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Energy Homeostasis in Humans

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Section A

General Concepts of Energy Metabolism

Types of Energy

- Solar
- Chemical
- Mechanical
- Thermal
- Electrical

Units of Energy

- **Calorie**
  - Defined as the amount of heat required to rise the temperature of
    one kg of water from 14.5 to 15.5° C
  - Also defined based on the heat of combustion of benzoic acid (thermochemical calorie)
  - Standardized in 1956—one cal = 4.1868 Joules

Units of Energy

- **Joule**
  - Defined as the energy expended when one kg is moved one meter by a force of one Newton
- **Watt**
  - Expresses rate of energy expenditure per unit time, i.e., work (J/sec)

- 1 L of O_2 = 4.825 kcal
- 1 g/atom of O_2 = 3 mol of ATP

Bomb Calorimeter

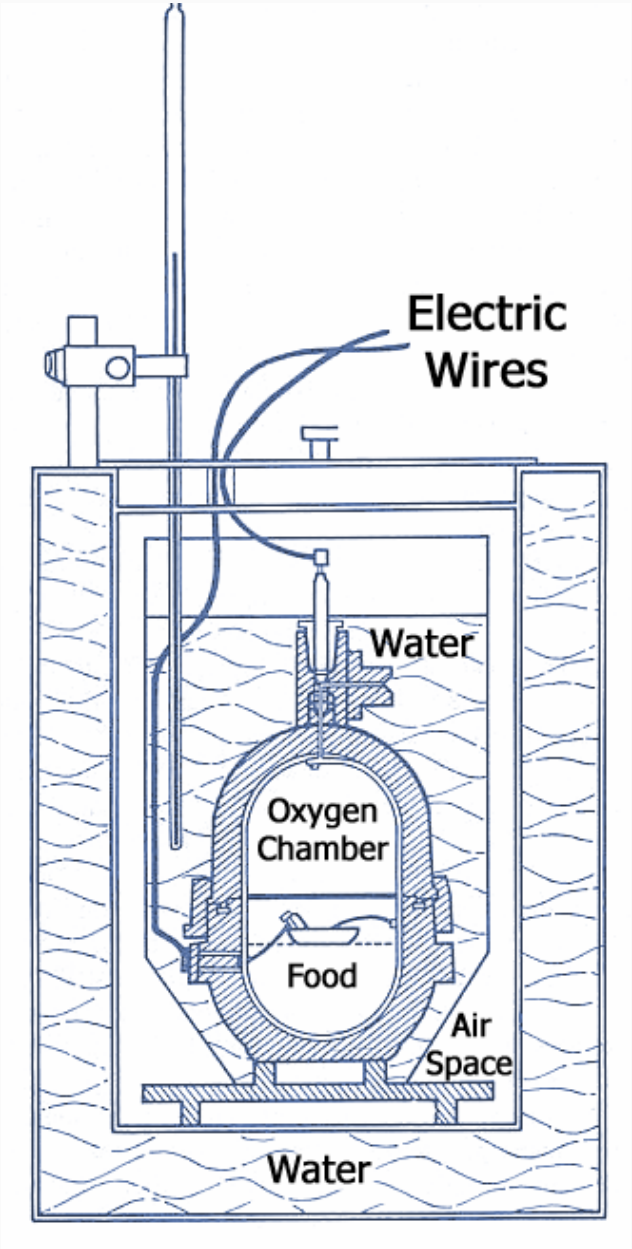

Diagram created by JHSPH CTLT

Energy Combustion

	O_2 (ml)	CO_2 (ml)	RQ	Energy (kcal)
Starch	828	828	1.00	4.183
Fat	2019	1427	0.70	9.461
Protein	966	781	0.81	4.442

Energy in Foods

Kcal/g	Heat of Comb ustion	Availabilit y	Loss	Net
Meat	5.35	92%	1.25	4.0
Butter	9.12	95%	—	9.0
Starch	4.12	99%	—	4.0
Ethanol	7.1	100%	tr.	7.0

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Section B

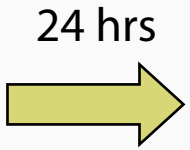
Energy Balance and Measurement of Energy Expenditure

Energy Balance

Energy IN = Energy OUT

Measurement of Energy Balance

Energy Intake

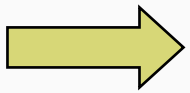


Energy Expenditure

Measurement of Energy Balance

Energy Intake

24 hrs



Energy Expenditure

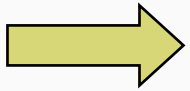
- Food freq. quest.
- 24-hr recall
- Food records
- Food weighing
- Direct observation

Measurement of Energy Balance

Energy Intake

- Food freq. quest.
- 24-hr recall
- Food records
- Food weighing
- Direct observation

