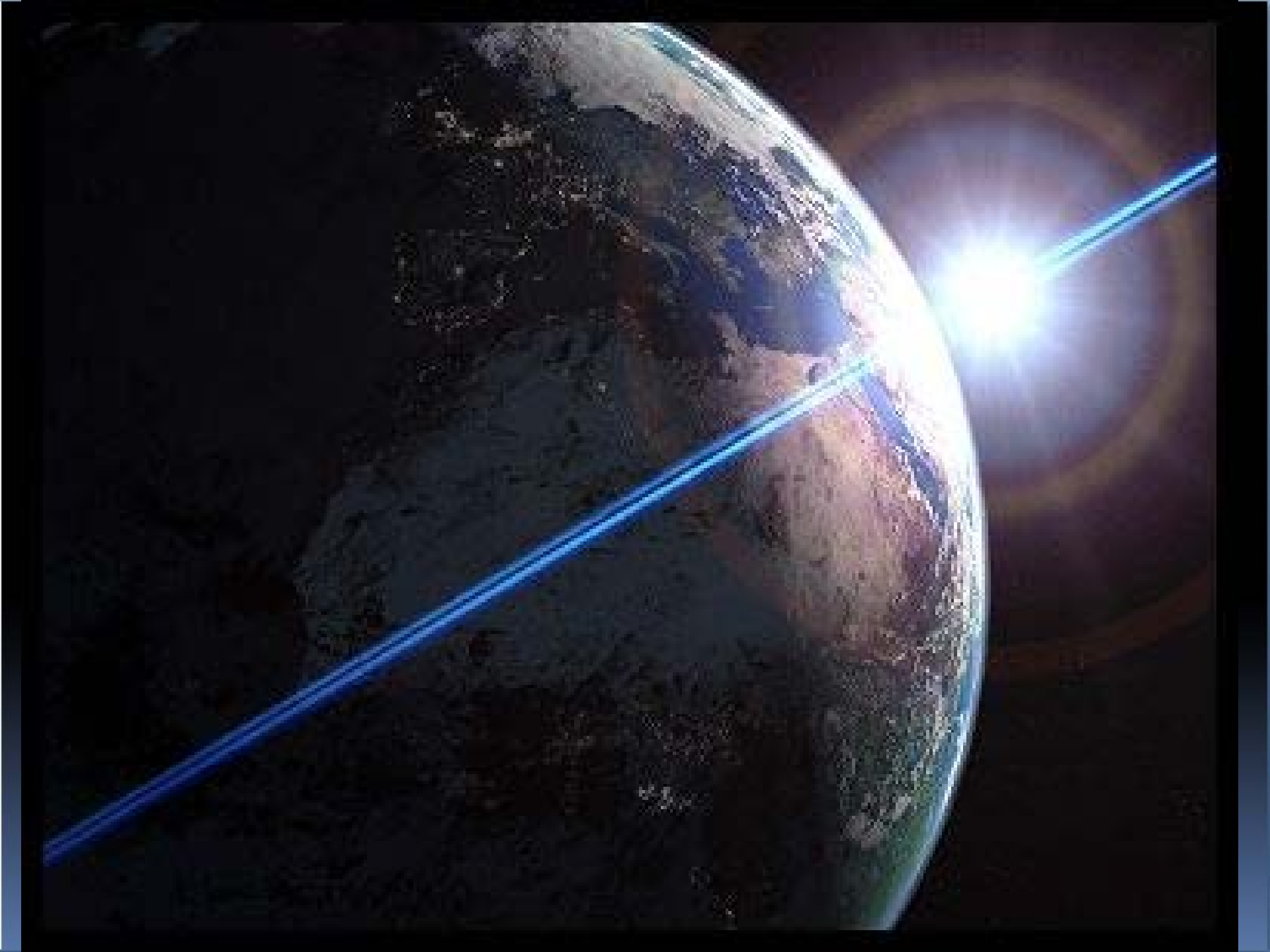
“Scientific truth does not triumph by convincing opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it…
Science progresses funeral by funeral.”
Max Planck

What makes the World go ‘round?

