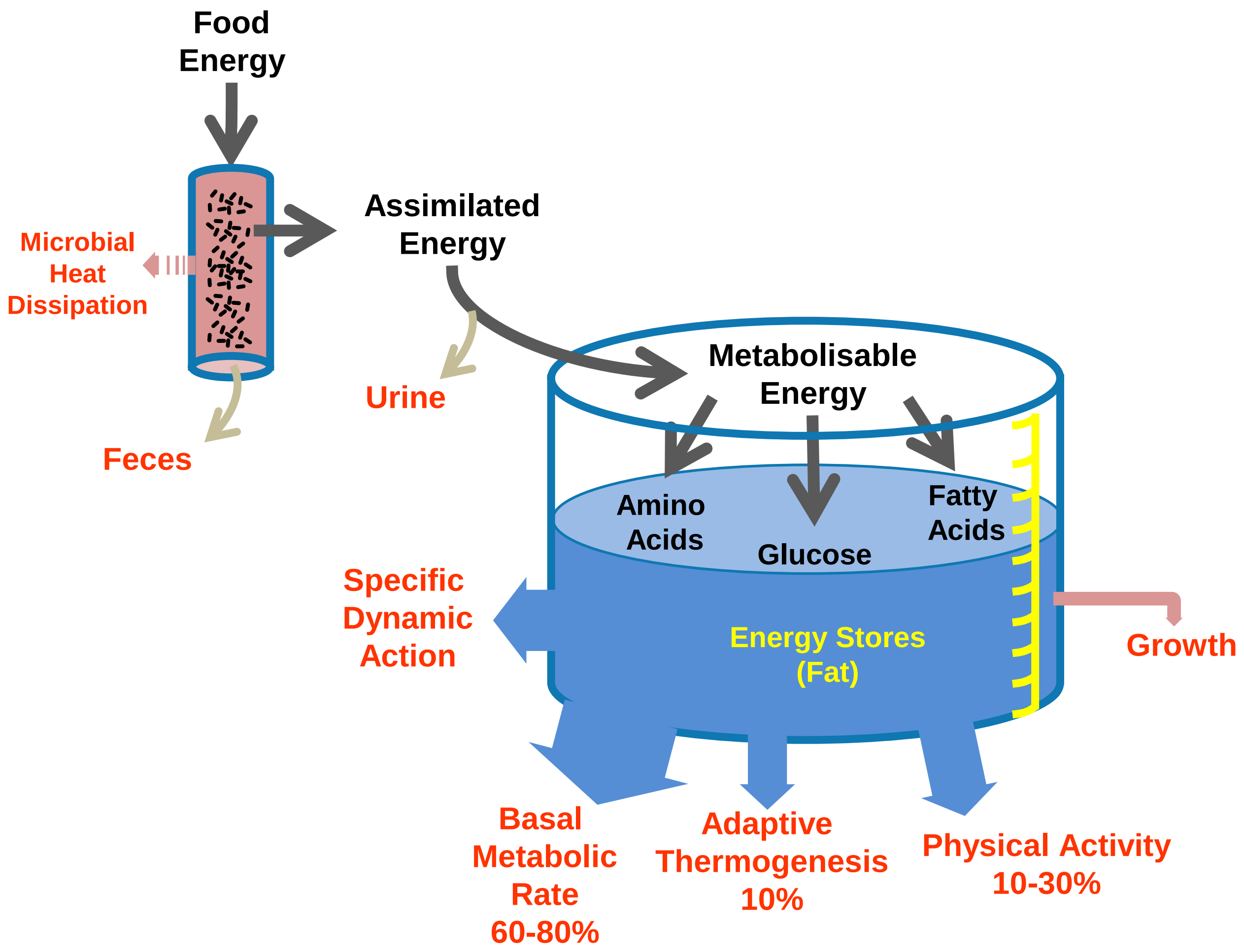
Assessing Basal Metabolic Rate in Humans using Indirect Calorimetry

