and body weight

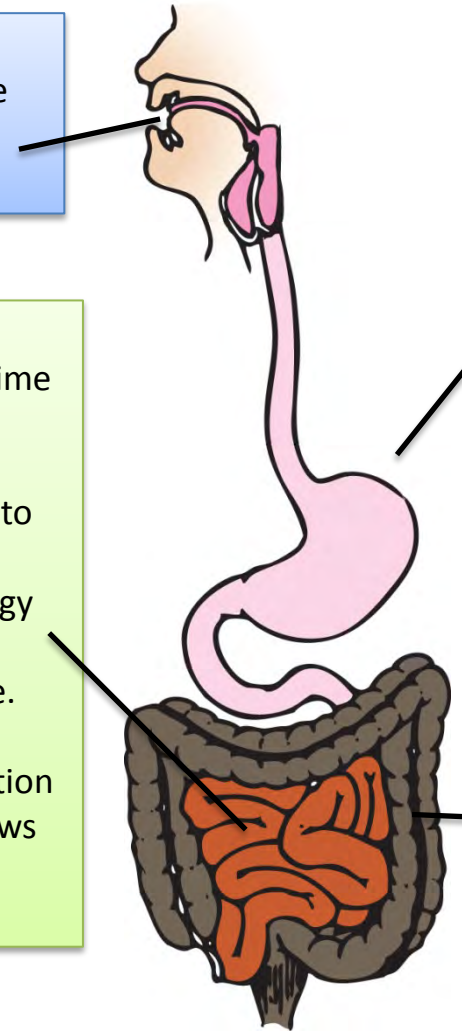
- Reduces energy density
- Diverse chemical structure and physicochemical properties (viscosity, solubility, fermentability) – polymers and linkages – influence effect size
- More viscous fibres (pectins, β -glucans, guar gum) have greater effect on subjective appetite and acute energy intake
- Overall (in RCTs) fibre intake reduced long term energy intake by 2.6%, and body weight by 0.4% per 4 weeks (320g in 80kg)

Mouth: Longer chewing time, more time for release of satiety signals

Small Intestine: Prolongs residence time in gut (increased viscosity) allowing nutrients more time to trigger gut peptide release. Lowers energy density as fibre not absorbed in intestine. Impacts on other macronutrient digestion and absorption – slows glucose absorption

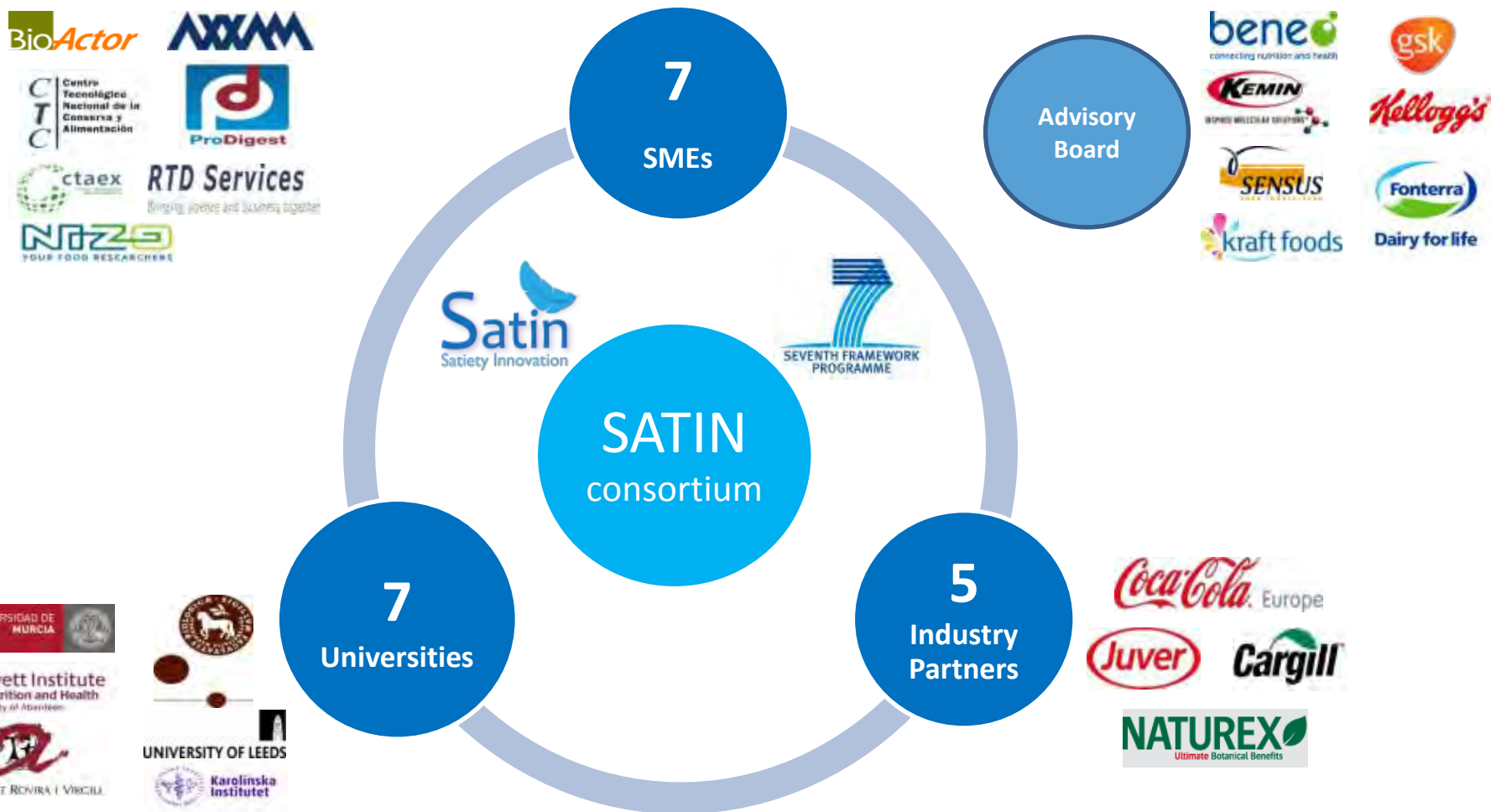
Stomach: Bulking - binds water, increasing gastric distension and fullness - delayed gastric emptying

Large Intestine: Fermentation produces SCFAs which may contribute to satiety through release of gut hormones