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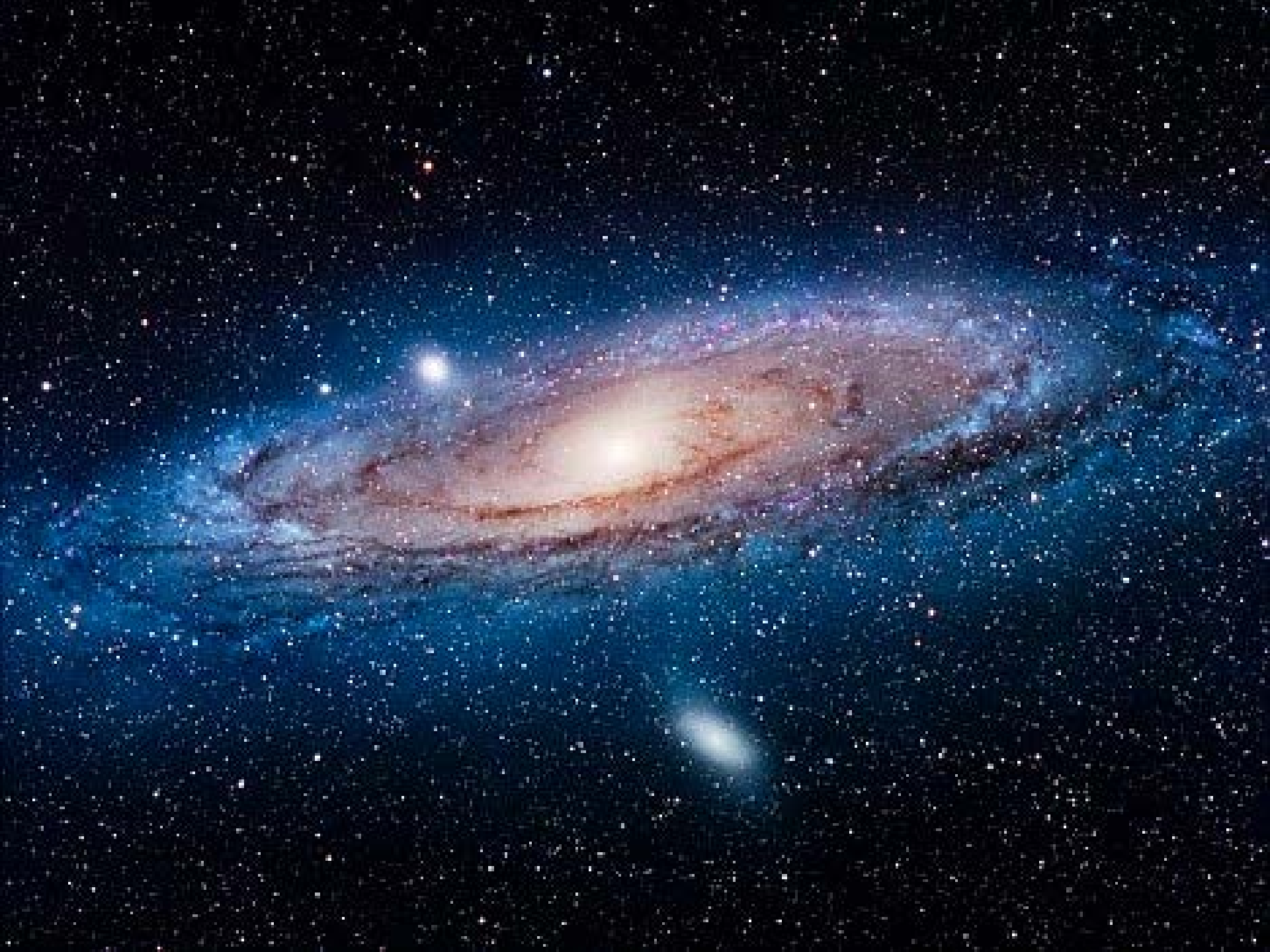
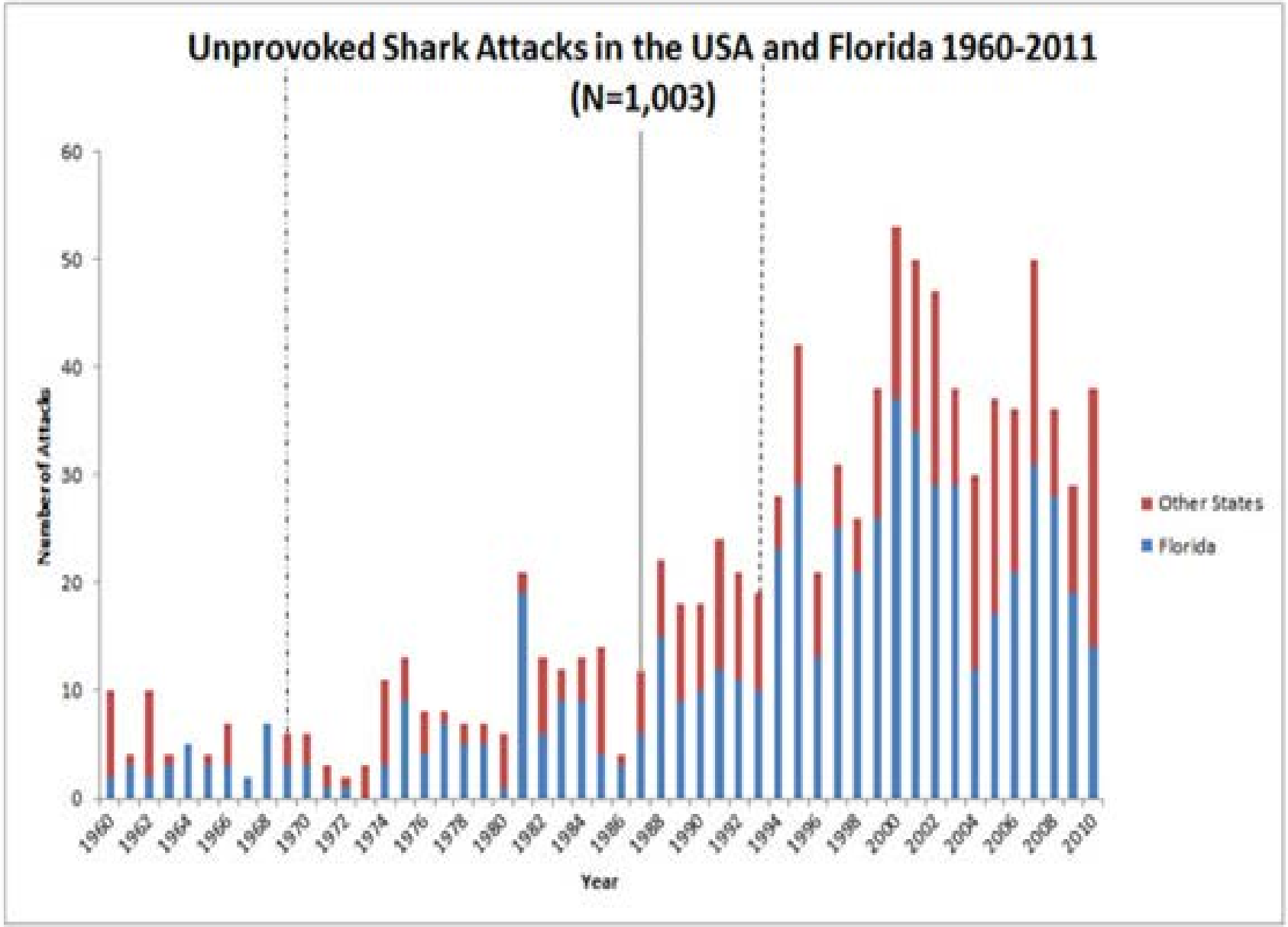