24 hrs

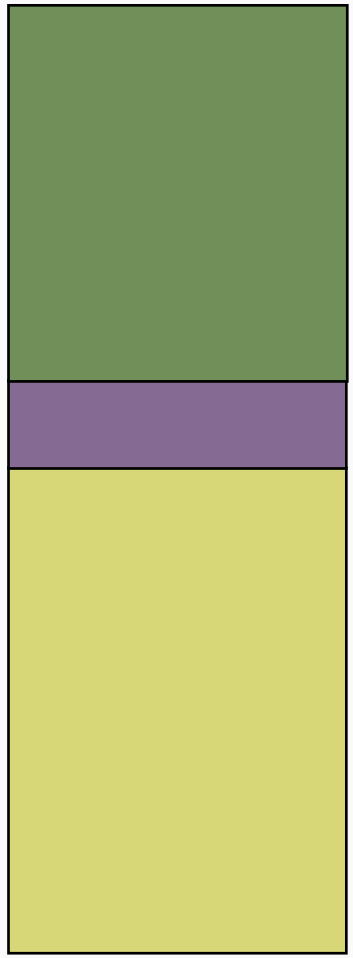


Energy Expenditure

- Gas exchange calorimetry
- Heart rate monitoring
- Estimated from activity
  - Motion sensors
  - Activity diary
  - Direct observation
- Doubly labeled water (D218O)

Components of EE

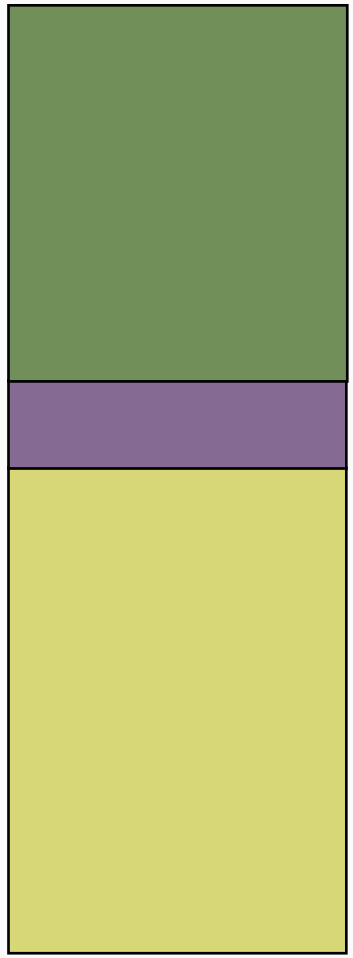
Basal Metabolic Rate
(BMR, REE)



Components of EE

Thermic Effects of Food
(TEF, FIT)

Basal Metabolic Rate
(BMR, REE)