Researching with the food industry

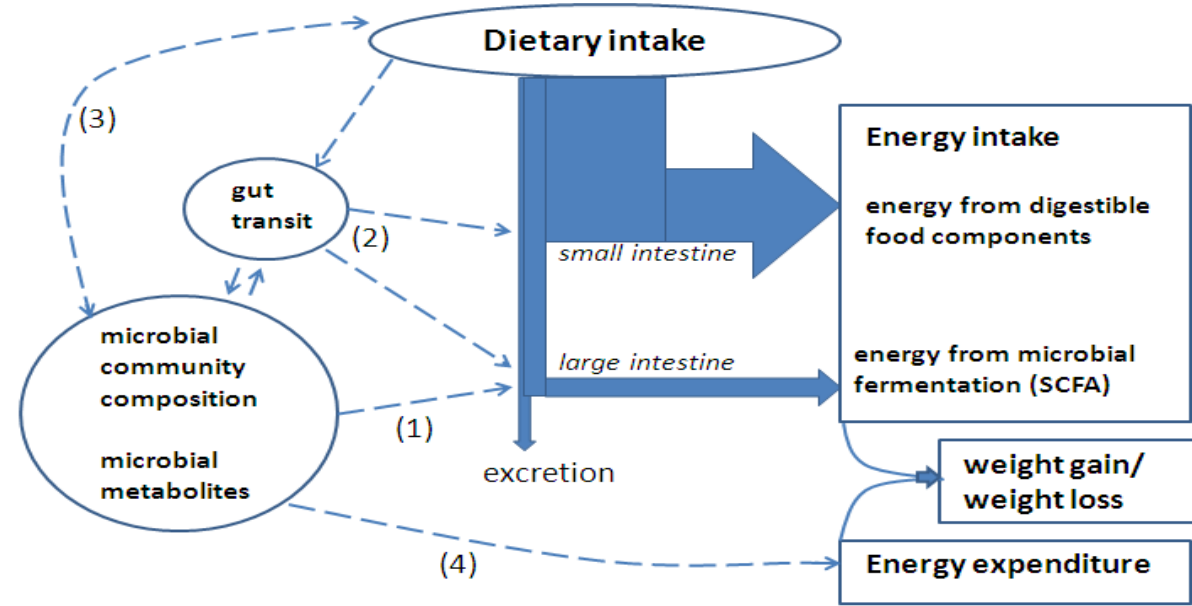
A case study; SATIN - 'Satiety control through food structures made by novel processing'



Coordinator: Prof Jason C. G. Halford



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LIVERPOOL



[Flint HJ (2011) J Clinical Gastroenterology 45, S128-S132]

 <p>WP1</p> <p>Develop and validate an <i>in vitro</i> screening model for the identification of potential satiety enhancing food components</p>	 <p>WP2</p> <p>Develop novel food processing technologies combining optimised food structures and flavours with active ingredients to enhance satiety/satiety</p>	 <p>WP3</p> <p>Assess novel ingredients/food on nutrient bioavailability, gut microbiota and biomarkers of satiety and health</p>	 <p>WP4</p> <p>Assess the effect of food on satiety/satiety and energy balance in relation to peptide profiles and energy metabolism controlling food intake</p>	 <p>WP5</p> <p>Explore consumer benefits of a diet comprising products that have been developed and shown to enhance satiety/satiety</p>
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Shoppers prioritise health ahead of ethics and the environment



- Given shoppers' current priority of saving money, it is no surprise that price and promotions play the most significant role in product choice decisions
- Quality ranks third and is often the gateway to thinking about sustainability issues
- Shoppers are primarily focused on the direct benefit to both themselves and their families when choosing products, and health ranks above ethical considerations in most people's shopping decision hierarchy
- Nearly half of shoppers (49%) say healthy options are important when they are choosing which products to buy. This is significantly higher than those stating that ethical considerations are important (one in five)
- However, sustainability can play an important role when shoppers are choosing between products

Importance of differing factors in product choice



Q. Rank your five most important considerations when shopping. Please think about the individual food and grocery products that you buy.

IGD ShopperVista July 2013, Base: all main grocery shoppers

© IGD 2013

Why you should eat bacon and eggs for breakfast: Starting the day with a high-protein meal reduces cravings later on

- A protein-rich breakfast boosts levels of dopamine in the brain
- Dopamine is the hormone which regulates cravings and food intake
- People who skip breakfast have lower levels of dopamine in their brain
- So it takes more food for people who skip breakfast to feel rewarded
- This leads to overeating and weight gain as they snack later on in the day

By MADLEN DAVIES for MAILONLINE

PUBLISHED: 11:27, 16 October 2014 | **UPDATED:** 14:28, 16 October 2014

Hoertel HA, Will MJ, Leidy HJ.

A randomised crossover, pilot study examining the effects of a normal protein vs high protein breakfast on food cravings and reward signals in overweight/obese ‘breakfast skipping’, late-adolescent girls.

Nutr J. 2014 Aug 6;13:80.


<http://www.dailymail.co.uk/health/article-2795286/why-eat-bacon-eggs-breakfast-starting-day-high-protein-meal-reduces-cravings-later-on.html#ixzz3SINSpBo7>



Full4Health

Learn more about this project

19 multidisciplinary academic and industry collaborators from across Europe are targeting mechanisms of hunger and satiety, and food-gut-brain interactions, in the fight against obesity

[Learn More](#) 

Understanding food-gut-brain mechanisms across the lifespan in the regulation of hunger and satiety for health



www.full4health.eu

FEB 2011-JAN 2016

Co-ordinator: Julian Mercer



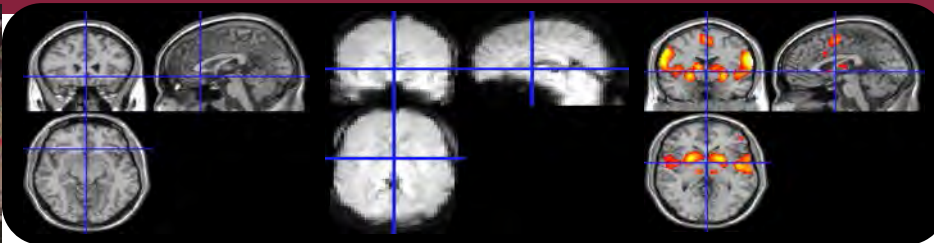
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Targeting the 'food-gut-brain' axis in diet and health



- ❑ evidence base - understanding **mechanisms of hunger and satiety**
- ❑ **gut-brain responses** to food across the lifespan (children, adolescents, adults, older adults), lean/obese, male/female
- ❑ protein/energy dietary intervention; psychological, behavioural response; biomarkers of appetite; brain activation
- ❑ the role of **dietary components** in the control of food intake and satiety
- ❑ a **food solution** to both caloric over-consumption and malnutrition



