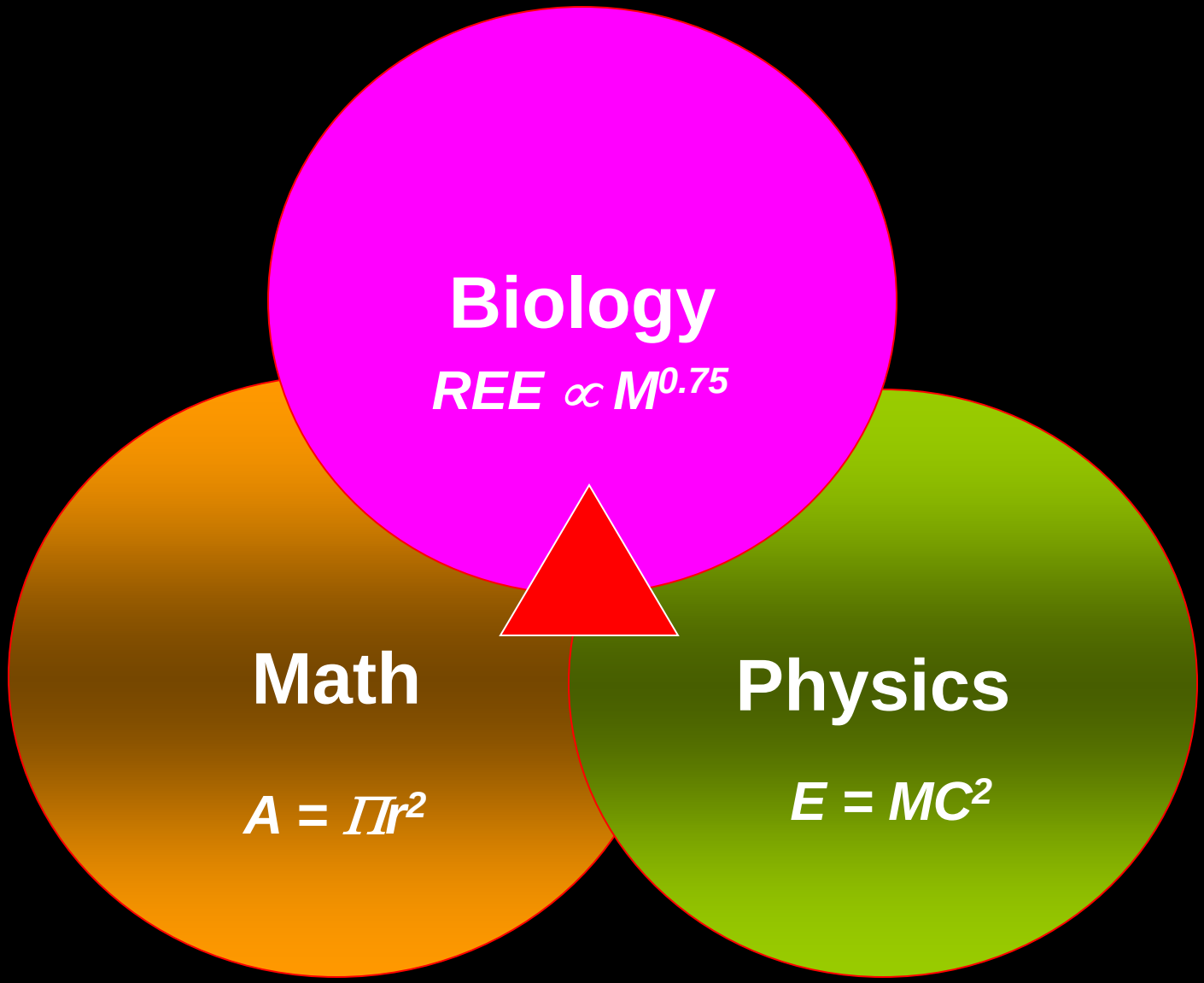

Biology
REE ∝ M0.75
Math
A = Πr2
Physics
E = MC2

History of Human Weight Change Models

Steven B. Heymsfield

PENNINGTON
BIOMEDICAL RESEARCH CENTER