Gloria Keppner

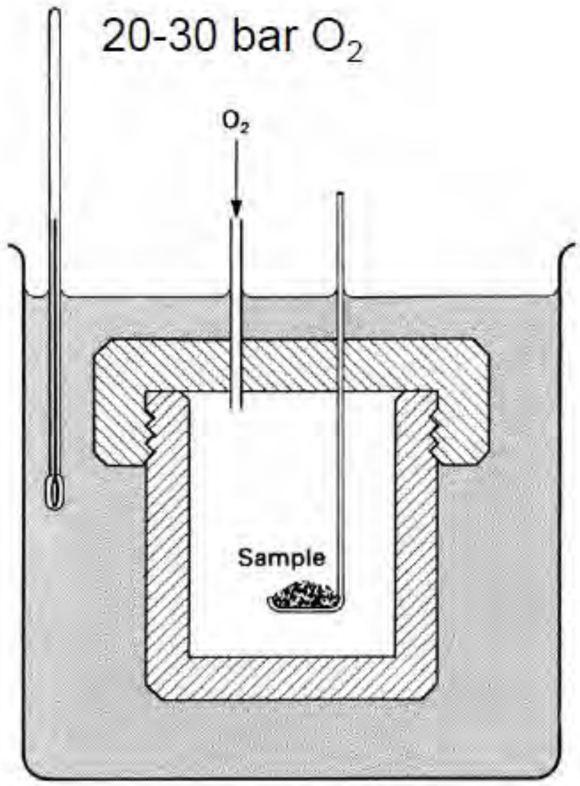
Chair for Molecular Nutritional Medicine
Technische Universität München

10/13/2016

Daily Energy Expenditure



Bomb Calorimetry



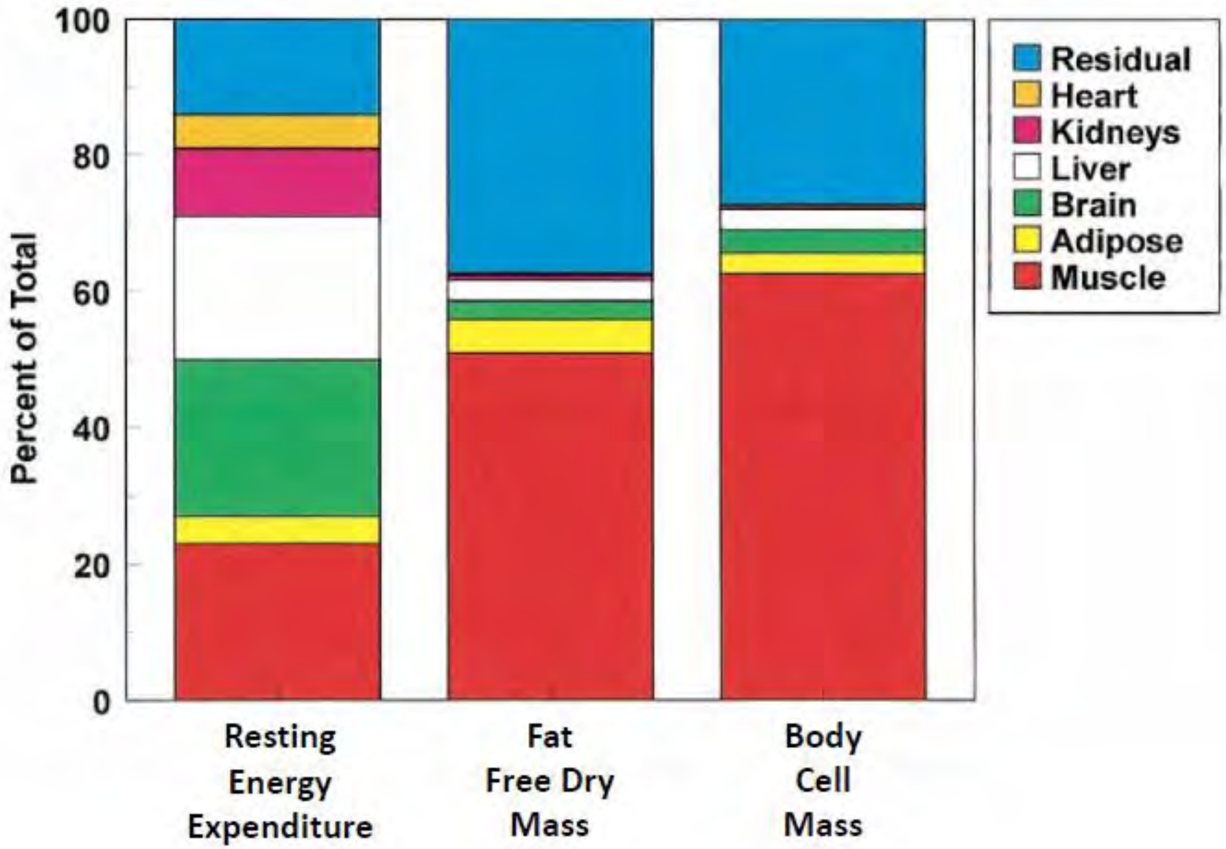
Basal Metabolic Rate

Energy to maintain the body function at rest and all vital functions!