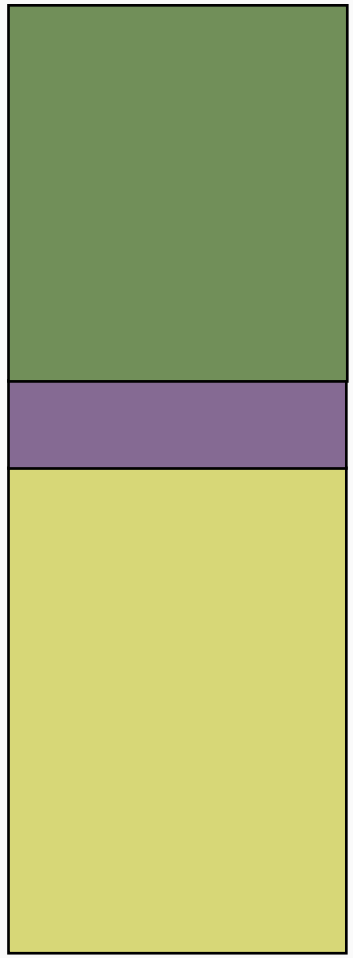


Components of EE

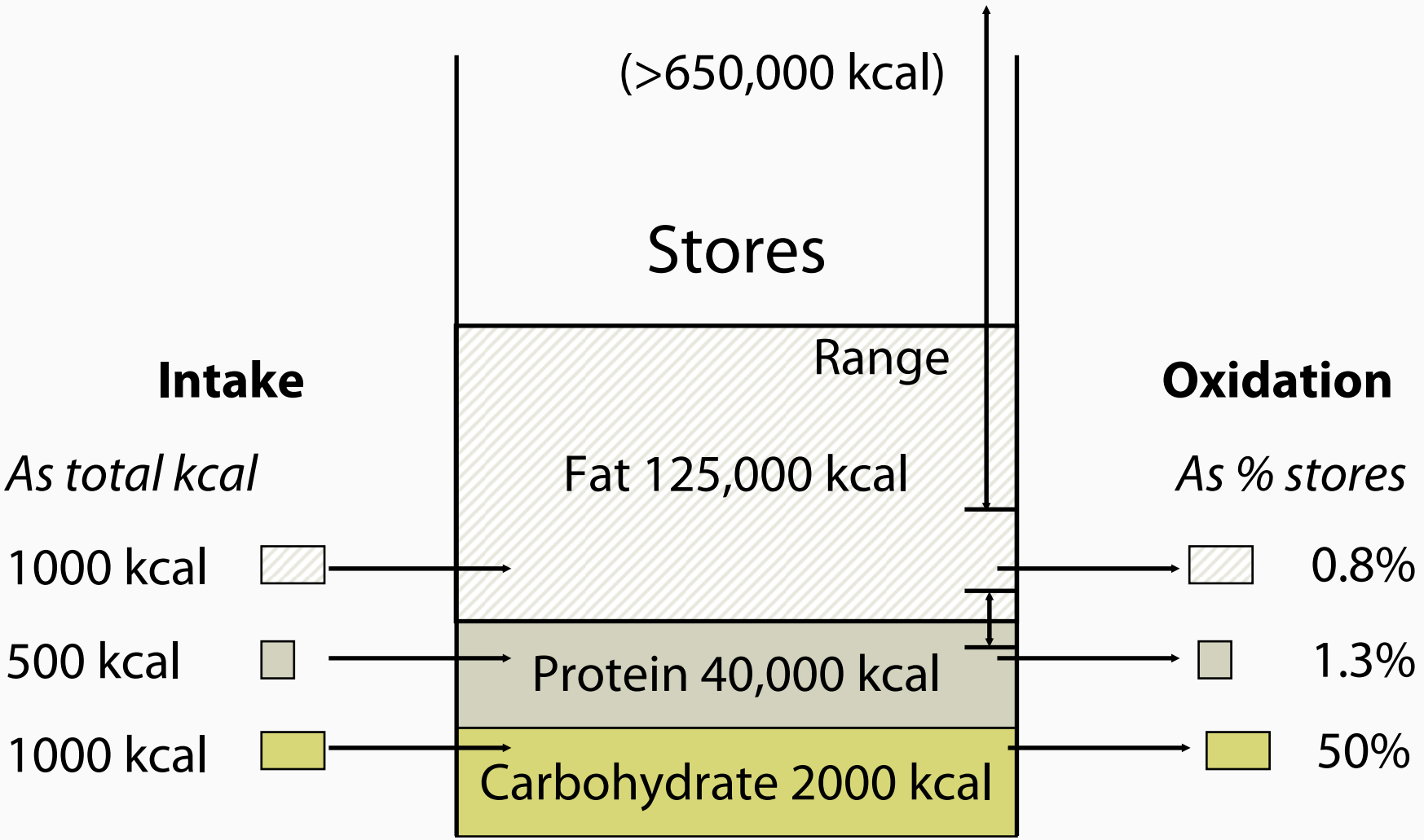
Physical Activity (PA)

Thermic Effects of Food
(TEF, FIT)