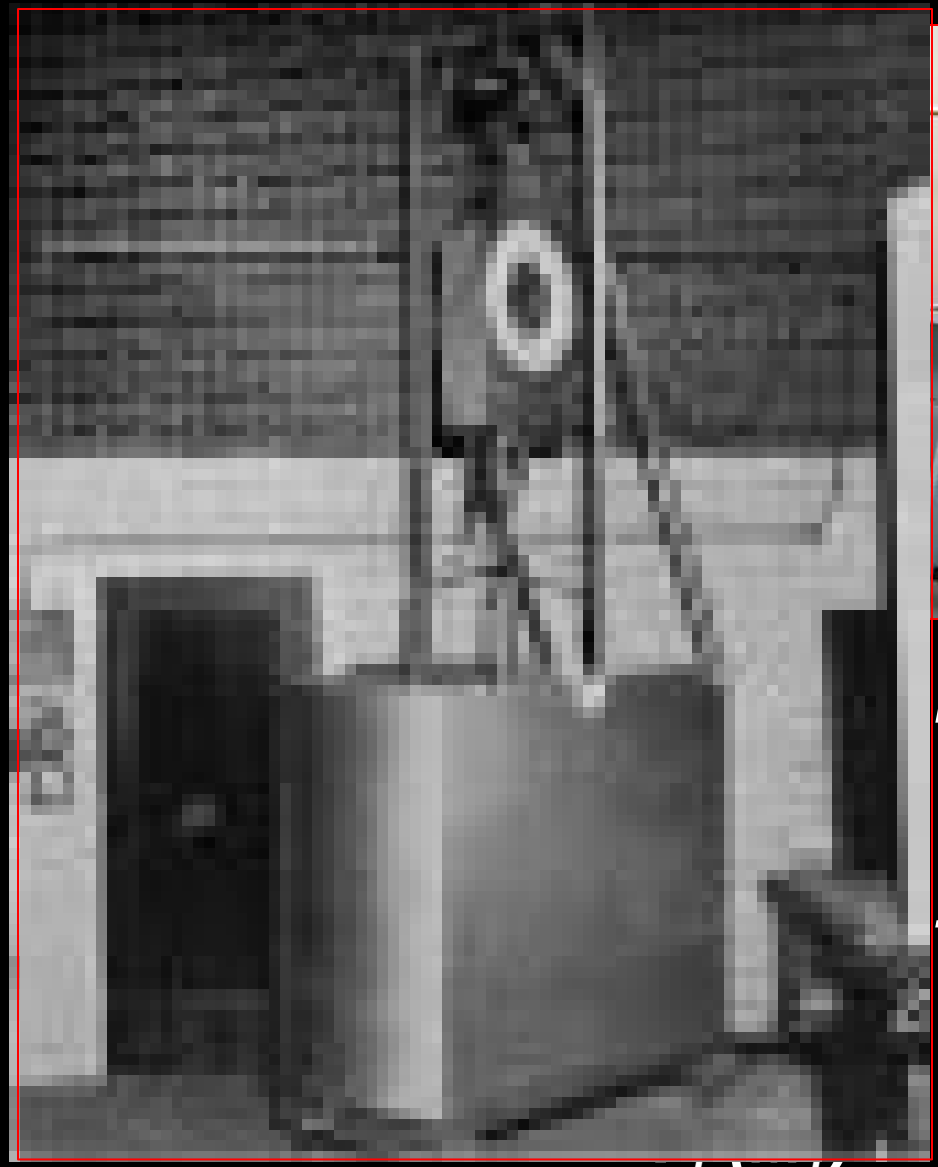
Energy Input = *How much does the person eat?*

Energy Output = How much energy does the person expend?

Energy Storage = How much weight does the person lose?