Definition

- Postabsorptive (10-12h after last meal)
- Normotherm (Tb ~ 37°C)
- Thermoneutral
- Resting (lying on back)
- No stress, no excitment
- Awake

Relative contribution of organs to BMR



Gallagher et al. 1998

How to measure Resting Metabolic Rate

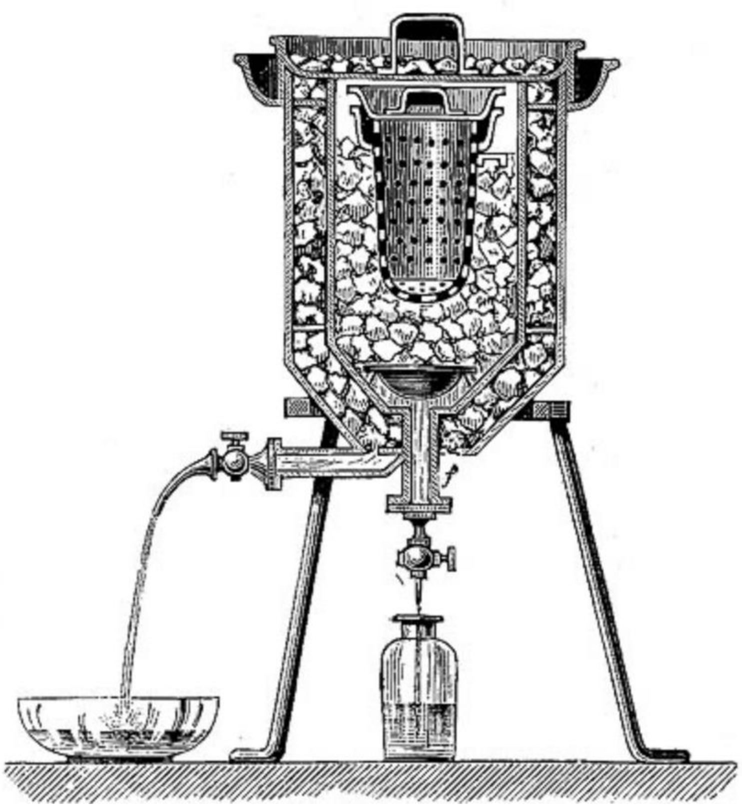
Direct Calorimetry

- Heat production
- Bomb calorimetry

Indirect Calorimetry

- Food intake / waste
- Double labled water
- Respirometry

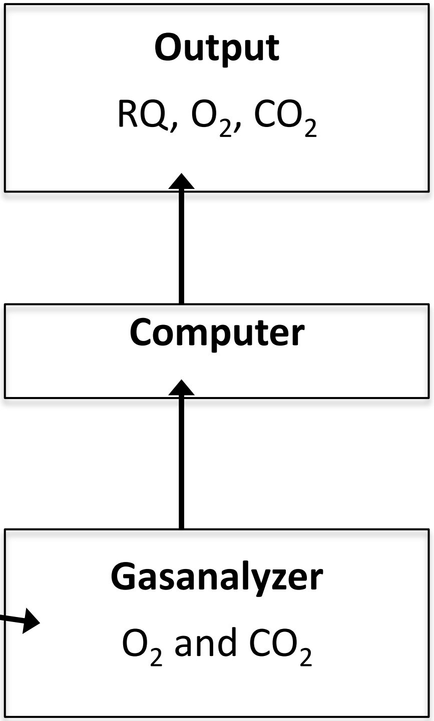
Ice Calorimeter



Leplace and Lavoisier 1780

“Respiration is thus a very slow combustion phenomenon, very similar to that of coal; it is conducted inside the lungs, not giving off light, since the fire matter is absorbed by the humidity of the organs of the lungs. Heat developed by this combustion goes into the blood vessels which pass through the lungs and which subsequently flow into the entire animal body.”