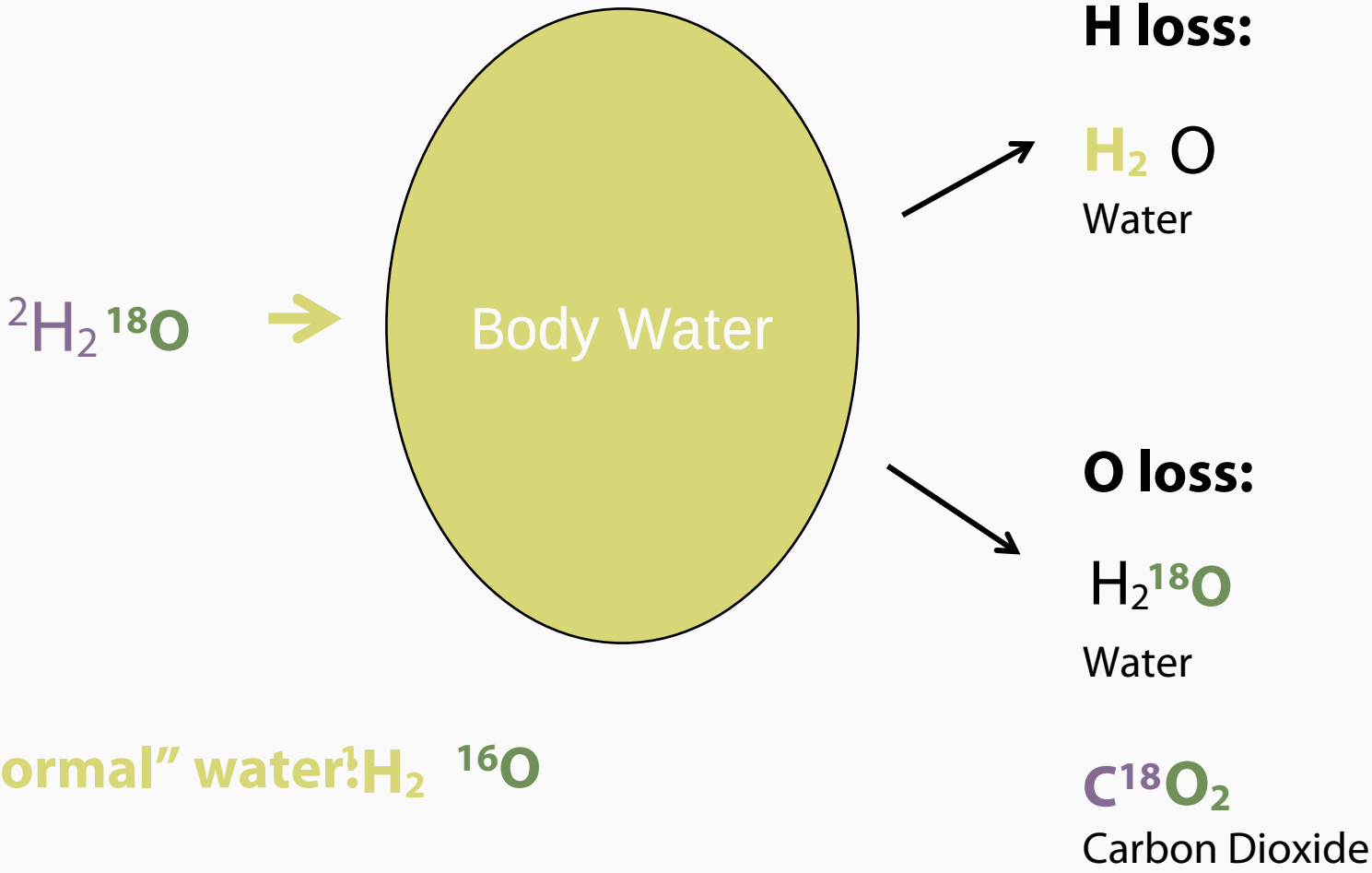
Basal Metabolic Rate
(BMR, REE)