$$d(\rho W)/dt = I - E$$

Two-Compartment Body Density Model - 1942

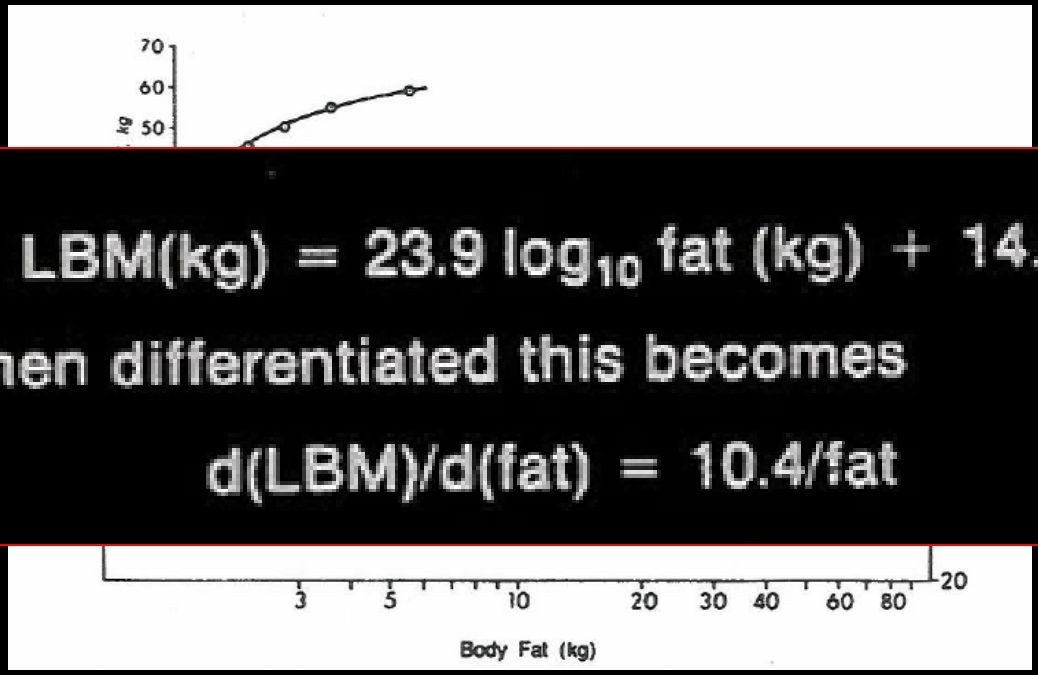


Lean Body Mass-Body Fat Interrelationships in Humans

Gilbert B. Forbes, MD

Lean and fat compartments of the body are companions. Dietary alterations induce changes in both compartments.