Indirect Calorimetry



Respiratory Quotient (RQ)

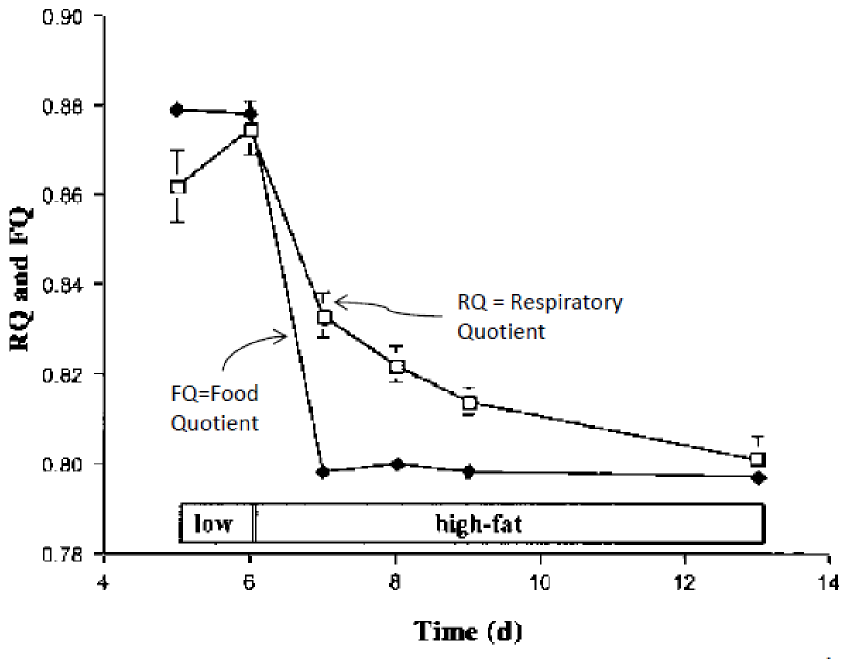
Defenition

Proportion between consumed oxygen (O_2) and produced carbon dioxide (CO_2)

$$RQ = V_{CO_2}\ (l/min) / V_{O_2} (l/min)$$

The RQ is specific for each metabolized substrate, due to different biochemical characteristics!