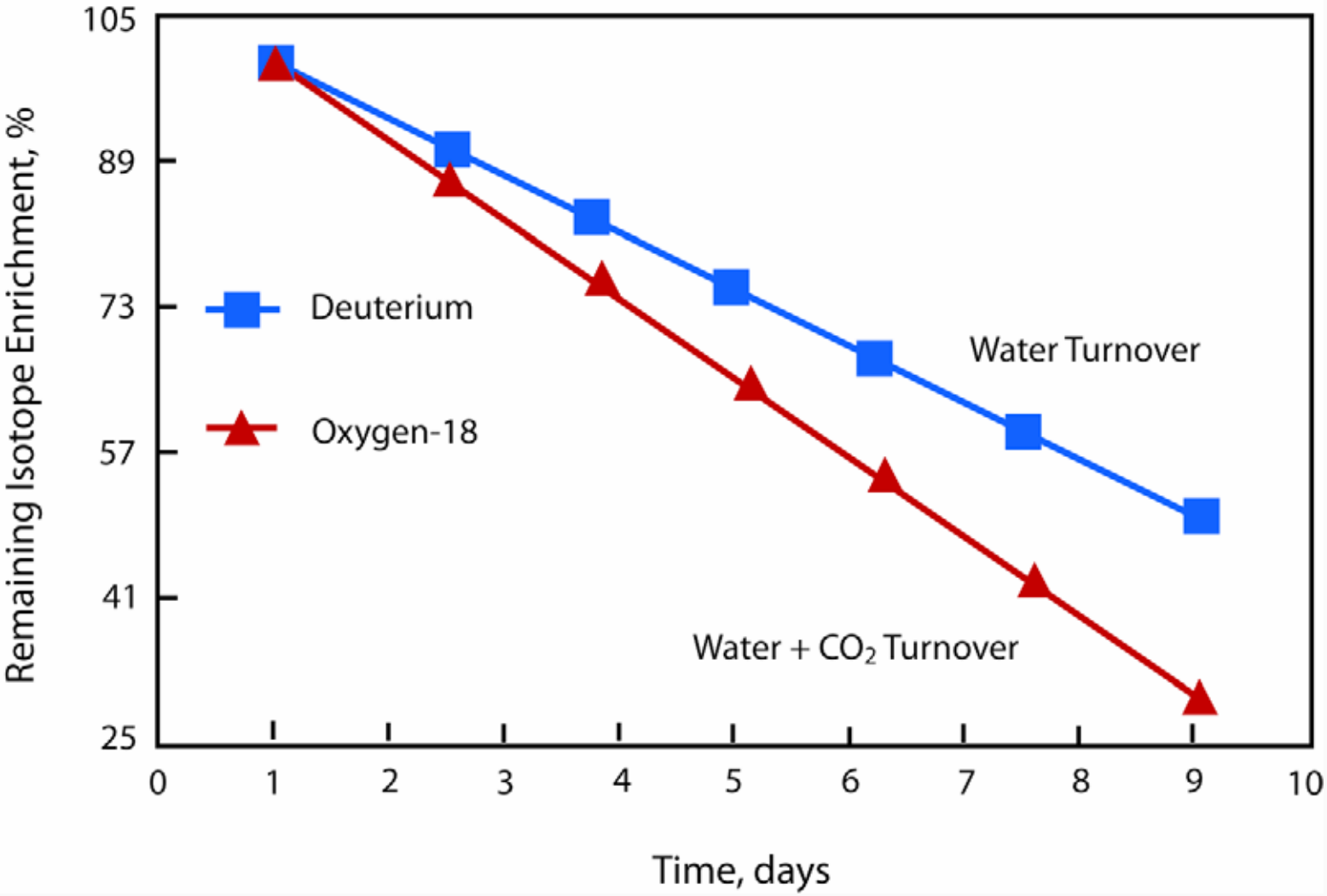
Daily Energy Balance



The Doubly-Labeled Water Method



Disappearance Rates of DLW Tracers



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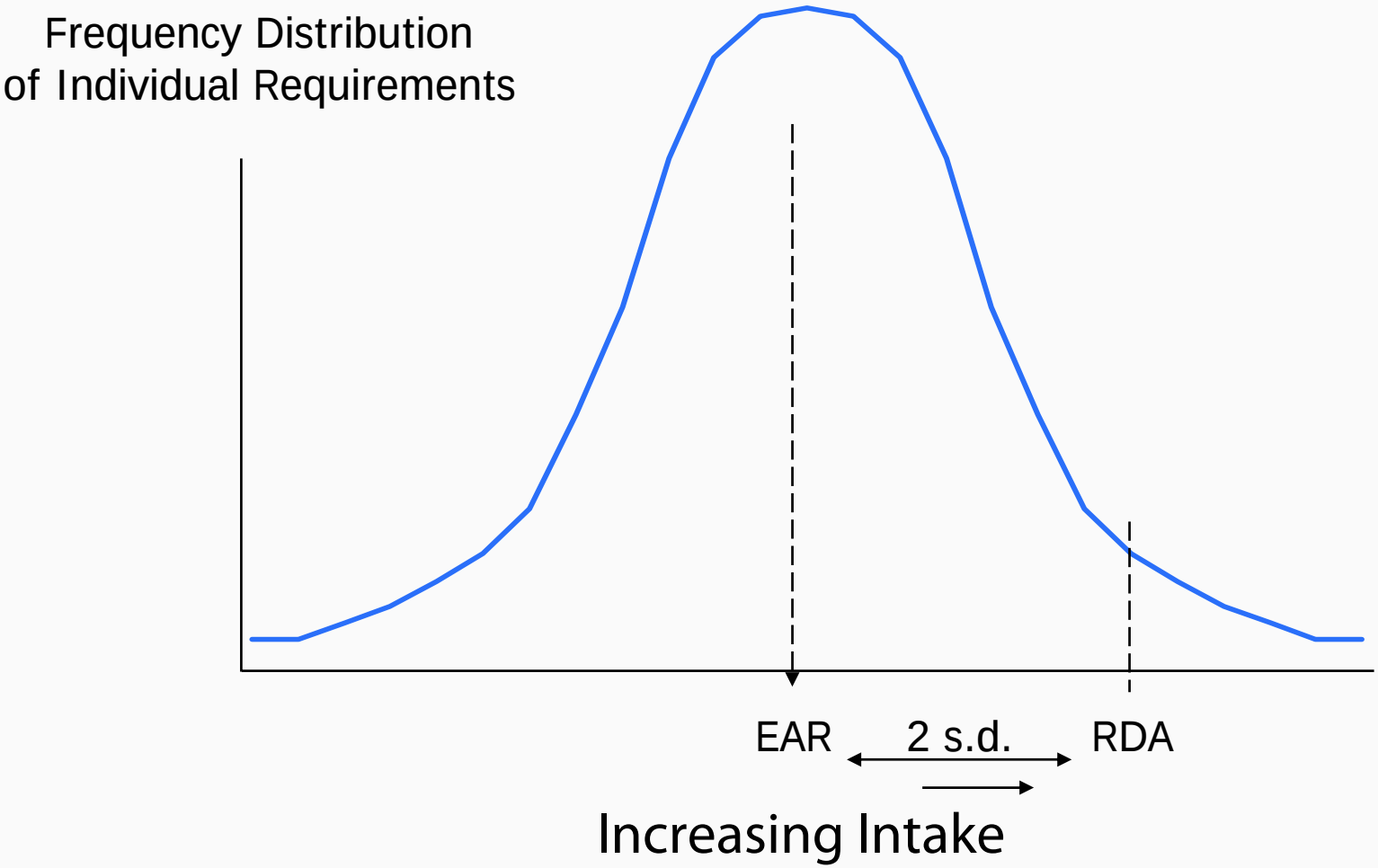
Section C