$E=mc^2$
ENERGY

All movement requires energy

Life cannot exist without energy

All organisms must obtain energy

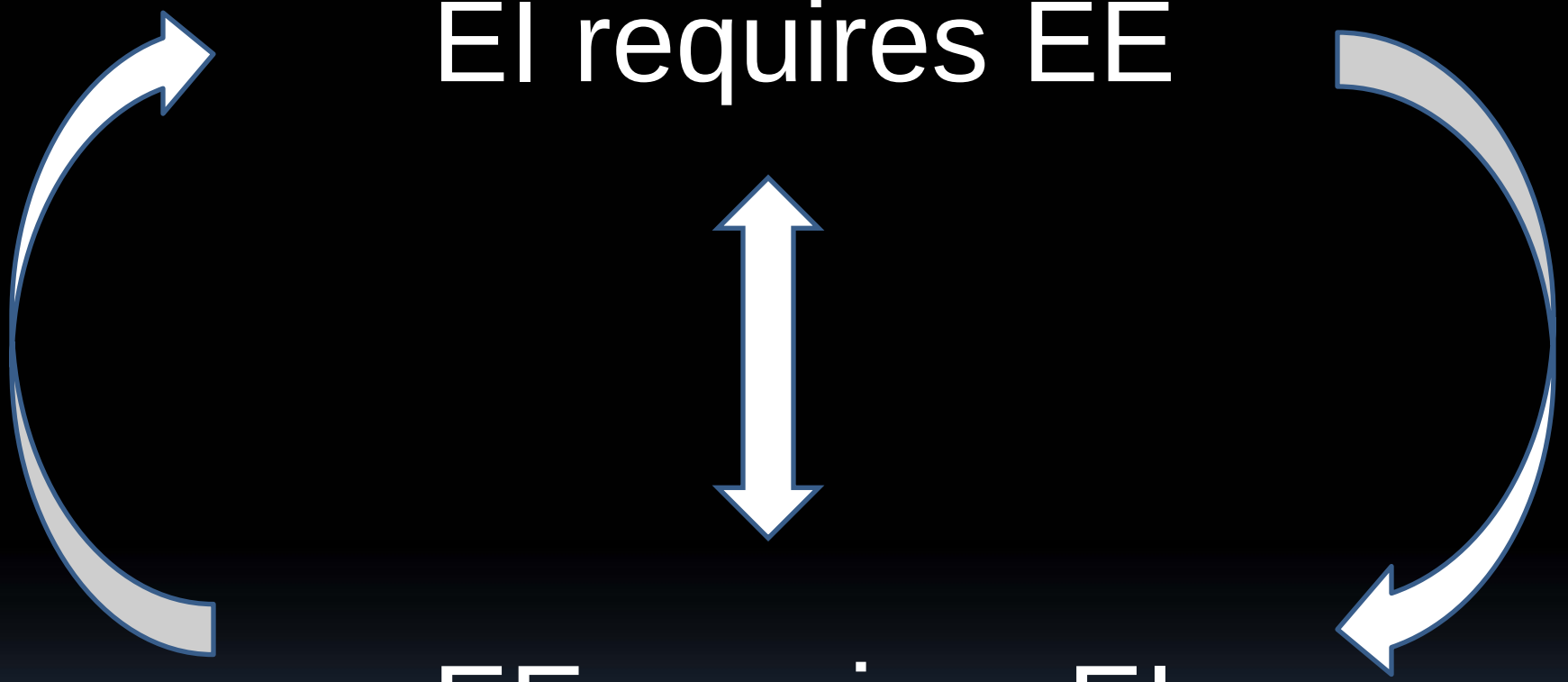

Unprovoked Shark Attacks in the USA and Florida 1960-2011
(N=1,003)
Number of Attacks
0
10
20
30
40
50
60
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
Other States
Florida

Heliotropism

Movement = Energy Expenditure (EE)

Reciprocal Relationship:

EI requires EE



EE requires EI

Natural Selection:

Organisms that maximize energy intake and minimize energy expenditure survive

But what is energy?

Energy

- From Greek: ‘energeia’
  - ‘activity’ or ‘operation’
- Quantitative (measured) property describing the state of a physical object or system
  - *"To **measure** is to know.“* Lord Kelvin (**Sir William Thomson**)

Energy

- Many classifications of energy: heat, kinetic, electromagnetic, radiant, nuclear and chemical
- Energy can be converted from one form to another but not destroyed
- Chemical and Heat

Organic Chemical Energy

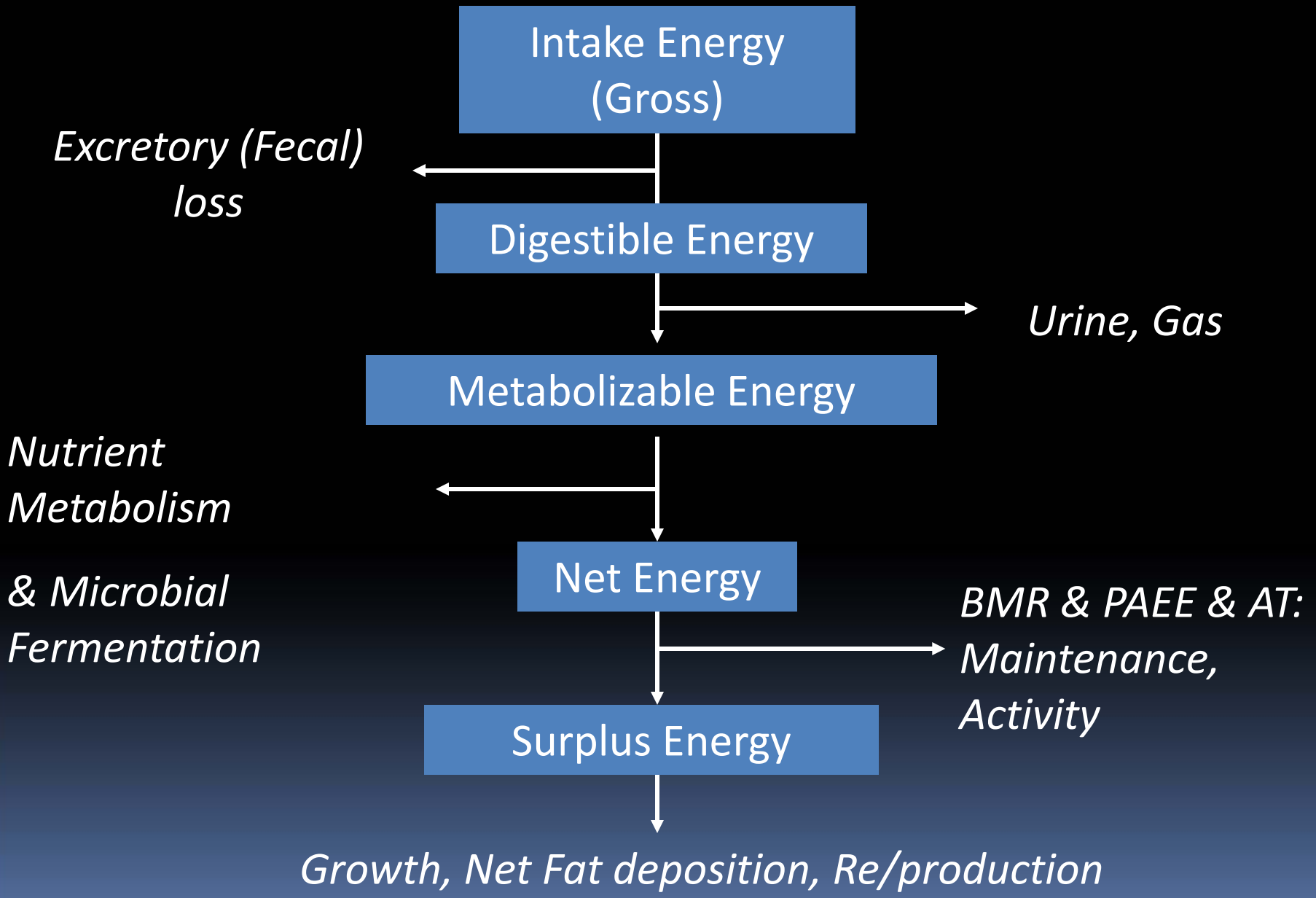
- Solar energy is converted via photosynthesis (plants, algae, cyanobacteria) to synthesize organic compounds
  - e.g., carbohydrates, proteins, lipids
  - Consumed by other organisms
- Rubner (1894): application of laws of Thermodynamics to biological organisms
- Metabolism of organic matter → CO_2 + H_2O + energy