Respiratory Quotient to determine the utilized substrate



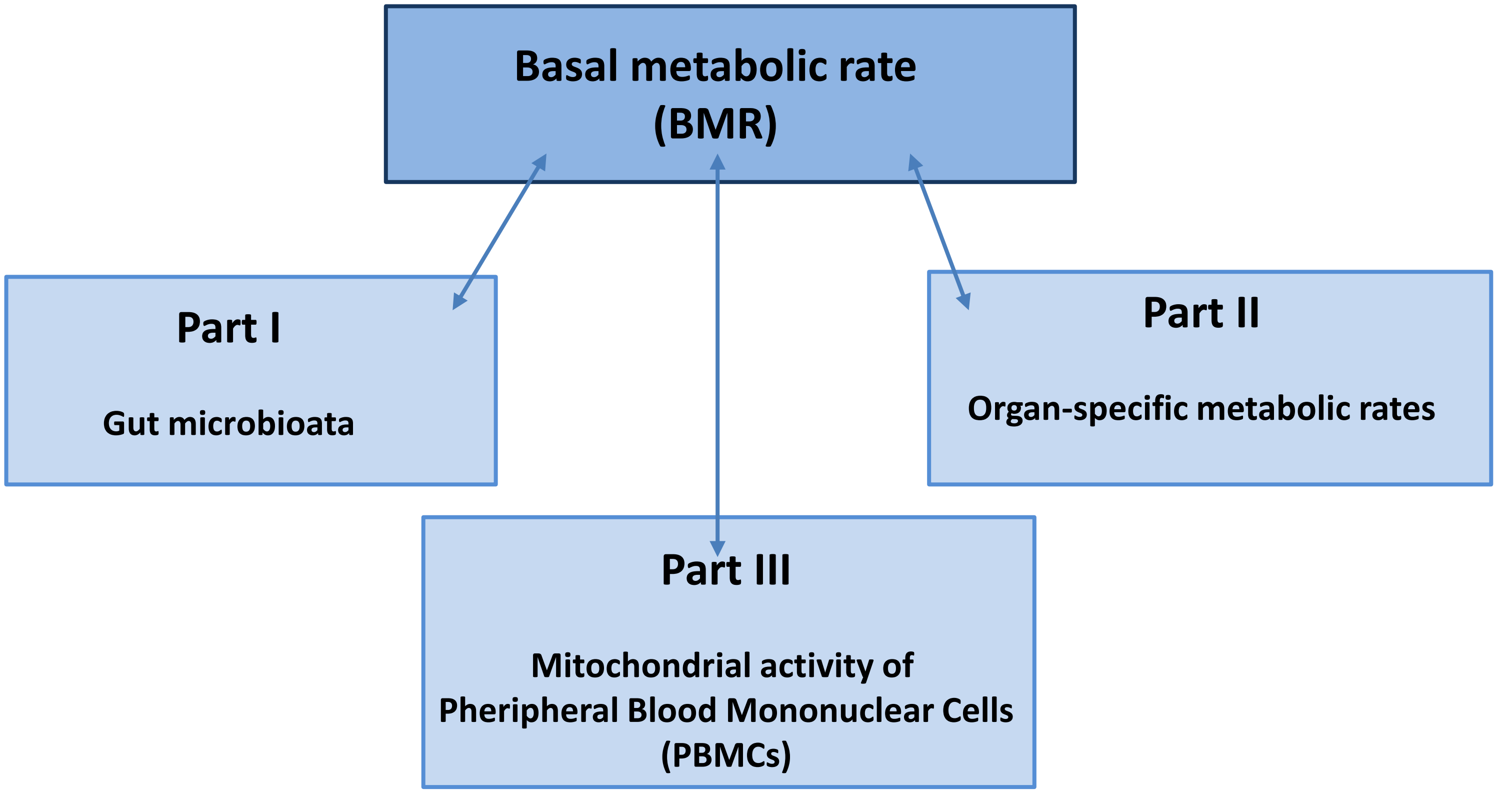
Schrauwen et al. 1997

Respiratory Quotients of different substrates

- Carbohydrates = 1
- Proteins = 0.8
- Fat = 0.7

RQ decreases with dietary fat content!

Impact of gut microbioata, liver metabolism and PBMC activity on energy expenditure



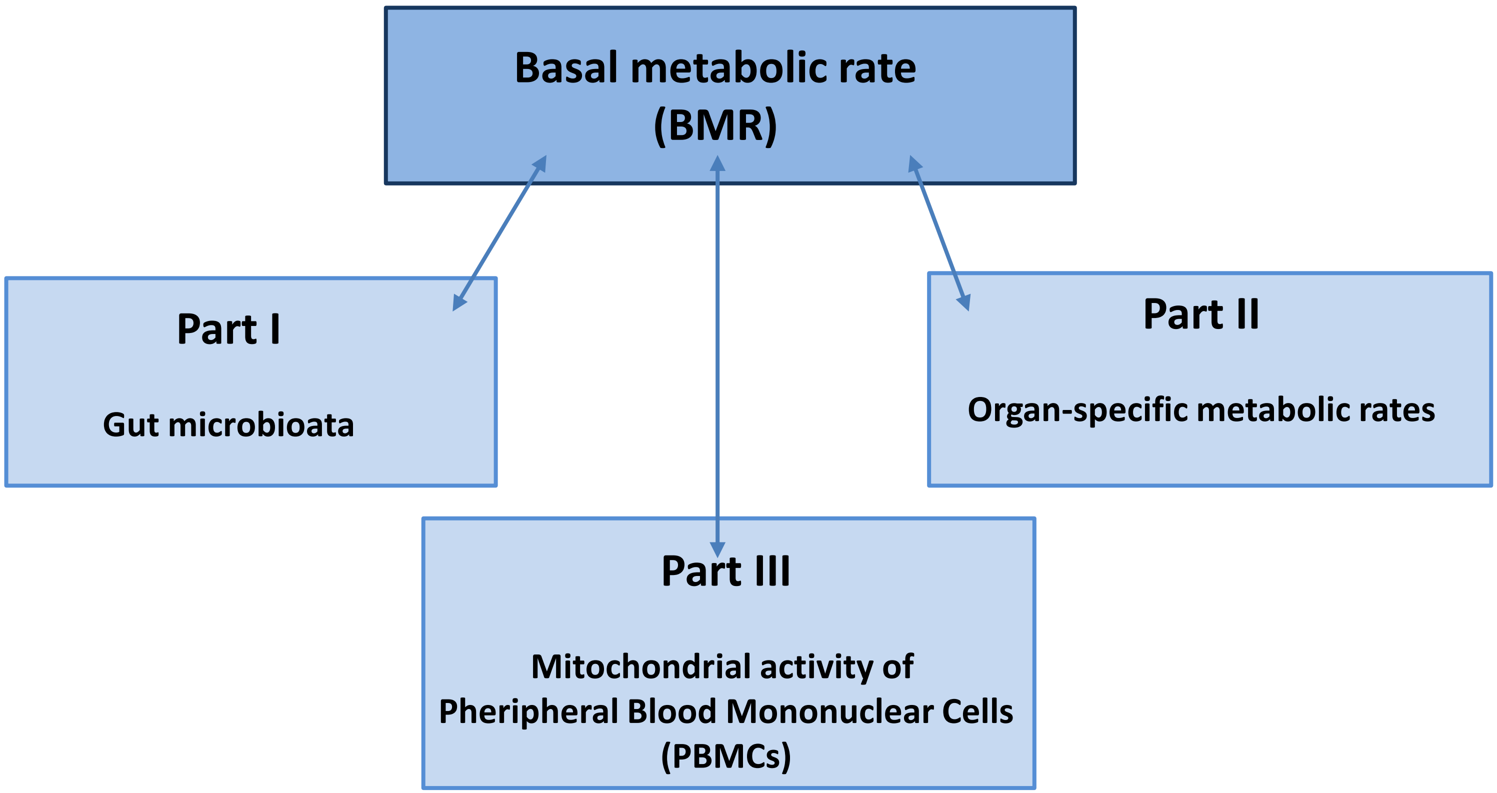
Brain and high metabolic rate organ mass: contributions to resting energy expenditure beyond fat-free mass[1–4]