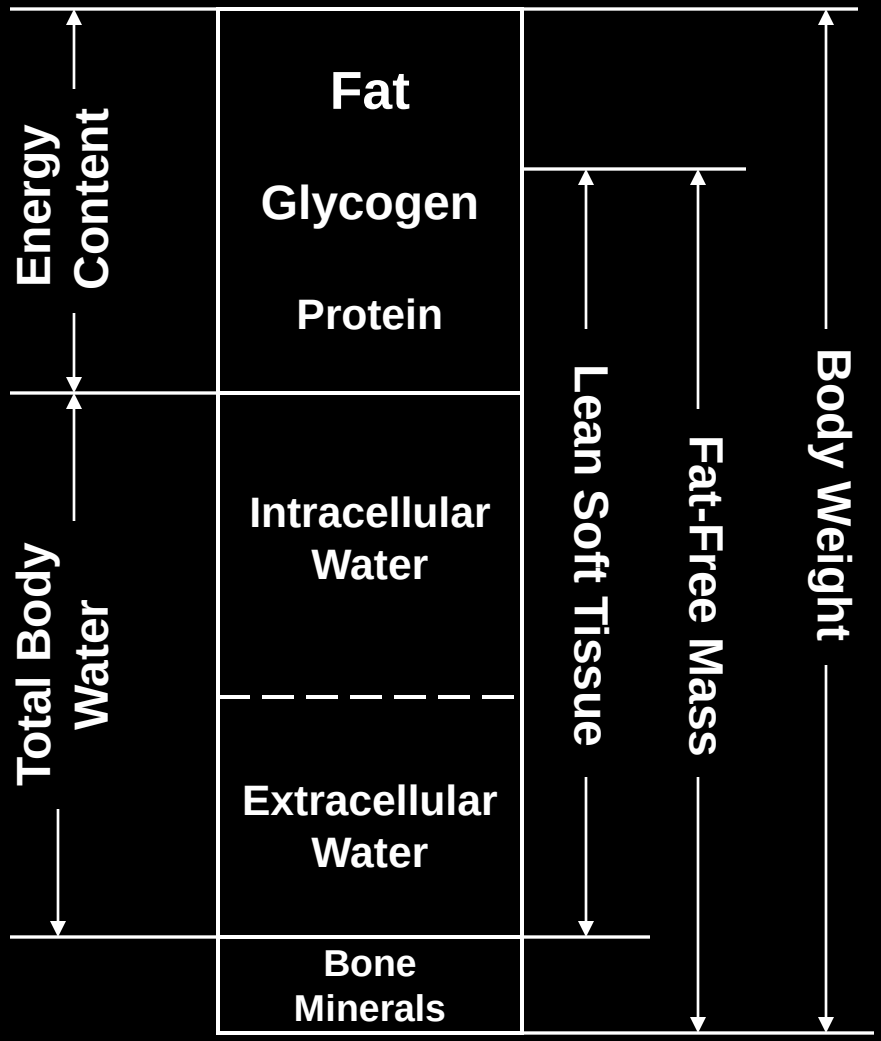
1987

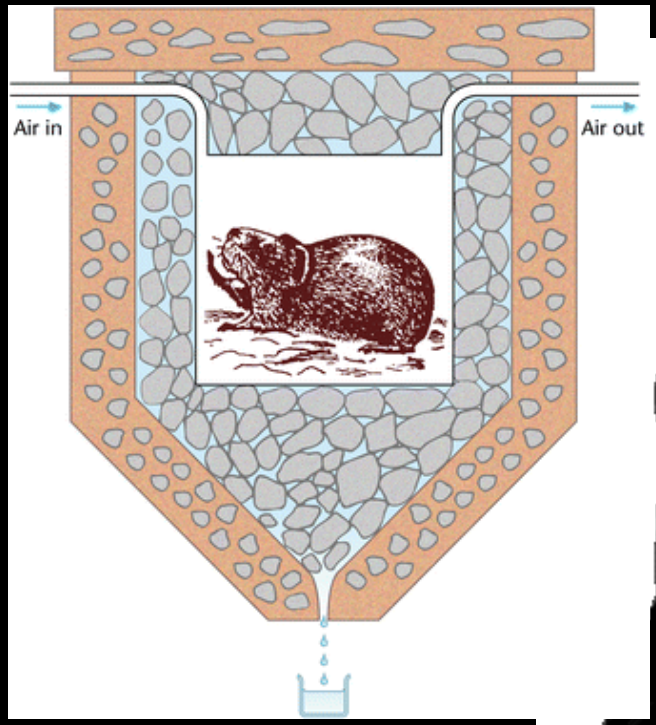


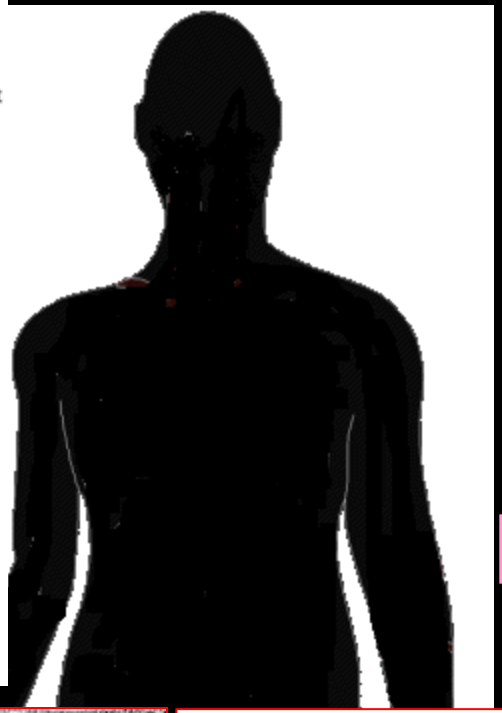
$$LBM(kg) = 23.9 \log_{10} fat\ (kg) + 14.2 \quad (i)$$

When differentiated this becomes

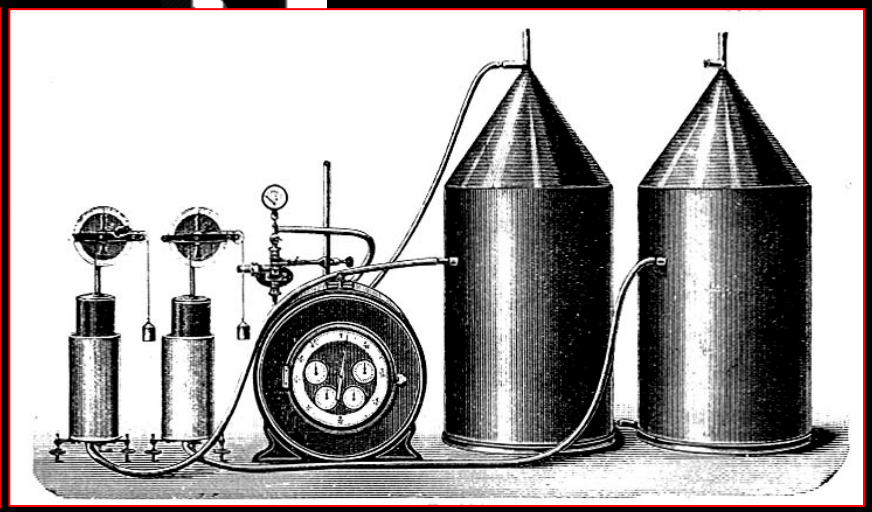
$$d(LBM)/d(fat) = 10.4/fat \quad (ii)$$


Fat
Glycogen
Protein
Intracellular Water
Extracellular Water
Bone Minerals
Energy Content
Total Body Water
Lean Soft Tissue
Fat-Free Mass
Body Weight