EUROPEAN COMMISSION



SEVENTH FRAMEWORK PROGRAMME

Home	The Project	Partners	Newsletters & Publications	Early Stage Researchers	News	Videos	Intranet	Links	Contacts
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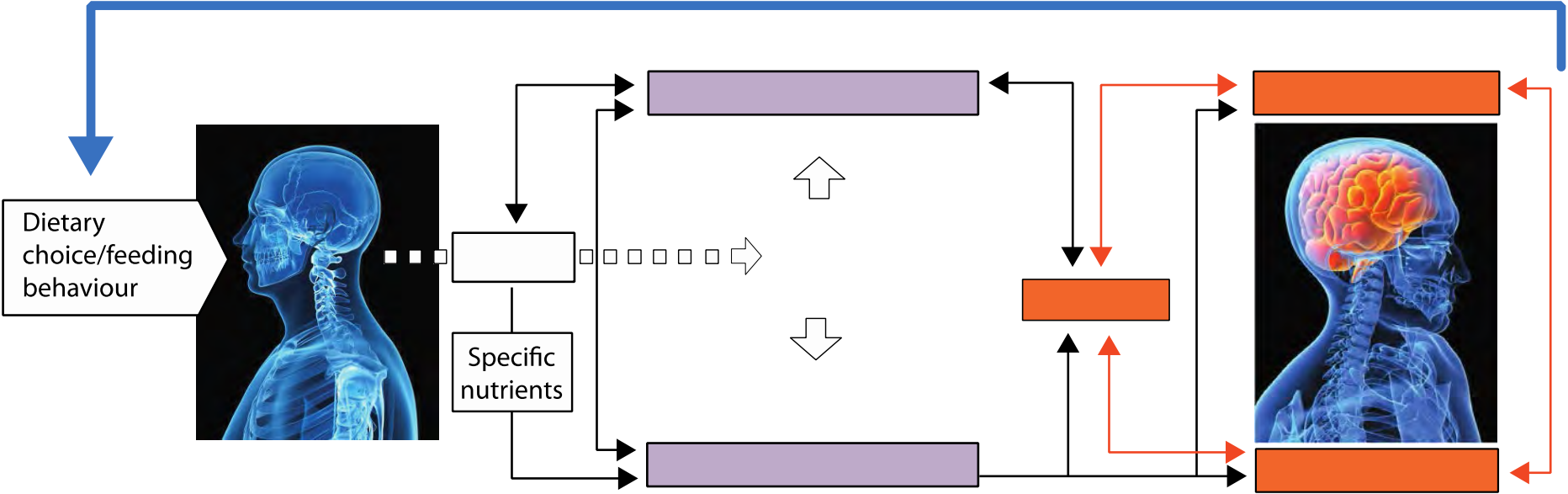
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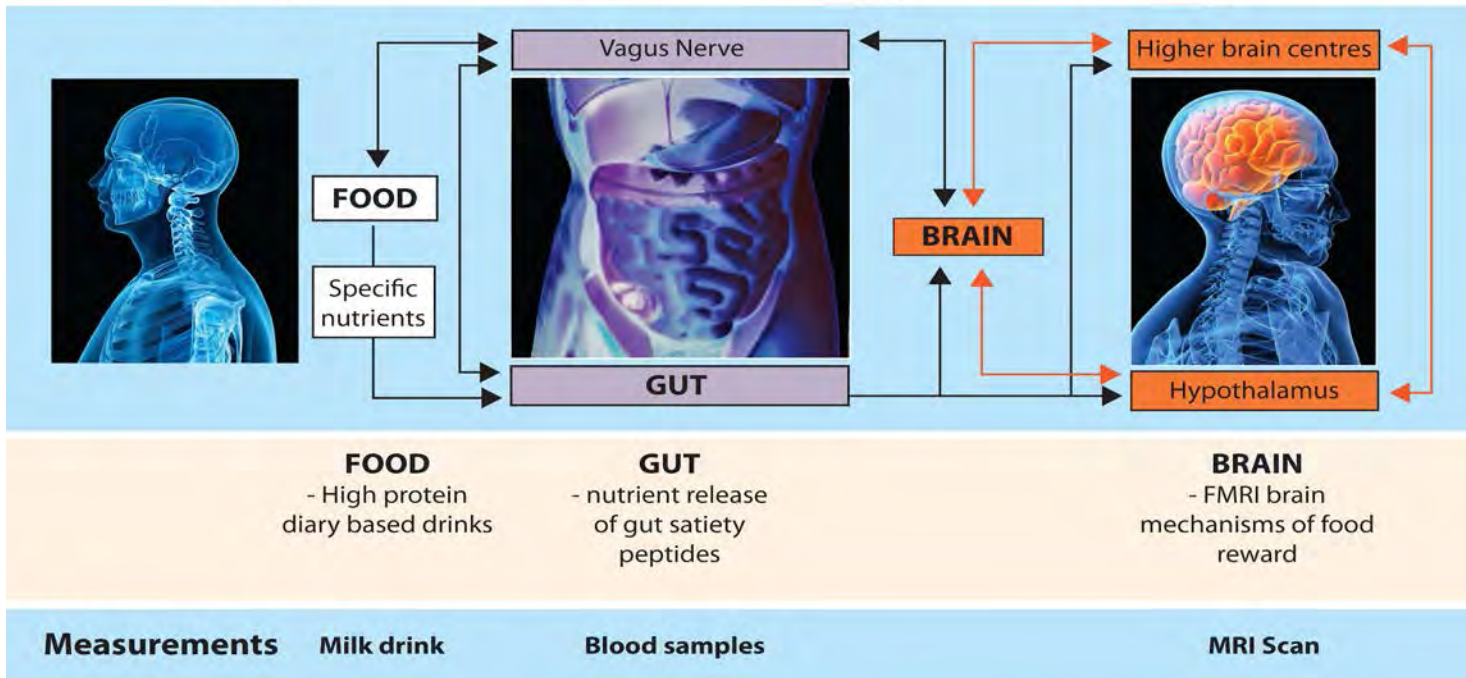
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Schematic diagram of the influence of food on gut-brain signalling, the integration of signals within the central nervous system, and feedback onto subsequent dietary choice and feeding behaviour.