Fahad Javed, Qing He, Lance E Davidson, John C Thornton, Jeanine Albu, Lawrence Boxt, Norman Krasnow, Marinos Elia, Patrick Kang, Stanley Heshka, and Dympna Gallagher

Model	Variable	R^2
1	REE = **age** + **sex** + **race** + **weight** + height	0.675
2	REE = **age** + sex + **race** + **fat** + **FFM**	0.696

→ 30% of the variability in REE are unexplained

Impact of gut microbioata, liver metabolism and PBMC activity on energy expenditure



Part I – Fecal Microbiome and Basal Metabolic Rate (BMR)

An obesity-associated gut microbiome with increased capacity for energy harvest

Peter J. Turnbaugh[1], Ruth E. Ley[1], Michael A. Mahowald[1], Vincent Magrini[2], Elaine R. Mardis[1,2] & Jeffrey I. Gordon[1]

MICROBIAL ECOLOGY

Human gut microbes associated with obesity

Ruth E. Ley, Peter J. Turnbaugh, Samuel Klein,
Jeffrey I. Gordon
Washington University School of Medicine,
St Louis, Missouri 63108, USA
e-mail: jgordon@wustl.edu

Impact of diet in shaping gut microbiota revealed by a comparative study in children from Europe and rural Africa

Carlotta De Filippo[a], Duccio Cavalieri[a], Monica Di Paola[b], Matteo Ramazzotti[c], Jean Baptiste Poullet[d], Sebastien Massart[d], Silvia Collini[b], Giuseppe Pieraccini[e], and Paolo Lionetti[b,1]

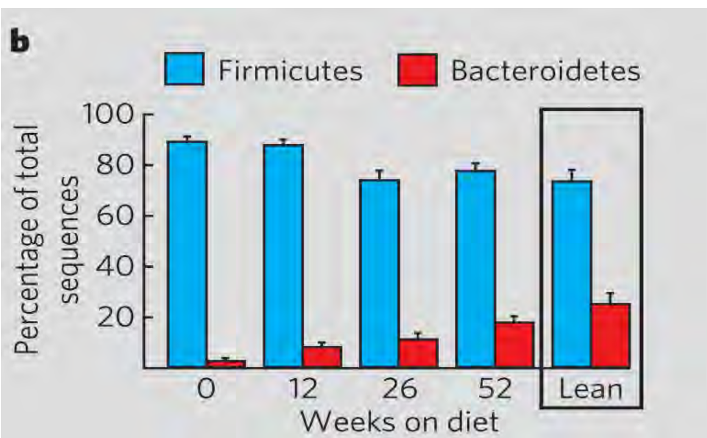
The gut microbiota as an environmental factor that regulates fat storage