Energy Units

- Joule (J): The SI unit of energy/work/heat.
  - KJ = kilojoule; MJ = Megajoule
- **c**alorie = amount of energy required to raise the temperature of 1 g water 1°C

- 1 **C**alorie = 1000 **c**alories = 1 kcal
- 1 kcal = 4.184 J
- 1 kJ = .239 kcals

Partitioning of Dietary Energy Intake



Food Energy/Atwater Values

Food component	Energy density	
	kJ/g	kcal/g
Fat	37	9
Ethanol (drinking alcohol)	29	7
Proteins	17	4
Carbohydrates	17	4

Metabolizable Energy = (Gross Energy) – (Energy losses in feces, urine, secretions & gas)

Atwater Factors vs. Atwater 'Specific' Factors

- Refinement based on re-examination of the Atwater system introduced in 1955
  - Merrill AL, Watt BK. Energy Value of Foods: Basis and Derivation. Agriculture Handbook no. 74. Washington, DC: ARS, US Department of Agriculture; 1973.
- Demonstrated substantial variability in the energy factors applied to various foods
  - PRO: 3.75-4.55 kcal/g
  - CHO: 2.45-4.20 kcal/g
  - *FAT: 9.3-9.5 kcal/g
    - *>30% overestimation due to fecal loss: Novotny JA, Gebauer SK, Baer DJ. Discrepancy between the Atwater factor predicted and empirically measured energy values of almonds in human diets. *Am J Clin Nutr.* Aug 2012;96(2):296-301.

Net Metabolizable Energy (NME)

Table 1. Gross intake (IE), digestible (DE), metabolisable (ME) and net metabolisable energy (NME) factors for important food components and the prediction of specific food NME values (for factors for other components, see Independent Nutrition Logic, 2000)

	IE*	DE*	ME*	NME	Units
General factors					
Fat (F; g)	39·3	37·4	37·4	36·6	kJ/g ingested F
Protein (P; g)	23·6	21·5	16·7	13·3	kJ/g ingested P
Available CHO (AC; g)†	15·7	15·7	15·7	15·7	kJ/g ingested AC as monosaccharide
Dietary fibre (DF; g)	17	7·8	7·8	6·2	kJ/g ingested DF‡
Fermentable†	17	11	11	8	kJ/g ingested fermentable DF
Non-fermentable†	17	0	0	0	kJ/g ingested non-fermentable DF
Alcohol (Alc)	29·4	29·4	28·8	26·4	kJ/g ingested Alc

Food energy (ME; kJ) = 37 F + 17 P + 16 AC + 8 DF + 29 Alc (rounded from 37·4 F + 16·7 P + 15·7 AC + 7·8 DF + 29·4 Alc).
Food energy (NME; kJ) = 37 F + 13 P + 16 AC + 6 DF + 26 Alc (rounded from 36·6 F + 13·3 P + 15·7 AC + 6·2 DF + 26·4 Alc).

* From Merrill & Watt (1973), using their IE, digestibilities and urinary energy loss (5·2 kJ/g digestible N) and energy loss in breath (2 % energy losses from alcohol as volatile substances in breath and urine).

† NME and ME values also applicable to isolates of NSP, resistant starch oligosaccharides and sugar alcohols.

‡ For traditional foods this can be Southgate (1969) dietary fibre, Association of Official Analytical Chemists (Prosky *et al.* 1988) dietary fibre or the sum of NSP and associated resistant starch when it is <20 % of non starch polysaccharide

Livesey G. A perspective on food energy standards for nutrition labelling. *Br J Nutr.* Mar 2001;85(3):271-287.