Energy Requirements

Dietary Reference Intakes



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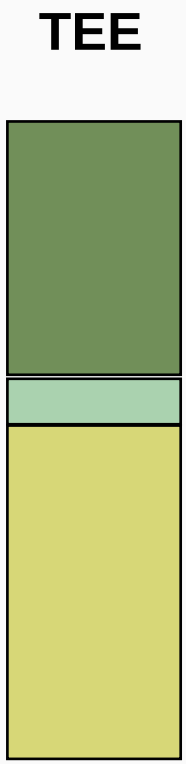
Determination of Dietary Energy Requirements: Factorial Method



Physical Activity Allowance

Food-Induced Thermogenesis (ignored)

BMR (measured/predicted)

Limitations of Previous Approach

- BMR not constant throughout the day
- Unreliable data on energy cost of physical activities, and only estimated for selected activities
- EPOC, fidgeting, other involuntary activities not accounted for

Selection of Approach for Current Revision

- Use energy expenditure to estimate dietary energy requirements
- Use total daily energy expenditure (TEE) measured by the doubly-labeled water technique

Adequacy Indicator

BMI

- Strengths
  - Recognized link to health outcomes
  - Reflects relationship of weight and height
  - Good population data in U.S. and other countries

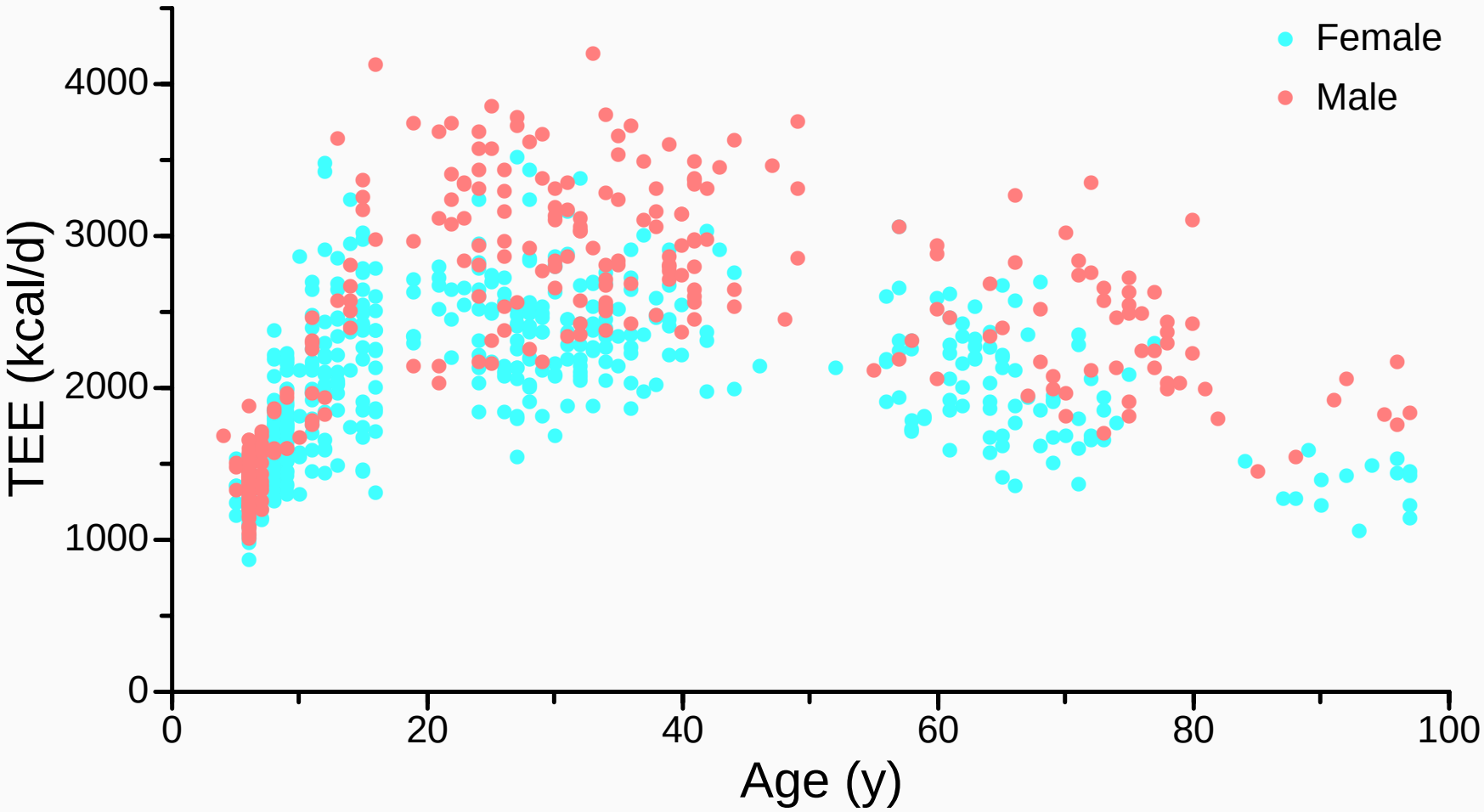
BMI

- Limitations
  - Not best indicator of body adiposity
  - Cutoffs may not be valid across populations
  - Some difficulty in defining cutoff points in children and across populations/countries

Estimated Energy Requirement (EER)

- A level of dietary energy intake sufficient to maintain a stable healthy body weight and an adequate level of physical activity
- Differs from EAR in that it is not a distribution of intakes reflecting physiological variability

Normative DLW Database TEE by Age



Measures of Physical Activity

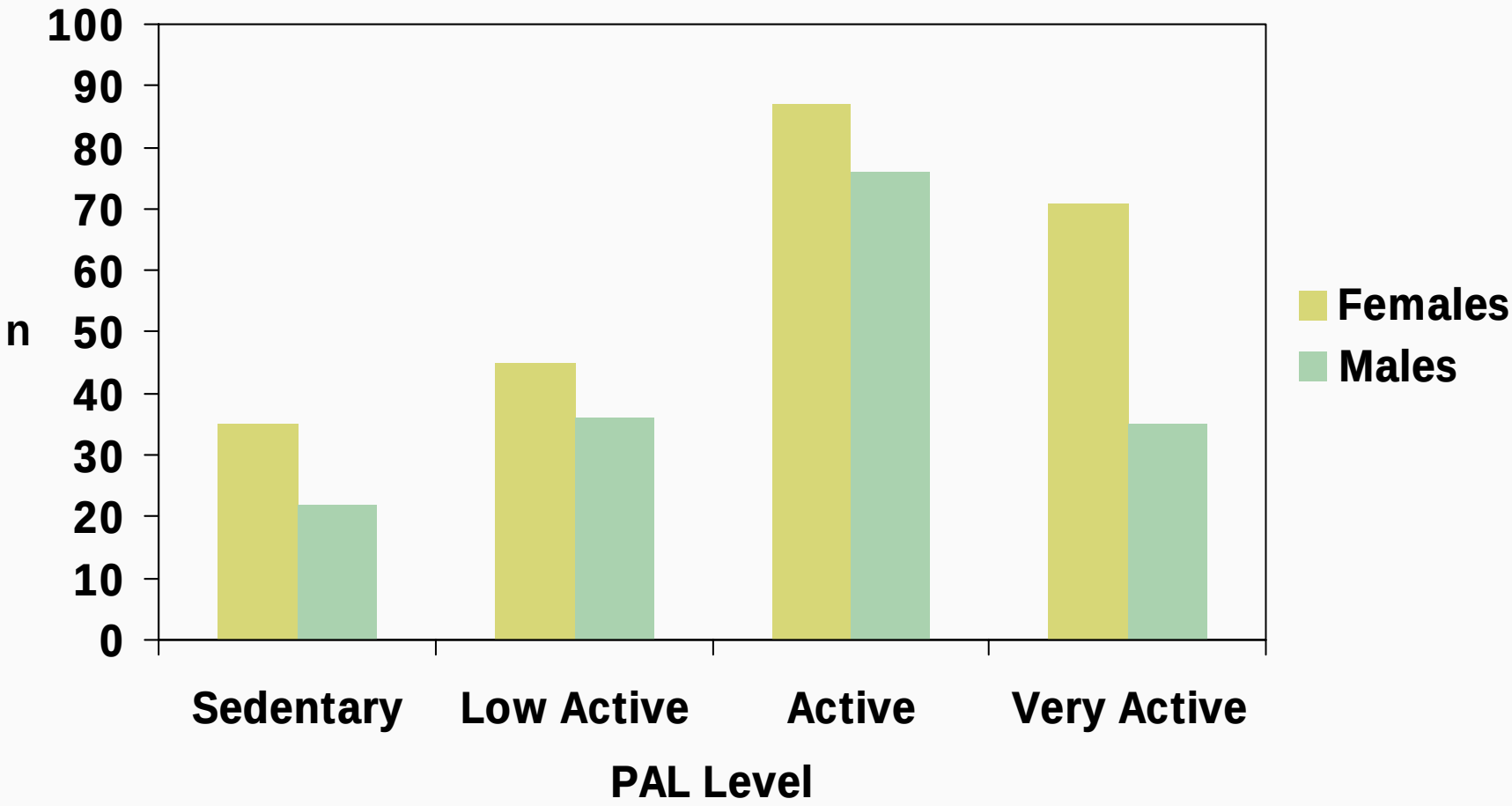
- PAL—TEE / BEE
- MET— O_2 consumption of 3.5 mL/kg/min
  (= 0.0175 kcal/kg/min)
- PAL equivalents of METs
  - 0.0175 x 1.15 / 0.9