CO_2
+
H_20
+
Urea

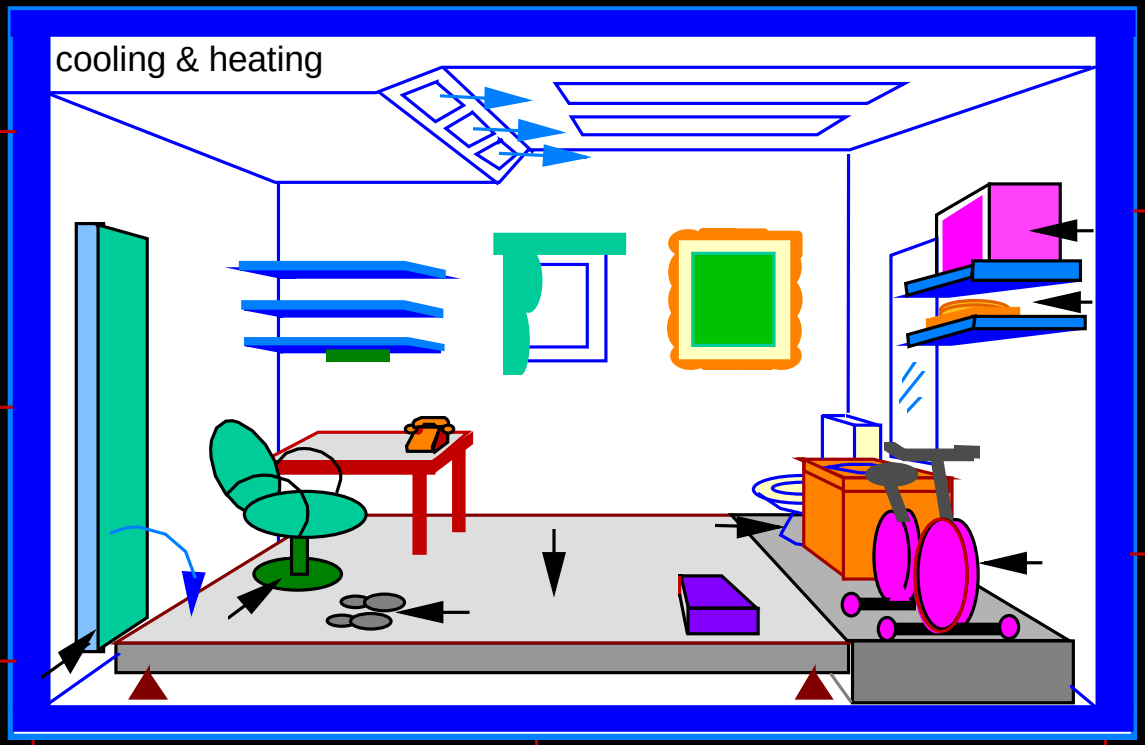


Energy Expenditure Evaluated in Respiratory Chamber

environ-
ment
control
& moni-
toring

measure-
ment &
calibration
instru-
ments

noise
filtering
& alarm



sensors
for chair,
mattress,
commode,
bike, food,
scale, TV,
standing

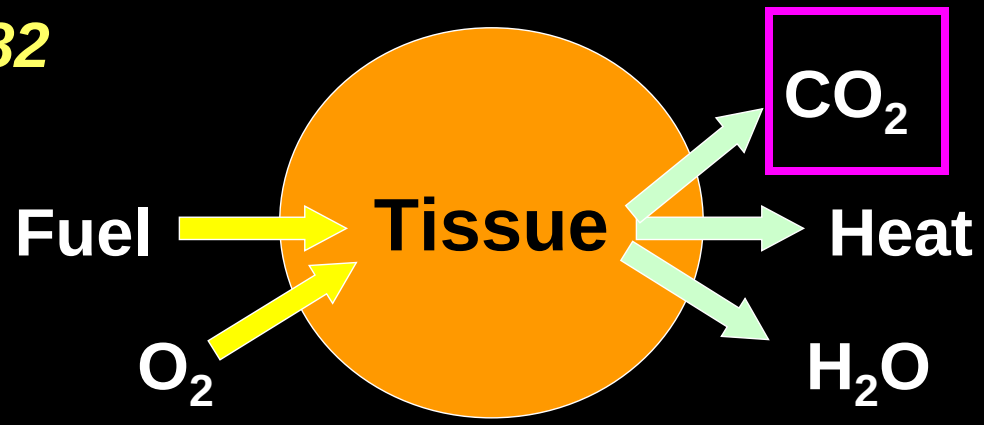
event
recordings
for meal,
exercise,
sleep,BMR,
standing,
biking