NME vs. ME

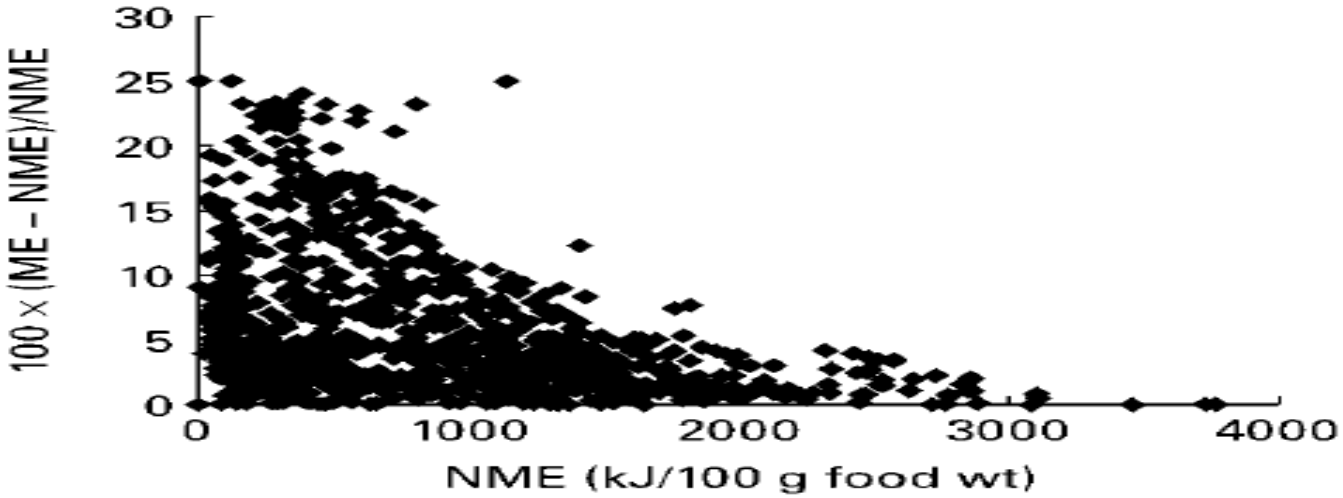


Fig. 3. Over-estimation of the isodynamic equivalents for energy expenditure and energy balance (net metabolisable energy; NME) by the (metabolisable energy; ME) standard when applied to 1189 foods in the British food tables, due to protein and unavailable carbohydrate. ME of foods was calculated using available carbohydrate as monosaccharide (15·7 kJ (3·75 kcal) ME/g), fat (37 kJ (9 kcal) ME/g), protein (16·7 kJ (4 kcal) MEkJ/g), dietary fibre (8·4 kJ (2 kcal) ME/g), alcohol (29 kJ (7 kcal) ME/g) and appropriate factors for organic acids. NME was calculated by replacing the ME factors for protein and dietary fibre with NME factors from the British Nutrition Foundation (1990) report: 13 kJ (3·2 kcal) NME/g and 6·2 kJ (1·5 kcal) NME/g respectively. For the present illustration dietary fibre was Southgate (1969) dietary fibre.

Livesey G. A perspective on food energy standards for nutrition labelling. *Br J Nutr.* Mar 2001;85(3):271-287.

Energy values of human milk

Available @ http://www.fao.org/docrep/006/y5022e/y5022e04.htm

	Composition g/liter	**ME-ATW** kJ/ml *(kcal/ml)*	**ME-specific** kJ/ml *(kcal/ml)*	**NME** kJ/ml *(kcal/ml)*
Protein	8.9	0.15 (*0.04*)	0.17 (*0.04*)	0.12 (*0.03*) **Δ20-30%**
Fat	32	1.18 (*0.29*)	1.17 (*0.28*)	1.18 (*0.29*)
CHO-lactose/ glucose	74	1.26 (*0.30*)	1.21 (*0.29*)	1.18 (*0.28*) **Δ3-7%**
Energy		2.59 (*0.63*)	2.55 (*0.61*)	2.48 (*0.60*) **Δ3-5%**

Take Home Message

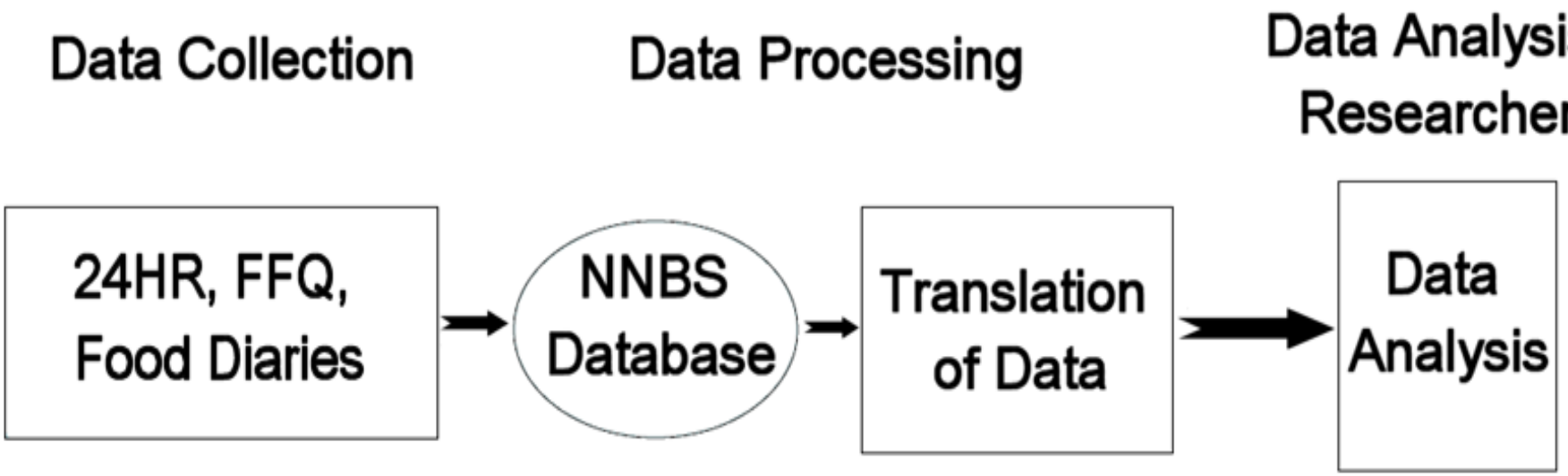
- Energy content depends on
  - Type of organic matter (food, etc.)
- Energy content is not constant across macronutrients or foods
  - Macronutrient substitutions via Atwater Factors are not energy equivalents
- Site of energy conversions
    - E.g., AA to CHO: Gluconeogenesis
      - CHO to CHO: Glycogenesis

Merrill AL, Watt BK. *Energy Value of Foods: Basis and Derivation. Agriculture Handbook no. 74.* Washington, DC: ARS, US Department of Agriculture; 1973.

Research Data

- Quantitative
  - Based on objective properties
    - Direct & Measureable
- Qualitative
  - Based on subjective properties
    - Perceptions: not directly measureable
- Pseudo-quantitative
  - Assigning numeric values to qualitative data

Dietary Recall to Dietary Energy Translation



Summary of Biases & Issues

- Misreporting
  - Under-reporting
  - Over-reporting
- Assigning caloric values to what the participant is willing and able to recall about what they think they ate yesterday
- Inadequate or incomplete database

Human Nature

- Poor at observing their own behavior
- What little is observed is not remembered accurately
- What little is remembered is not described accurately
- What is described is simplified
- Dietary Recall: Simplified, inaccurate description of poorly observed & remembered eating behaviors

OPEN ACCESS Freely available online

PLOS | ONE

Validity of U.S. Nutritional Surveillance: National Health and Nutrition Examination Survey Caloric Energy Intake Data, 1971–2010

Edward Archer[1]*, Gregory A. Hand[1], Steven N. Blair[1,2]

1 Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, United States of America, 2 Department of Epidemiology and Biostatistics, University of South Carolina, Columbia, South Carolina, United States of America

Abstract

Importance: Methodological limitations compromise the validity of U.S. nutritional surveillance data and the empirical foundation for formulating dietary guidelines and public health policies.