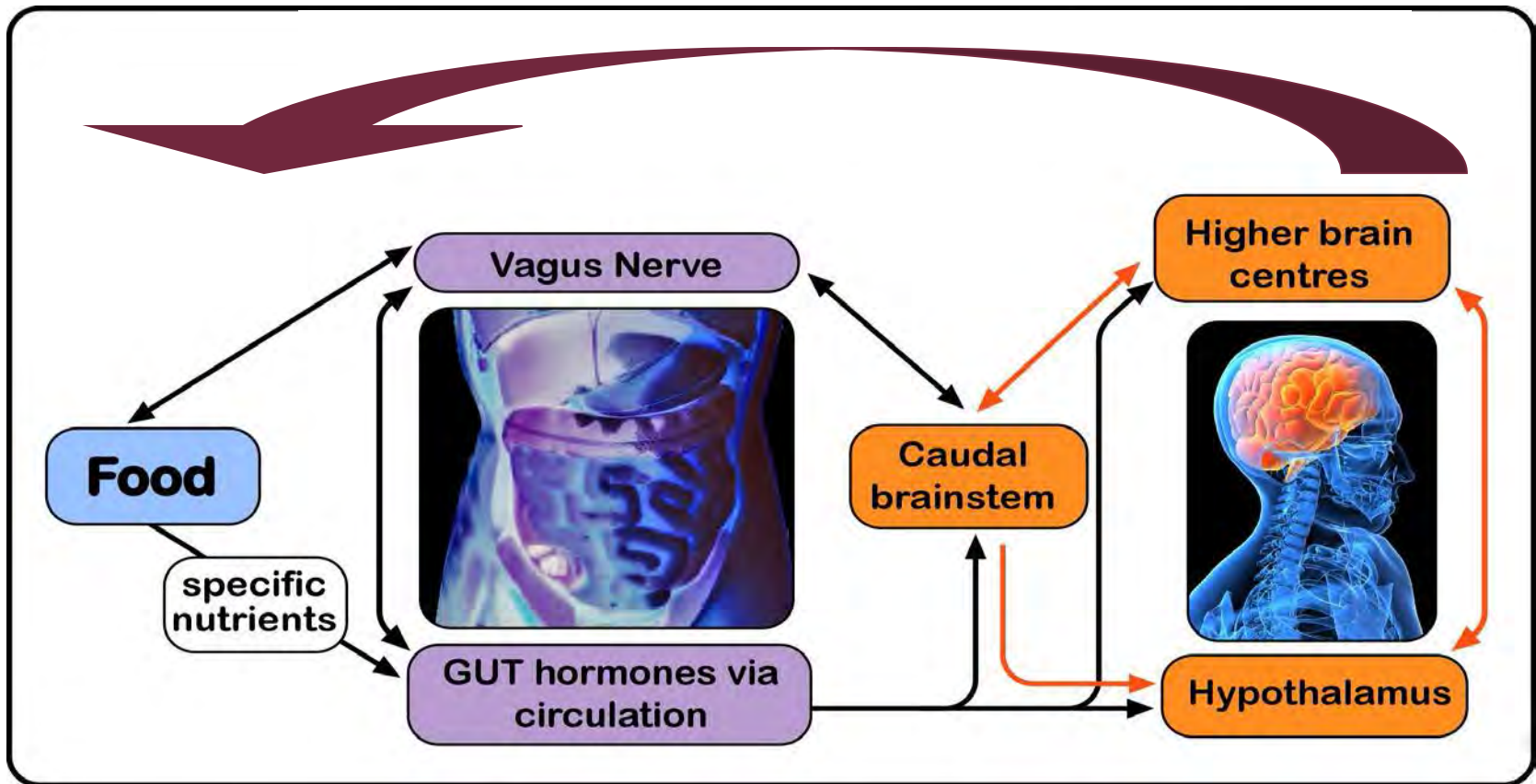
INTEGRATION



School Age Old Age

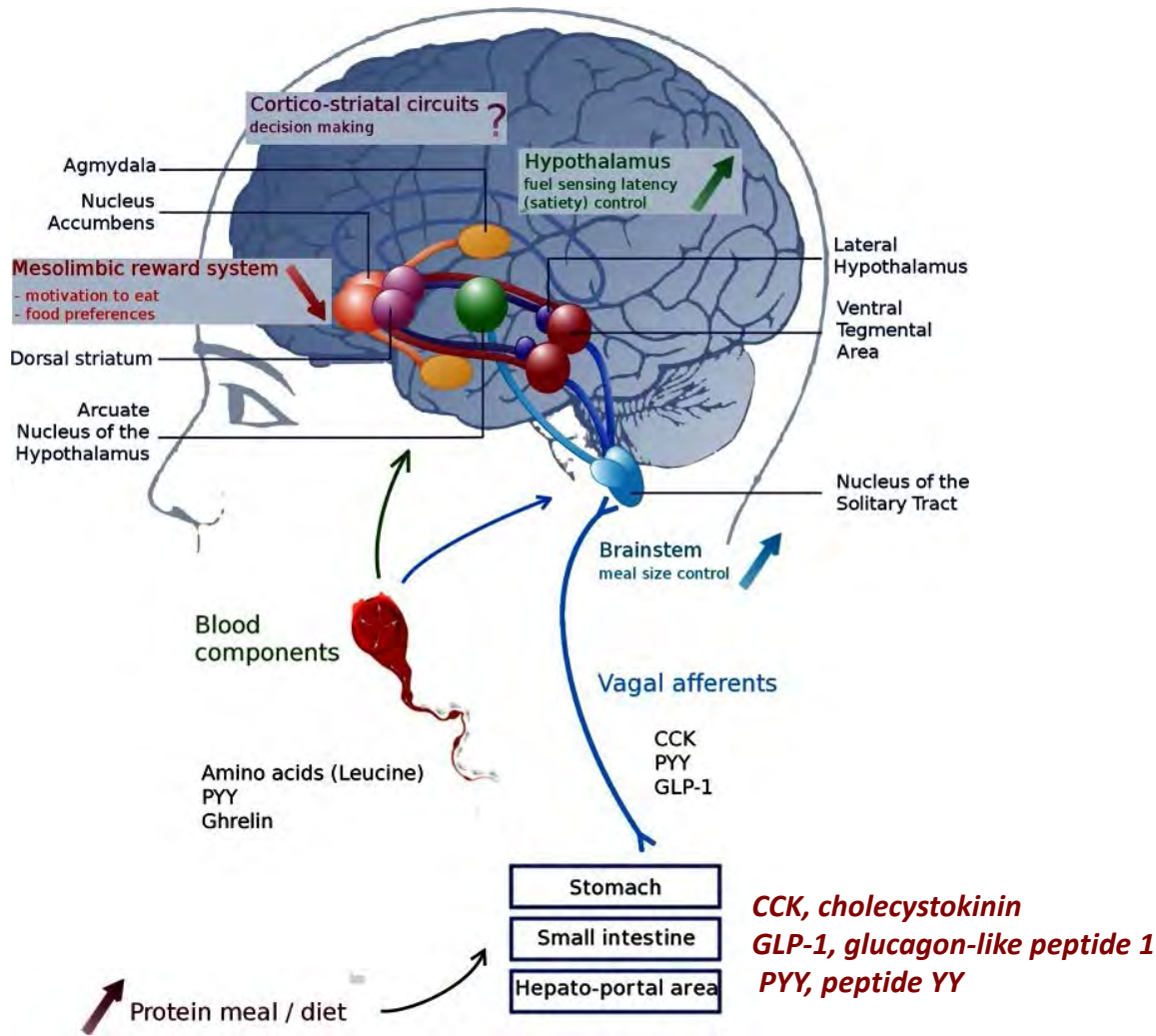


Manipulating gut-brain interactions through reformulation of food



- reduced energy density at the same palatability
- nutrient release of gut satiety peptides
- exploiting brain mechanisms of food reward