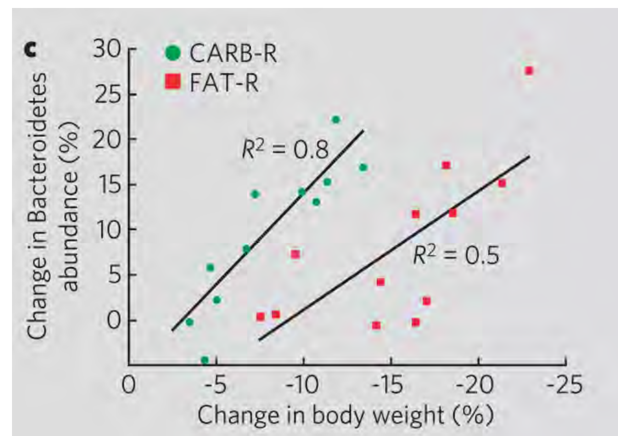
Fredrik Bäckhed*[†‡], Hao Ding[‡§¶], Ting Wang[||], Lora V. Hooper[†]**, Gou Young Koh[††], Andras Nagy[§‡‡], Clay F. Semenkovich[§§], and Jeffrey I. Gordon*[†¶¶]

MICROBIAL ECOLOGY

Human gut microbes associated with obesity

Ruth E. Ley, Peter J. Turnbaugh, Samuel Klein, Jeffrey I. Gordon
Washington University School of Medicine,
St Louis, Missouri 63108, USA
e-mail: jgordon@wustl.edu





Summary Part I

- Gut microbiota is influenced by dietary habits
- Increased ratio of Firmicutes to Bacteroidetes in obese people
- Increase in fat mass by colonization of germ-free mice
- Recipients colonized with bacteria from obese compared to lean donors gained more body fat

Hypothesis I

Individual differences in gut microbiota composition affect the BMR

Brain and high metabolic rate organ mass: contributions to resting energy expenditure beyond fat-free mass[1–4]

Fahad Javed, Qing He, Lance E Davidson, John C Thornton, Jeanine Albu, Lawrence Boxt, Norman Krasnow, Marinos Elia, Patrick Kang, Stanley Heshka, and Dympna Gallagher

Model	Variable	R^2
1	REE = **age** + **sex** + **race** + **weight** + height	0.675
2	REE = **age** + sex + **race** + **fat** + **FFM**	0.696
3	REE = **age** + sex + race + **fat** + **FFM** + **HMRO**	0.723
4	REE = age + sex + race + **fat** + **FFM** + **HMRO** + **brain**	0.745

→ **25% of the variability in REE are unexplained**

Summary Part II

- 70% of BMR variation is explained by sex, age, race, lean mass and fat mass
- Additionally 5% variation of BMR can be explained by HMRO
- Organ metabolic activity may vary between the subjects

Hypothesis II

Specific metabolic activity of liver is associated with the variation of BMR

Part III: Respiratory Capacity of Peripheral Blood Mononuclear Cells (PBMCs) and BMR

NIH Public Access
Author Manuscript
Vasc Med. Author manuscript; available in PMC 2014 February 24.

Published in final edited form as:
Vasc Med. 2014 February ; 19(1): 67–74. doi:10.1177/1358863X14521315.

Relation of Mitochondrial Oxygen Consumption in Peripheral Blood Mononuclear Cells to Vascular Function in Type 2 Diabetes Mellitus

Mor-Li Hartman, **Orian S. Shirihai**, **Monika Holbrook**, **Guoquan Xu**, **Marsha Kocherla**, **Akash Shah**, **Jessica L. Fetterman**, **Matthew A. Kluge**, **Alissa A. Frame**, **Naomi M. Hamburg**, and **Joseph A. Vita**
Evans Department of Medicine and the Whitaker Cardiovascular Institute, Boston University School of Medicine, Boston, MA

Hypothesis III

Oxygen consumption rate of PBMCs correlates with BMR

Thank’s for your attention

AG Klingenspor

Prof. Martin Klingenspor
Dr. Florian Bolze,
Dr. Tobias Fromme,
Dr. Yongguo Li,
Dr. Stefanie Maurer,
Dr. Monja Willershäuser,
Andrea Bast,
Katharina Braun,
Catalina Bonnet,
Gloria Keppner
Sabine Schweizer,
Hui Wang,
Sabine Mocek

enable
healthy food choices in all stages of life