Objectives: Evaluate the validity of the National Health and Nutrition Examination Survey (NHANES) caloric intake data throughout its history, and examine trends in the validity of caloric intake estimates as the NHANES dietary measurement protocols evolved.

Design: Validity of data from 28,993 men and 34,369 women, aged 20 to 74 years from NHANES I (1971–1974) through NHANES 2009–2010 was assessed by: calculating physiologically credible energy intake values as the ratio of reported energy intake (rEI) to estimated basal metabolic rate (BMR), and subtracting estimated total energy expenditure (TEE) from NHANES rEI to create 'disparity values'.

Main Outcome Measures: 1) Physiologically credible values expressed as the ratio rEI/BMR and 2) disparity values (rEI–TEE).

Results: The historical rEI/BMR values for men and women were 1.31 and 1.19, (95% CI: 1.30–1.32 and 1.18–1.20), respectively. The historical disparity values for men and women were −281 and −365 kilocalorie-per-day, (95% CI: −299, −264 and −378, −351), respectively. These results are indicative of significant under-reporting. The greatest mean disparity values were −716 kcal/day and −856 kcal/day for obese (i.e., ≥30 kg/m2) men and women, respectively.

Conclusions: Across the 39-year history of the NHANES, EI data on the majority of respondents (67.3% of women and 58.7% of men) were not physiologically plausible. Improvements in measurement protocols after NHANES II led to small decreases in underreporting, artifactual increases in rEI, but only trivial increases in validity in subsequent surveys. The confluence of these results and other methodological limitations suggest that the ability to estimate population trends in caloric intake and generate empirically supported public policy relevant to diet-health relationships from U.S. nutritional surveillance is extremely limited.

Method

- Examined 39 Years of NHANES data
  - 28,993 men and 34,369 women, aged 20 to 74 years
- “Physiologically Plausible” Reporters
- Biologically Possible to Survive

Method

- Reported Energy Intake (rEI) ÷ Basal Metabolic Rate (BMR)
  - aka: “Goldberg cutoff”
- Expected value ~1.55
- <1.35 or >2.40 = Implausible

Method: Example

- rEI ÷ BMR
- 1500/1000 kcals
- Ratio = 1.5
  - Plausible
- 1000/1000kcals
- Ratio = 1.0
  - Implausible

Method

- rEI ÷ BMR
- Expected value ~1.55
- <1.35 or >2.40 = Implausible
  - <1.35 = Confined to bed, no activity
  - > 2.40 = Arctic explorer X-country skiing while dragging a sled 10 hrs/day

The Mean rEI/BMR Values

- Men: 1.31
- Women: 1.19

- Obese Men: 1.21
- Obese Women: 1.10
  - Expected value of Comatose patient with an IV drip
  - ~50% of obese women reported lower values

Method #2

- Institute of Medicine
  - Total Energy Expenditure Predictive equations
  - Based on Objective database
- rEI - TEE = Disparity value
  - Negative values = underreporting

Disparity Values

- Men -281 kilocalorie-per-day
- Women: -365 kcal/d

- Obese Men: -467.4 kcal/d
- Obese Women: -553.5 kcal/d

Over-reporting: rEI/BMR > 2.40

- 4.9% of men
  - High of 6.4% NHANES III
- 2.9% of women
  - 3.9% in NHANES 2003-2004

Correlations with IOM TEE

- Men: 0.225
- Women: 0.163
- Correlation of 1.0 is perfect
  - 0.7 = acceptable
  - 0.5 = marginal
  - **< 0.25 = No meaningful relationship**

Validity of NHANES

"Across the 39-year history of the NHANES, EI data on the majority of respondents (67.3% of women and 58.7% of men) were not physiologically plausible."