Mechanisms responsible for the protein induced reduction in food intake



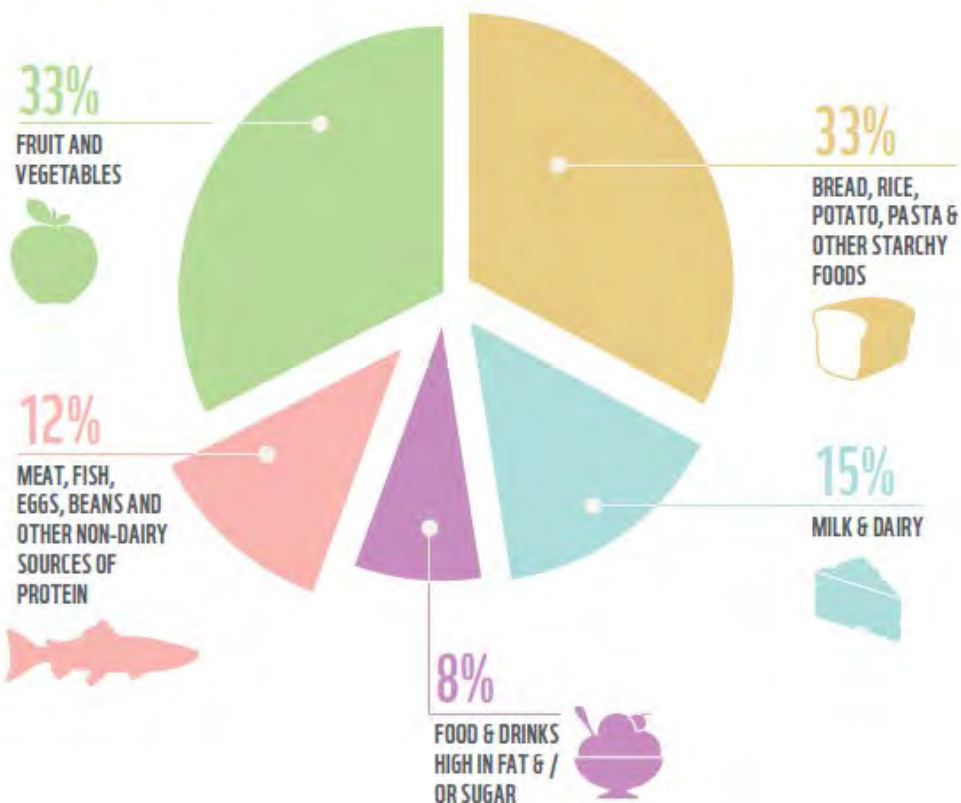
- Protein intake leads to the production of specific hormones that reach the brain via the vagus nerve or bloodstream
- Role of increased satiety and protein ingestion to decrease the motivation to eat in the mesolimbic reward system
- The role of decision-making areas is not yet well understood.

Journal M, Chaumontet C, Darcel N, Fromentin G, Tome D (2012)
Brain responses to high-protein diets. Adv Nutr. 1;3(3):322-9.

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Current UK Advice - Eatwell

Eatwell plate (recommended)



Top 10 protein sources in the UK

1. **Chicken and Turkey dishes 20.3%**
2. **Beef and Veal dishes 15.5%**
3. **Baked Beans 7.0%**
4. **Eggs 6.7%;**
5. **Bacon and Ham 6.6%**
6. **Meat Pies and Pastries 6.3%**
7. **Oily Fish 5.4%**
8. **Sausages 4.2%**
9. **Pork and Pork dishes 3.9%**
10. **White Fish coated and/or fried 3.9%**

*Livewell Report 2011: a balance of healthy and sustainable food choices
Commissioned by WWF-UK*

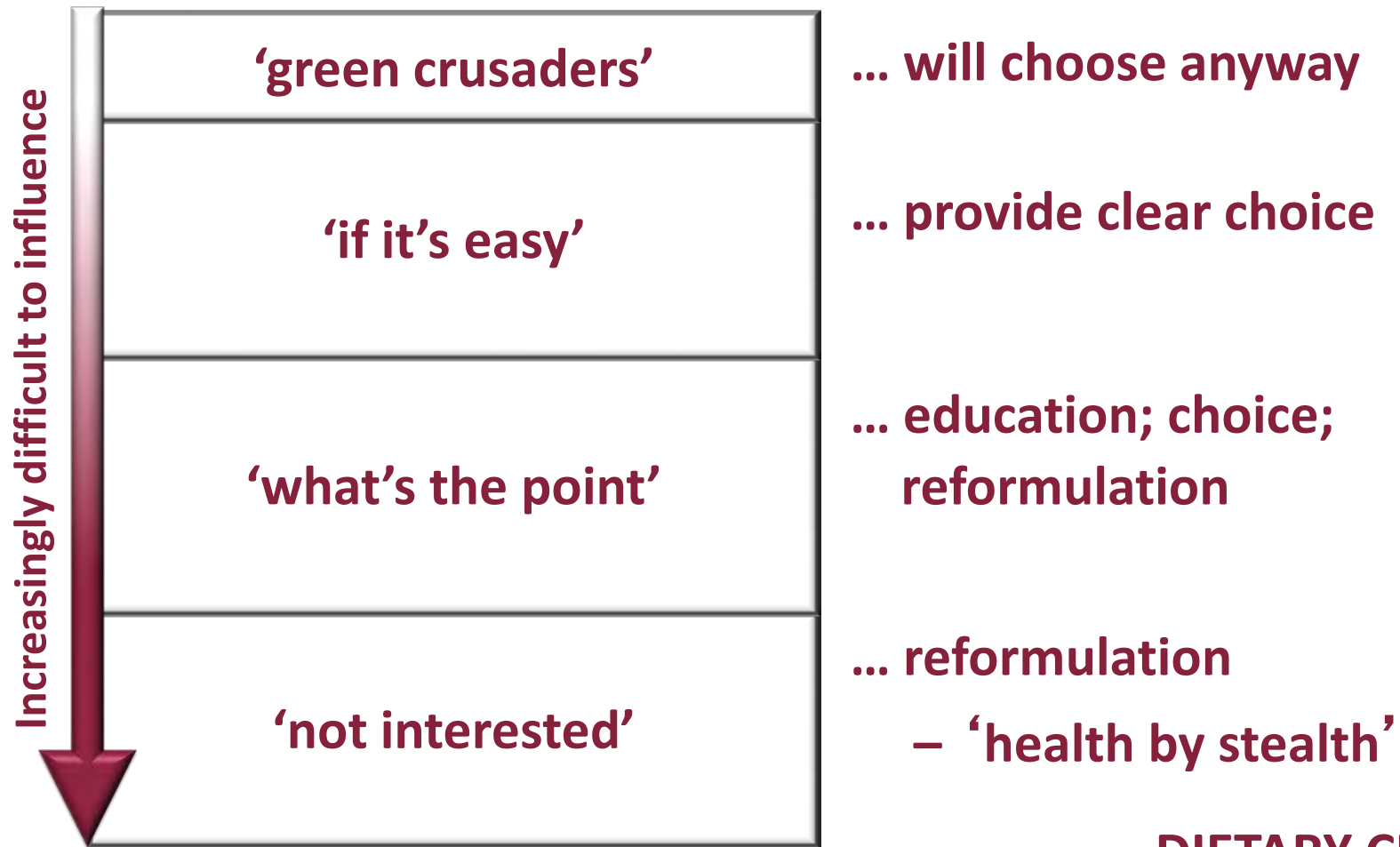
Barriers to consume more plants and less meat:

- **Practical barriers:** lack of knowledge and skills to prepare such foods and the lack of time to prepare them (Lea, Worsley and Crawford 2005).
- **Barriers at the level of culture and cognition:** social meanings of meat might be an important barrier for consumers to change dietary patterns (Twigg 1983; Sobal 2005; Ruby 2012).



How to deliver behaviour change?