PAL Levels

PA Category	Range	Mean F	Mean M
Sedentary	1.0–1.39	1.23	1.29
Low Active	1.4–1.59	1.52	1.51
Active	1.6–1.89	1.74	1.74
Very Active	1.9–2.5	2.09	2.06

Data from Institute of Medicine/National Academy of Sciences

DLW Database: Distribution of PAL Levels



Equation for Prediction of TEE: General Models

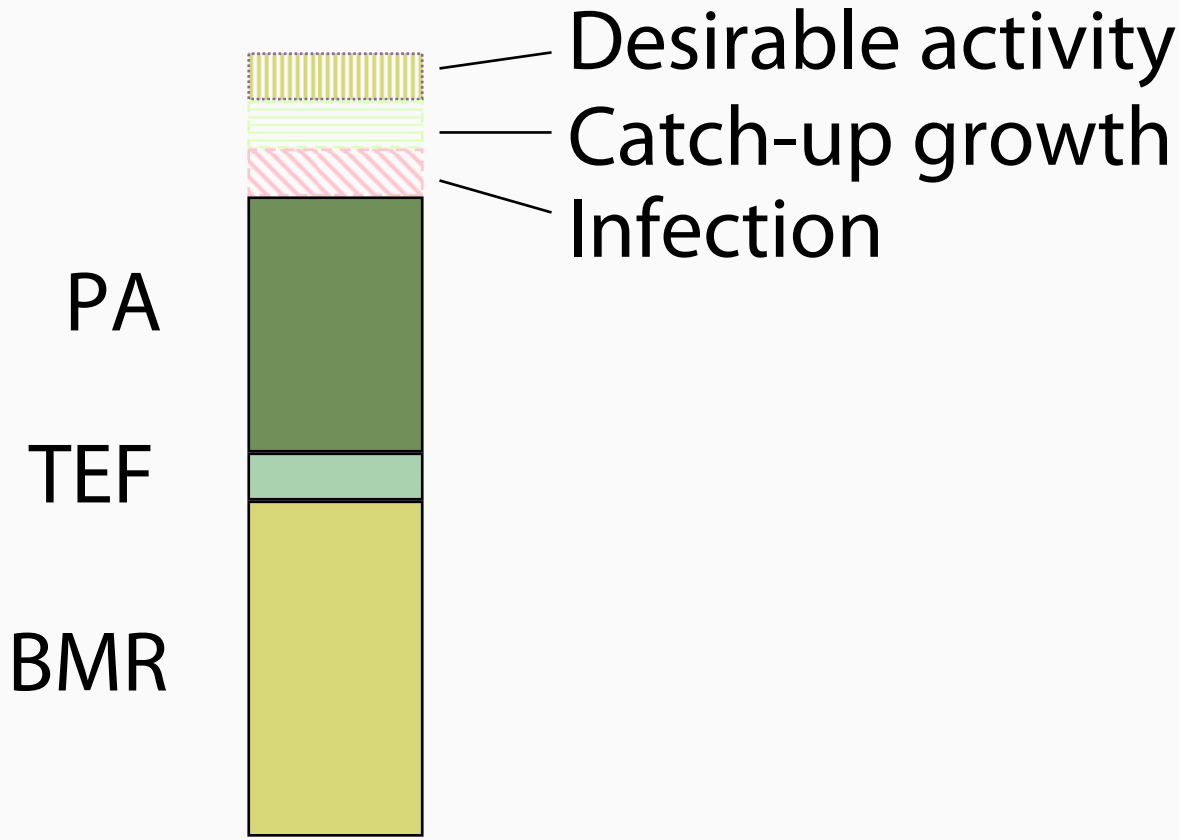
0–2 Years of Age

- TEE = 89 x Weight – 100

Ages 3 Years and Over

- TEE = A + B x Age + PA x (D x Weight + E x Height)
  - A—Constant term
  - B—Age coefficient
  - PA—Physical activity coefficient
  - D—Weight coefficient
  - E—Height coefficient

Energy Allowances +



Adapted by CTLT from Institute of Medicine/National Academy of Sciences

Factors Affecting Energy Requirements