Archer et al., PLoS ONE 2013;8(10): e76632

Previous Research

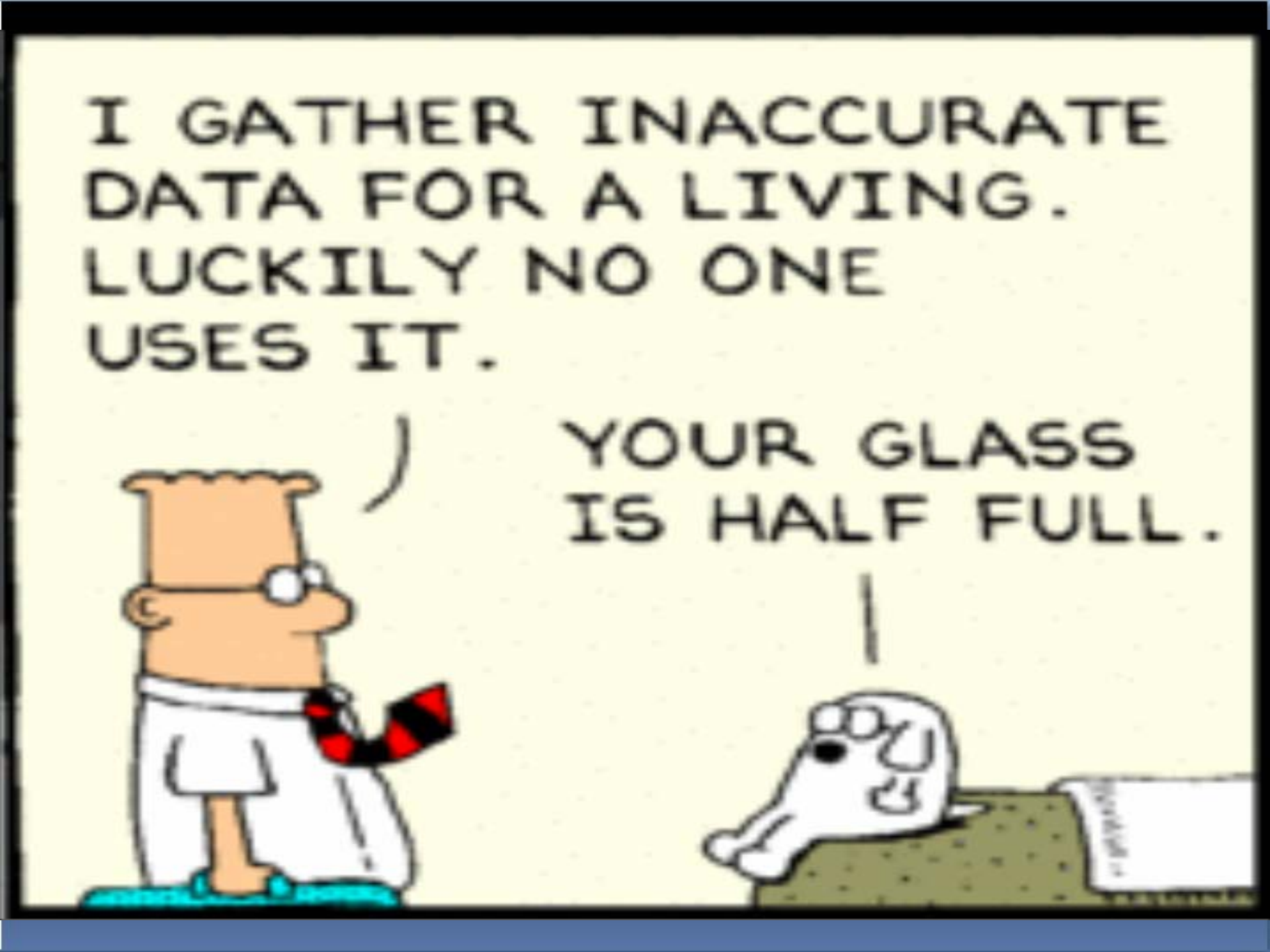
Goldberg, et al. (1991) Eur J Clin Nutr 45: 569-581.

- Goldberg et al. (1991)
- 37 studies across 10 countries
- >65% of the mean rEI/BMR values were implausible
  - Study specific cutoff
- Plural of anecdote is not data

NCI Seminar Series

and Subar et al (2003) Am J Epi 158

Nutrient	1 FFQ	2 FFQ	1 24HR	4 24HR	14 24HR
	Attenuation factor/correlation with truth				
Energy	.04/.10	.05/.11	.10/.21	.20/.30	.26/.35
Protein	.14/.30	.16/.32	.14/.29	.32/.44	.46/.53


I GATHER INACCURATE DATA FOR A LIVING. LUCKILY NO ONE USES IT.
YOUR GLASS IS HALF FULL.

Nutrition & Obesity

- Numerous unscientific statements about nutrition, obesity and health.

- "…Americans continued to consume an average of 3800 calories per person per day, or about twice the daily requirement."
  - Kennedy & Abelson. The Obesity Epidemic. Science 2004; 304:1413