Green/Ethical customer categories



DIETARY CHANGE

DRAFT SCIENTIFIC OPINION

Guidance on the scientific requirements for health claims related to appetite ratings, weight management, and blood glucose concentrations¹

EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA)^{2,3}

European Food Safety Authority (EFSA), Parma, Italy

Appetite

1. Must result in changes in energy intake (if this is claimed physiological effect rather than decreased body weight)
2. Must be sustained across day – no compensation
3. Must be enduring – observable e.g. Up to four weeks during dosing
4. Biomarkers useful for proof-of-concept but not necessary for efficacy
5. Appetite ratings must be assessed using VAS.

'Claims on changes in appetite ratings have been made in the context of body weight. In this context evidence for a sustained effect on appetite ratings and body weight with continuous consumption of the food, should be provided'

Blundell (2010) *Nat. Rev. Endocrin* 6: 53-55, Halford & Harrold (2012) *Proc Nut Soc* 71: 350-362, *EFSA Journal* 10 (2) 2604

SCIENTIFIC OPINION

Guidance on the scientific requirements for health claims related to appetite ratings, weight management, and blood glucose concentrations¹

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Appetite

1. Considered only in context of decreased body weight - *intake no longer as important but body weight is (most claims to date focus on intake – and are negative)?*
2. Must be sustained (12 weeks) with continuous consumption of food to exclude adaptation through compensatory mechanisms – *must have body weight change to make any communication on appetite (how many claims have actually been reviewed with body weight)?*
3. Biomarkers may support behavioural assessment
4. Behavioural assessment (appetite ratings) must be assessed using VAS.

Health IMPACTS of sustainable ingredient selection in the food and drink industry

There is a real need to evaluate how plants can be used as sustainable alternative protein sources with a focus on partial replacement of meat in healthy, balanced diets



SUSTAINABLE FOOD PLANTS: Identification and characterisation of plant varieties (rich in proteins) that can be grown locally, and establish their nutritional attributes: comprehensive foods analysis, as macro-, micro-, and non-nutrients.



HUMAN DIETARY INTERVENTION STUDIES: Investigation of dietary components (i.e. protein-rich plants) and their impact on human health.



CONSUMER STUDIES: Identification, understanding of potential barriers of acceptance and change within both the agri-food supply chain and consumers for novel plant-based food (i.e. protein-rich).

The research will create an informed platform to advise-assist-support the Food Industry to respond to change

Definition of a sustainable diet

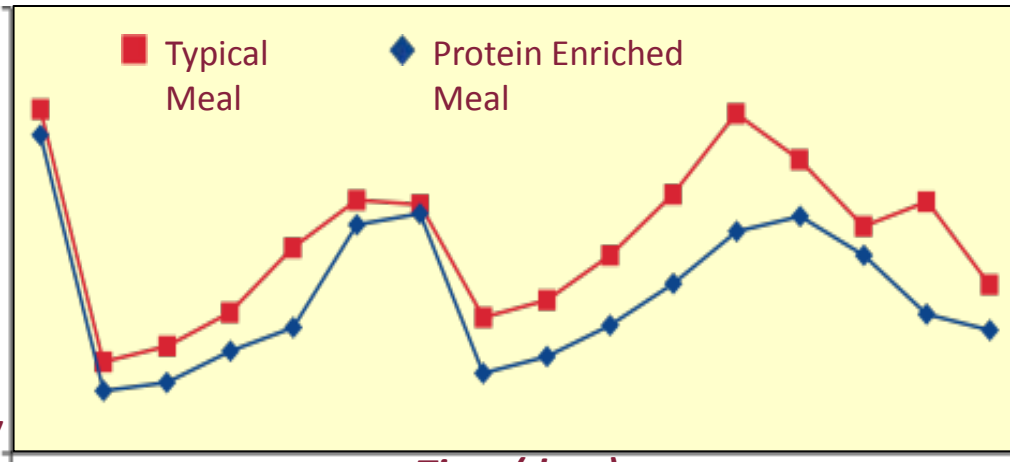


‘Diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations.’

‘Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.’

UN General Assembly, Report ‘The Right to Food’, to the Human Rights Council, GE11-17569 2012

Working with the food industry – product ranges based on the scientific evidence base



Time (days)



Rowett work forms basis of 'Fuller Longer' range at M&S launched in Jan 2010



YOUR M&S



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Wanted! Palatable foods that match the nutritional and energetic needs of the consumer

- “consumers require healthier low energy, low fat, energy dilute foods that are affordable, attractive and convenient, and... as tasty and gratifying as the unhealthier items they are intended to replace” – Halford and Harrold (2012)
- Evidence base: bioactive components, mode of action
- Population subgroup-specific solutions

High protein,
balanced
carbohydrate
product
ranges



Protein-induced Satiety

- Evidence of effects on appetite and energy intake leading to weight loss/maintenance
- Difficulty in showing independence of protein effect - manipulation of protein content of foods affects levels of other macronutrients
- Uncertain mechanism of action
- Protein source
- Sustainability – viability for consumer application in a changing world

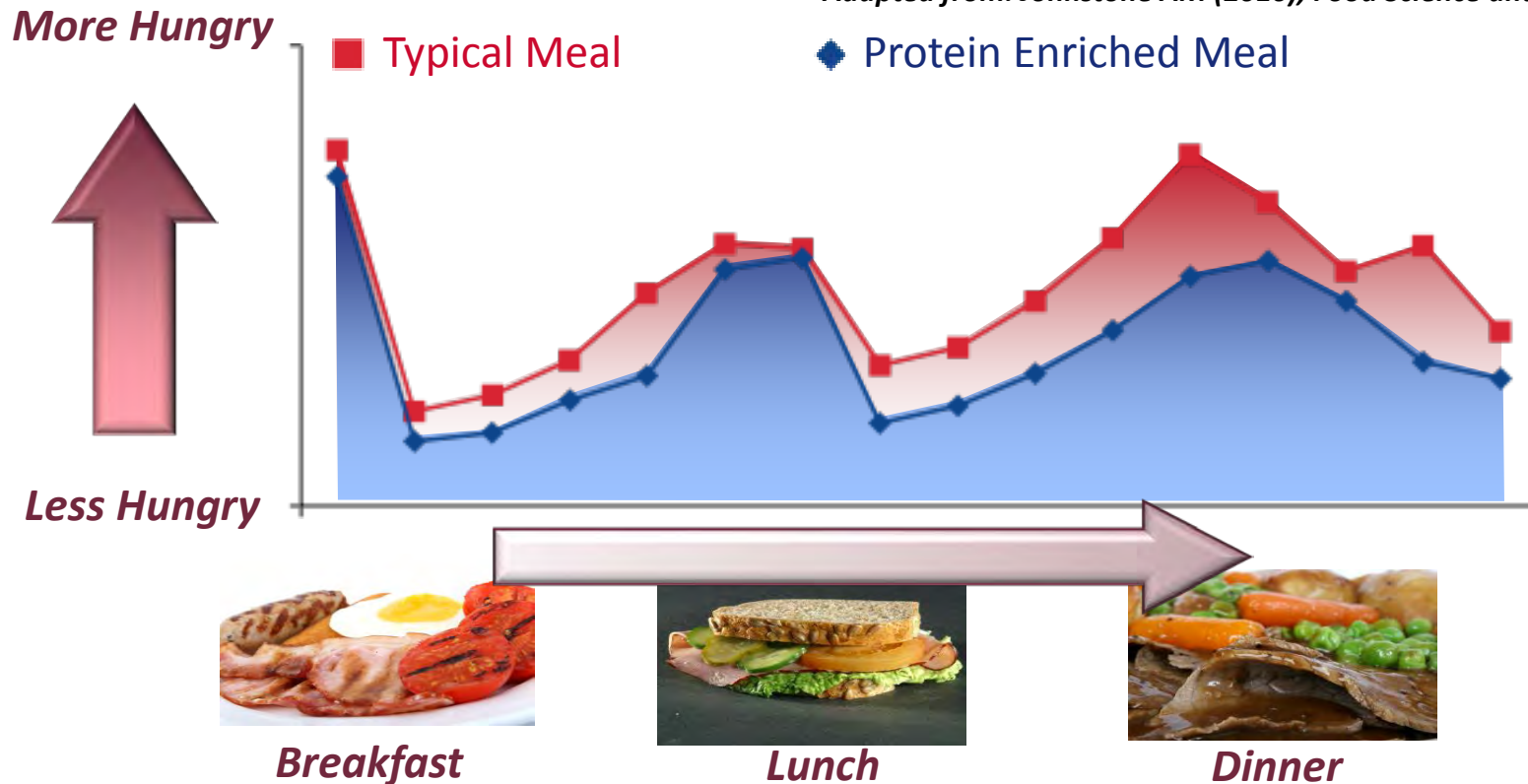
Protein is more Satiating than Carbohydrate or Fat