EE & RQ measurement system

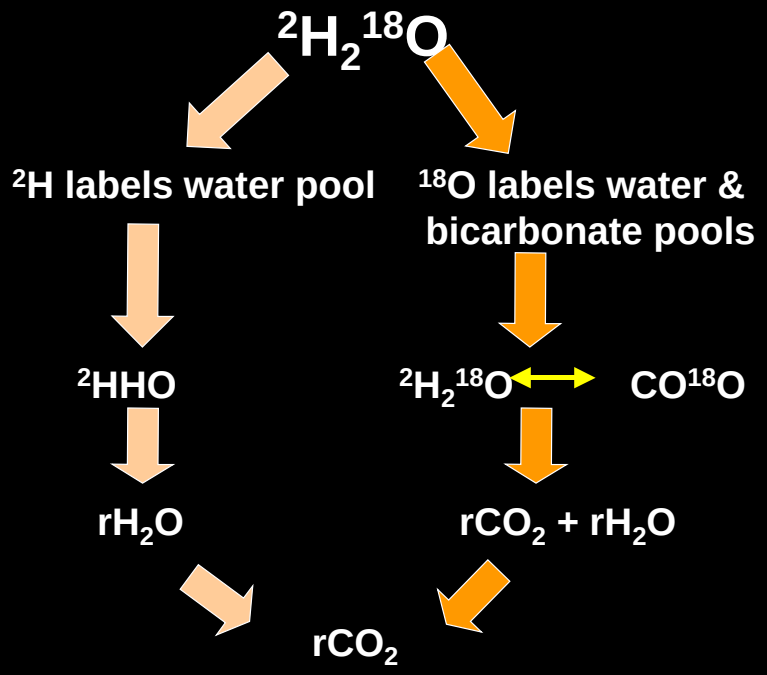
physical activity & exercise measurement system