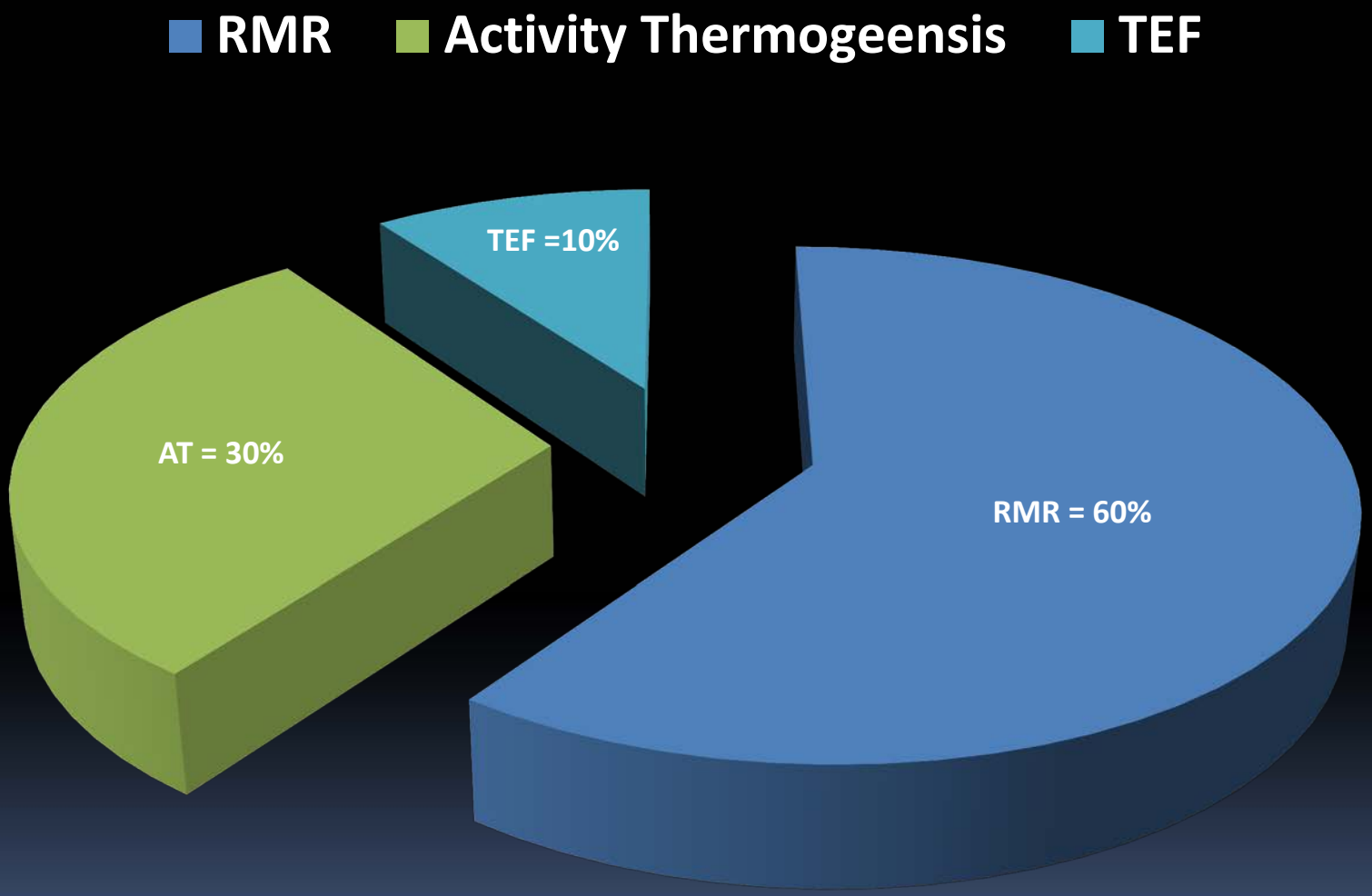
ORIGINAL ARTICLE

MAYO CLINIC

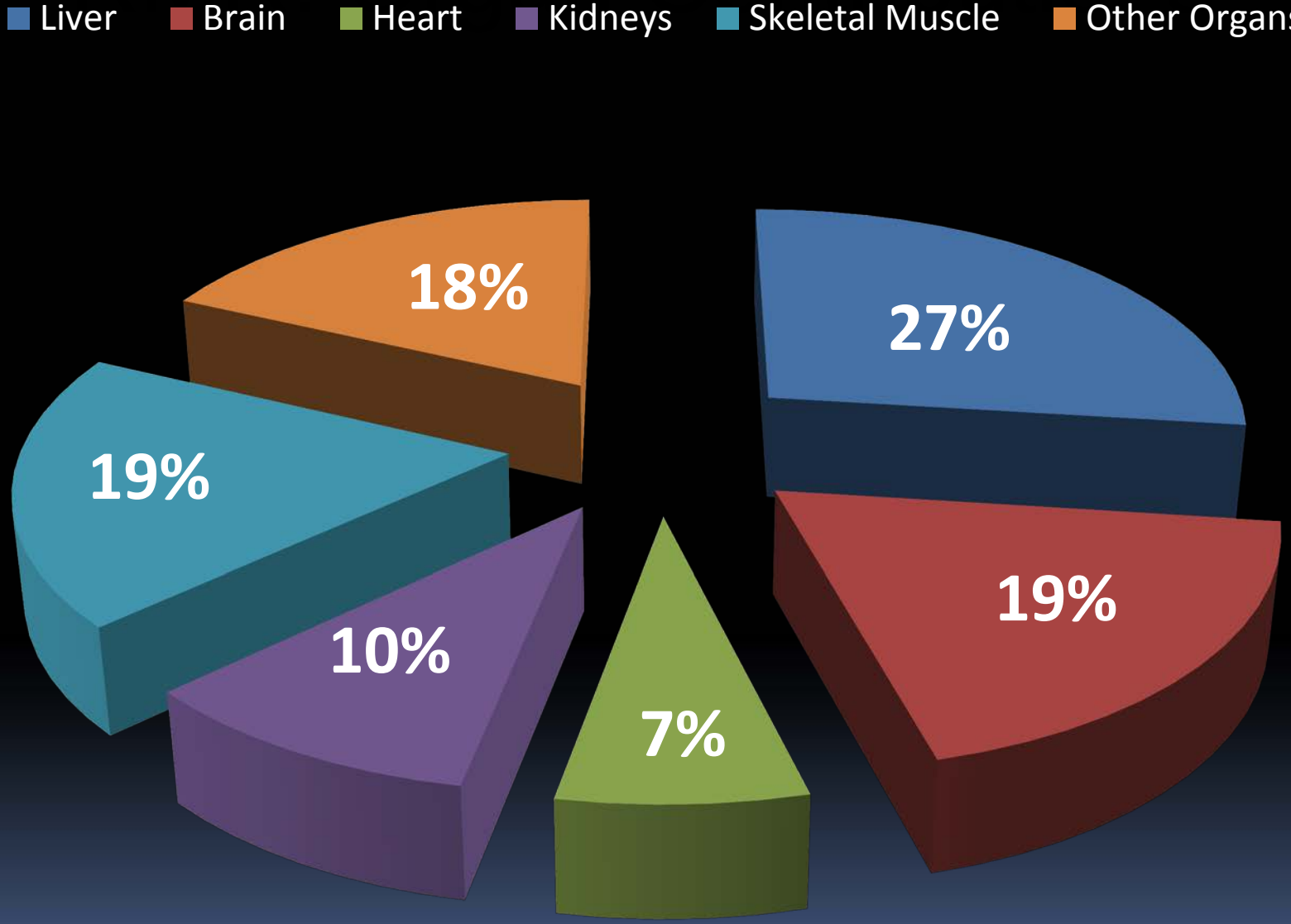
Validation of a Novel Protocol for Calculating Estimated Energy Requirements and Average Daily Physical Activity Ratio for the US Population: 2005-2006

Edward Archer, PhD, MS; Gregory A. Hand, PhD, MPH; James R. Hébert, ScD, MSPH; Erica Y. Lau, MPhil; Xuewen Wang, PhD; Robin P. Shook, PhD, MS; Raja Fayad, MD; Carl J. Lavie, MD; and Steven N. Blair, PED

Components of Total Daily Energy Requirements (TDEE)



Components of Resting Metabolic Rate (RMR)



Estimating Energy Expenditure

- *A Priori* assumption: EI = EE
- Total daily EE (TEE)
  - TEE = BMR x APAR x TEF x AT
- BMR: Mifflin-St. Joer equation
- APAR: Accelerometry based physical activity monitors
- TEF: Constant 7.5% of TEE
- AT: Ignored

Nationally Representative Estimates

- Men: 2940 kcal/day
- Women: 2275 kcal/day
- Range:
  - 3230 kcal/day in obese men
    - (BMI ≥30kg/m^2)
  - 2026 kcal/day in normal-weight women
    - (BMI < 25kg/m^2).

Validation via IOM TEE

- 0.98 correlation w/ IOM TEE
- Absolute estimates higher in all individuals
- Range
  - Low: 46 kcal/d (1.3%) in obese men
  - High: 178 kcal/d (6.8%) in obese women.

Summary

- No valid data on population-level energy intake exist.

- "the ability to estimate…trends in caloric intake and generate empirically supported public policy…from U.S. nutritional surveillance is extremely limited."

Archer et al., PLoS ONE 2013;8(10): e76632

“The reasonable man adapts himself to the world: the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man.”

George Bernhard Shaw

Thanks!

Questions?!?!