Effect on satiety	Reference	Population	Macronutrient	Duration
Proteins > carbohydrates	Porrini et al., 1995 (24)	12 normal males	56% protein, 25% fat, 19% carbohydrates	2 h
Proteins > carbohydrates > lipids	Johnstone et al., 1996 (25)	6 normal males	60% protein, 20% fat, 20% carbohydrates	15 d
Proteins > carbohydrates = lipids	Poppitt et al., 1998 (26)	12 normal females	37% protein, 29% fat, 34% carbohydrates	90 min
	Stubbs et al., 1999 (27)	16 normal males	60% protein, 20% fat, 20% carbohydrates	24 h
Proteins = carbohydrates > lipids	Potier et al., 2010 (28)	56 normal subjects	drink containing proteins only	Preload
	Westerterp-Plantenga et al., 1999 (29)	8 normal females	29% protein, 10% fat, 61% carbohydrates	24 h
Proteins > lipids	Porrini et al., 1997 (30)	14 normal males	54% protein, 45% fat, 1% carbohydrates	2 h
	Weigle et al., 2005 (31)	19 normal subjects	30% protein, 20% fat, 50% carbohydrates	4 wk
Proteins > lipids > carbohydrates	Batterham et al., 2006 (32)	10 normal males	65.3% protein, 17.4% fat, 17.3% carbohydrates	25 min
Whey = soy > egg = sucrose	Anderson et al., 2004 (33)	13 normal males	egg, whey, soy, sucrose in beverages	1 h
Whey > soy = casein (10% protein)	Veldhorst et al., 2009 (34)	25 normal subjects	10% protein, 35% fat, 55% carbohydrates	20 min
Whey = soy = casein (25% protein)	Veldhorst et al., 2009 (34)	25 normal subjects	25% protein, 20% fat, 55% carbohydrates	20 min

From: *Journel M, Chaumontet C, Darcel N, Fromentin G, Tome D. Brain Responses to High-Protein Diets (2012), American Society for Nutrition. Adv. Nutr. 3: 322–329*

Example of daily hunger pattern

Adapted from: Johnstone AM (2010), *Food Science and Technology*, 24, 30-33



- Satiety – between-meal interval (fullness)
- Satiation – within-meal termination of eating (fullness & pleasantness)
- Hunger – the subjective expression of a willingness or motivation to obtain and eat food
- Appetite – the disposition or desire to eat a specific food

High protein diets for weight control

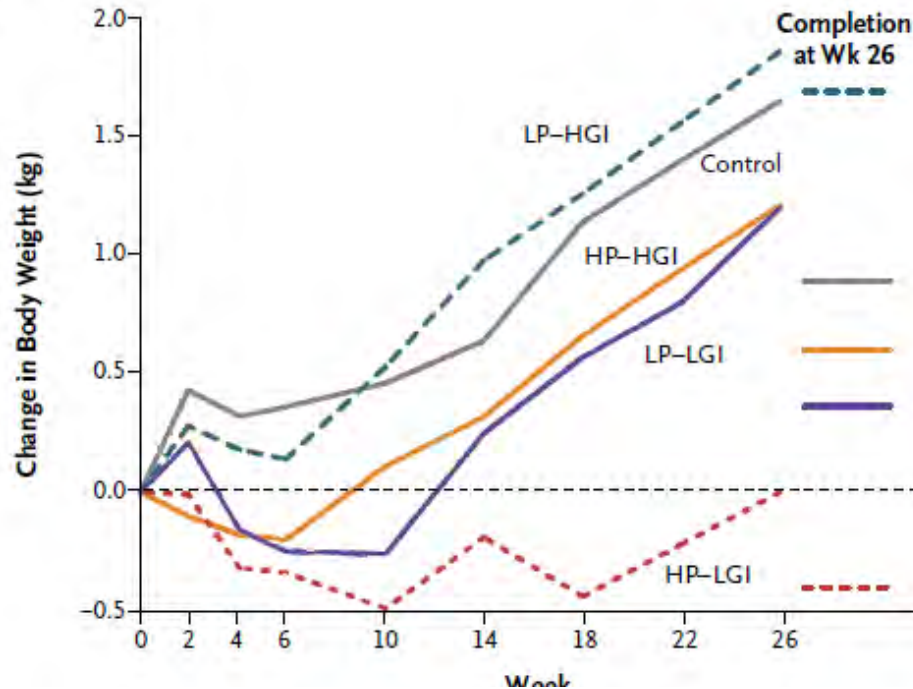
- Increased protein intake is associated with a voluntary reduction in food intake, at least in the short-term (up to 6 months) (Skov et al., 1999),
- Furthermore, subjects report less hunger on high-protein diets (30%) in comparison to normal-protein (15%) diets (Weigle et al., 2005).
- The Atkins™ diet is a low-carb diet, that is high-protein & high fat. No metabolic advantage of this combination. Don't need a ketogenic diets to give appetite effects, but you do need high protein (Johnstone et al., 2008).

Weigle et al. (2005) Am J Clin Nutr 82, 41-8.

Skov et al., (1999) Int J Obes Relat Metab Disord; 23(5):528-36.

Johnstone et al. (2008) Am J Clin Nutr. 2008; 87, 44-55.

High protein-low GI diet for weight maintenance



EU FP6 Diogenes

- the “world’s largest diet study” recommends a diet that is:

- high in proteins (lean meat, low-fat dairy products and beans)
- low in refined starch calories e.g. white bread and white rice

Diet can be eaten until full without counting calories and without gaining weight

- Weight regain was 0.93 kg less for participants on a high protein diet than for those on a low protein diet.
- Fewer participants in the high-protein, low-GI groups dropped out of the project than in the low protein, (~26% vs. ~37%)

Larsen et al. (2010) Diets with High or Low Protein Content and Glycemic Index for Weight-Loss Maintenance New England Journal of Medicine, 363: 2102-2113.