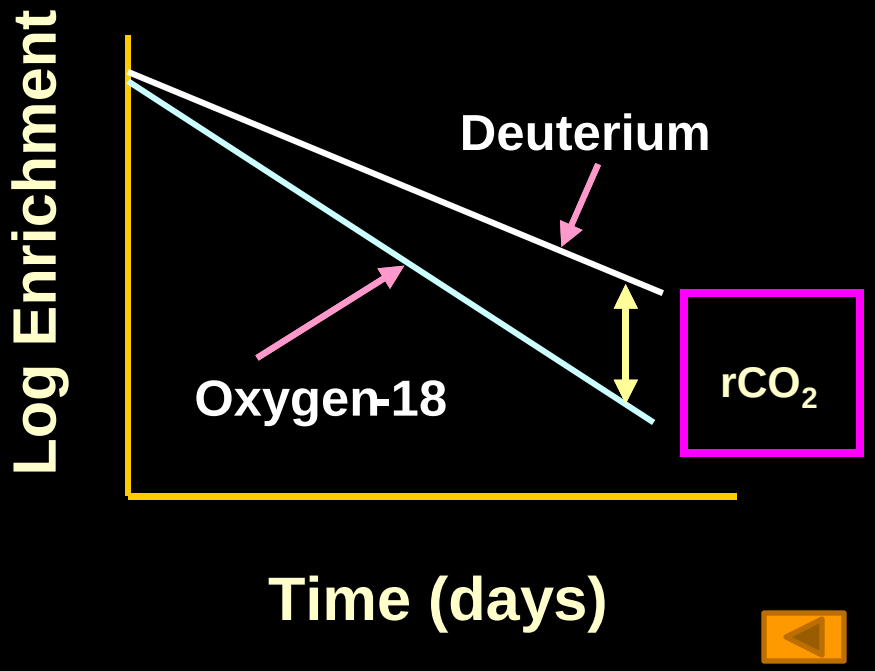
behavior monitoring system

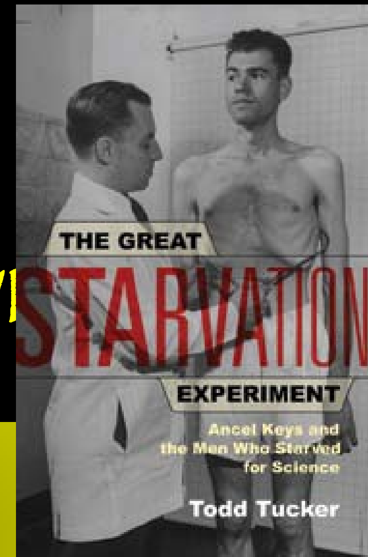
Schoeller, 1982



H_2O
$^2H_2{}^{18}O$







1

1920

1940

1960

1980

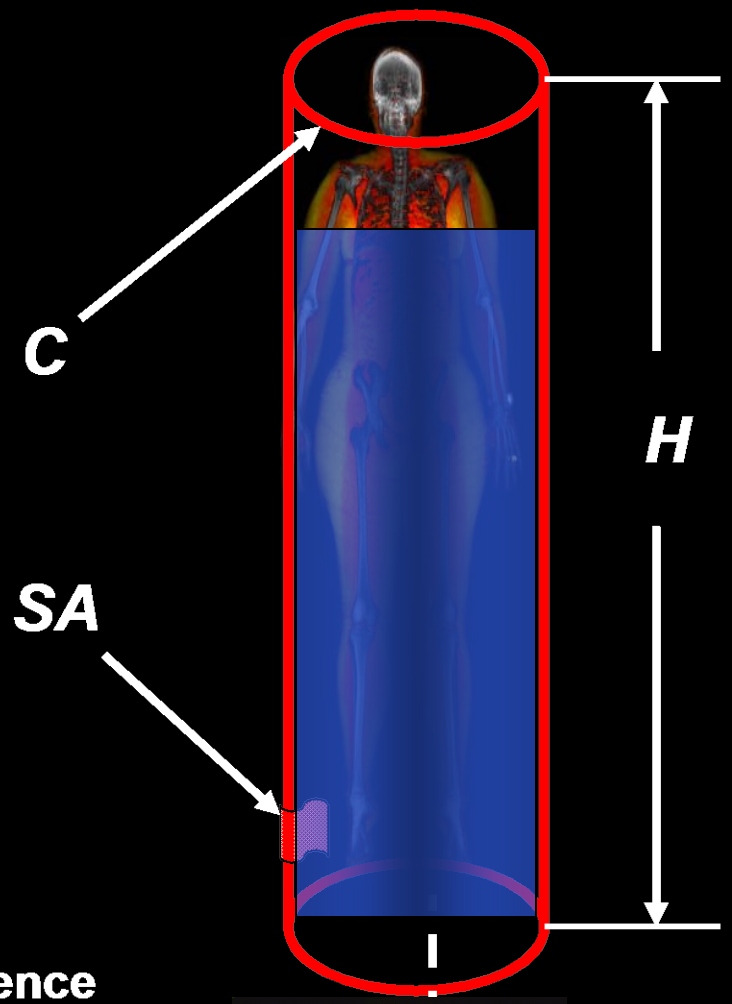
1990

2000

2010

2020

Rubner's Surface Area Law - 1883



$EE \propto SA$

$EE \propto M^{0.66}$

C, circumference
H, height
M_T, total mass
SA, Surface Area
V_T, total volume

A STUDY OF PROLONGED FASTING

BY

FRANCIS GANO BENEDICT

WASHINGTON, D. C.
PUBLISHED BY THE CARNEGIE INSTITUTION OF WASHINGTON
1915

- Luciani & Bufalini: “equilateral hyperbola”