DRAFT SCIENTIFIC OPINION

Guidance on the scientific requirements for health claims related to appetite ratings, weight management, and blood glucose concentrations¹

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European Food Safety Authority (EFSA), Parma, Italy

Weight Management

1. Weight loss must be observed for at least 12 weeks with continuous consumption of food
2. Weight regain prevention must be observed for 24 weeks after weight loss
3. Changes in body fat not strictly required if study duration is appropriate but can be performed on subsample as supporting evidence (measures of body composition: MRI/DXA not waist circumference or bio-impedance)

'Changes in energy intake etc have been proposed in the context of claims related to the reduction of body weight. Evidence for a sustained effect of any of these variables with continuous consumption of the food may be considered in support of mechanism by which the food may exert the claimed (BW) effect'

Halford & Harrold (2012) Proc Nut Soc 71:350-362

SCIENTIFIC OPINION

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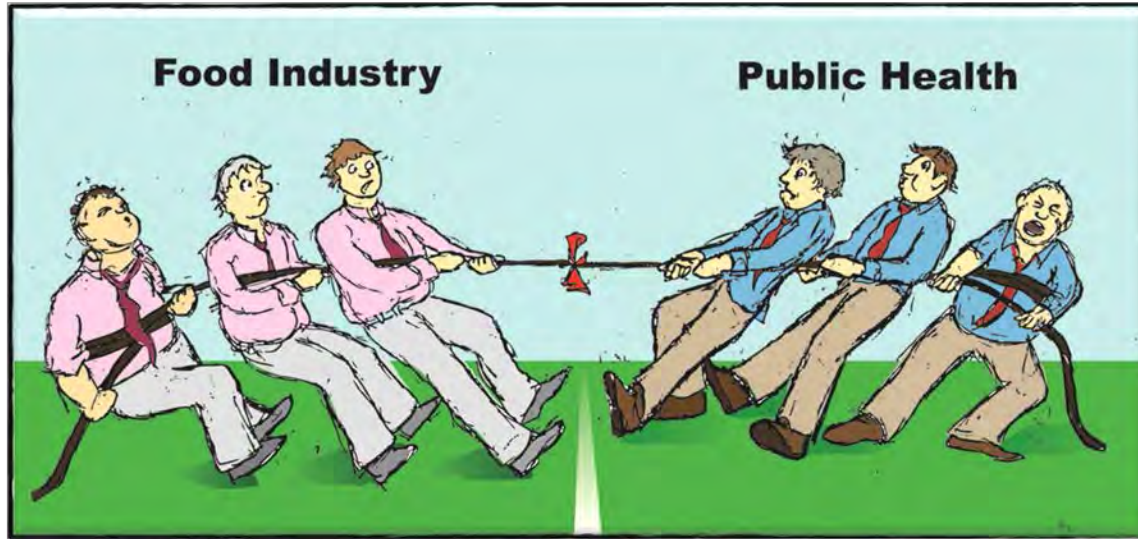
Weight Management

1. Weight loss must be observed for at least 12 weeks with continuous consumption of food and be sufficient large not to be attributed to loss of water or lean mass
2. Weight regain prevention must be observed for 24 weeks after weight loss
3. Changes in appetite ratings, energy intake, energy expenditure or fat oxidation considered in support of mechanism to achieve weight reduction (if sustained effect) – *appetite can be used as supporting evidence*

Behaviour change – a non-invasive approach to managing the epidemic of non-communicable disease

- Diet and lifestyle change to address chronic ill health and promote healthy ageing
- Dietary choices are a key component of ‘health’ behaviour - what people choose to eat ultimately determines the relationship between diet and health
- Promoting healthier dietary choices and exploiting habitual choice? - reformulation
- Bringing together academics, policy makers and the food and drink industry
- Multidisciplinary approaches – molecular/mechanistic, sensory, psychological, economic

Research for Policy and Industry

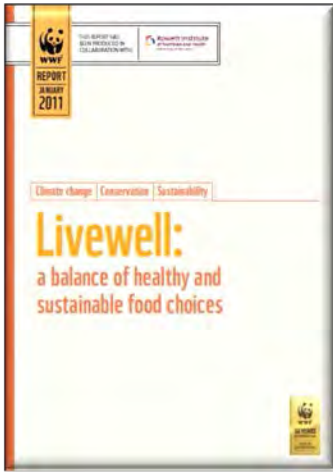


Can research bridge the gap?
Addressing public health and
sustainable economic development



Working with the stakeholders

- product ranges based on the scientific evidence base



NGO - Rowett work with WWF to examine sustainable diets

Macdiarmid J, Johnstone AM, et al. (2012) Sustainable diets for the future: Can we contribute to reducing greenhouse gas emissions by eating a healthy diet?

Am J Clin Nutr. 2012 ;96(3):632-9.



INDUSTRY - Rowett work forms basis of 'Fuller Longer' range at M&S launched in Jan 2010



KNOWLEDGE EXCHANGE - Opportunities with different audiences



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Food as part of the solution?

- A strategy? – a range of products which address different parts of the satiety cascade, and different food ‘occasions’
- Benefits to the consumer of enhanced satiety beyond weight loss or weight maintenance – e.g. satisfaction post-meal, managing eating behaviour across the day (coping with hunger), self-control and self-efficacy, success in compliance with weight management
- Energy density, food matrix, fibre, protein, plant products
- Better controlled/standardized trials; mechanism of action
- Reassessment of current EFSA guidelines to provide some likelihood of a health claim around satiety being granted

Mercer JG, Johnstone AM, Halford JC (2015) Approaches to influencing food choice across the age groups: from children to the elderly. Proc Nutr Soc. 19:1-9.

Johnstone AM, Gonzalez RR, Harrold J (2012) An overview of the SATIN project. Nutrition Bulletin 37: 384-388.

Acknowledgments



The Scottish Government
Riaghaltas na h-Alba

'Healthy Safe Diets' & Health impacts of sustainable ingredient selection in the food & drink industry

Claire Fyfe, Rowett

www.abdn.ac.uk/rowett/research/strategic-partnership.php



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Rowett Institute of Nutrition and Health

Thank you, Questions?



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<https://www.futurelearn.com/courses/nutrition-wellbeing/>



Nutrition and Wellbeing

Demystify the complex and conflicting messages we hear about diet, health and lifestyle today, with this free online course.

ABOUT THE COURSE

This free online course will help you understand the scientific basis of human nutrition, and current nutrition concepts and controversies.

It draws on world-leading nutrition experts, to demystify the complex and often conflicting messages we hear about diet and health from sources like the media, food industry and scientific community.

Join now - starts 17 Aug



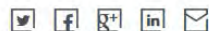
FREE online course

Duration: 4 weeks

3 hours pw

Certificates available

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- 4 week online course
- Starts in August 2015
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