- Benedict and EH Lange

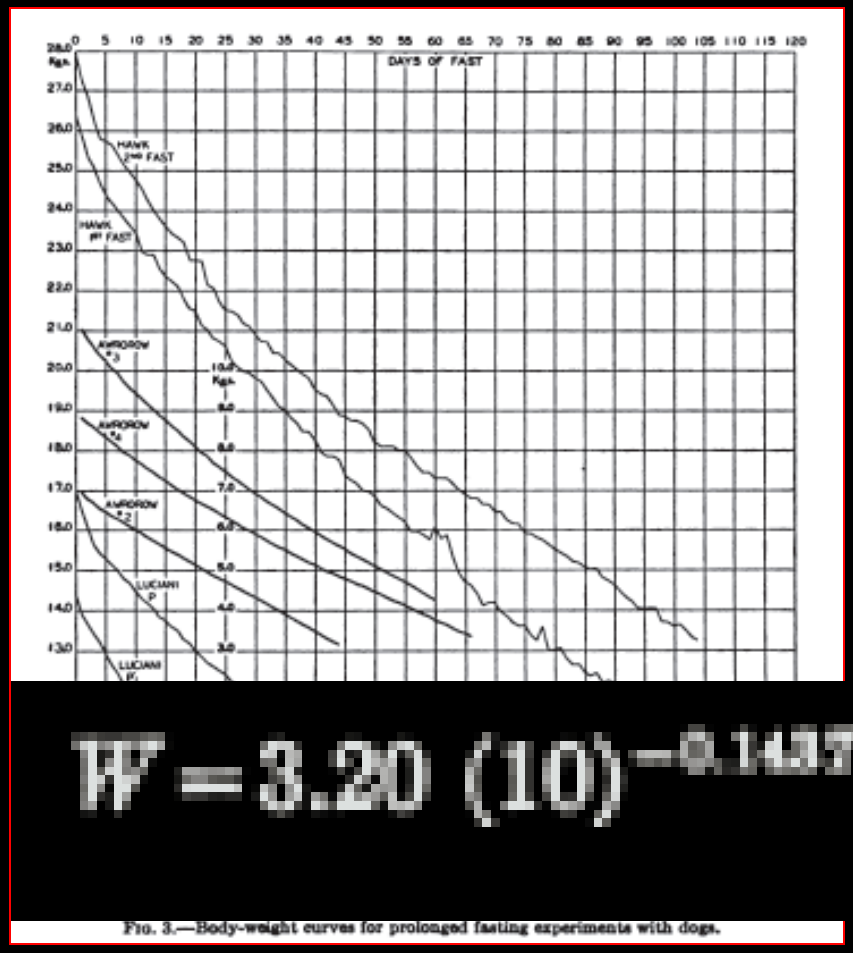


Fig. 3.—Body-weight curves for prolonged fasting experiments with dogs.

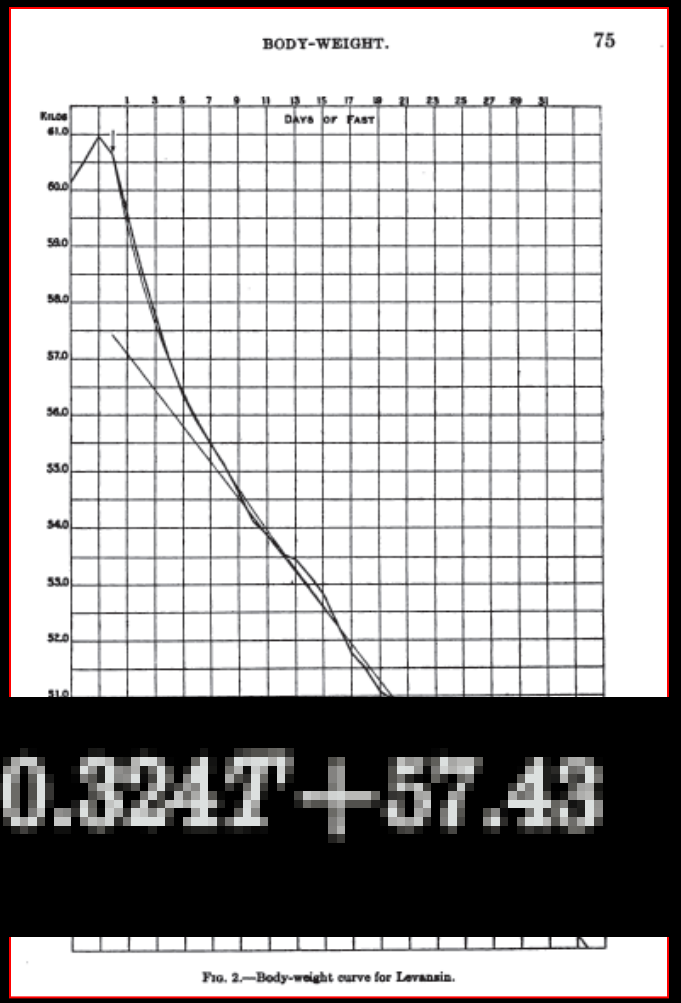
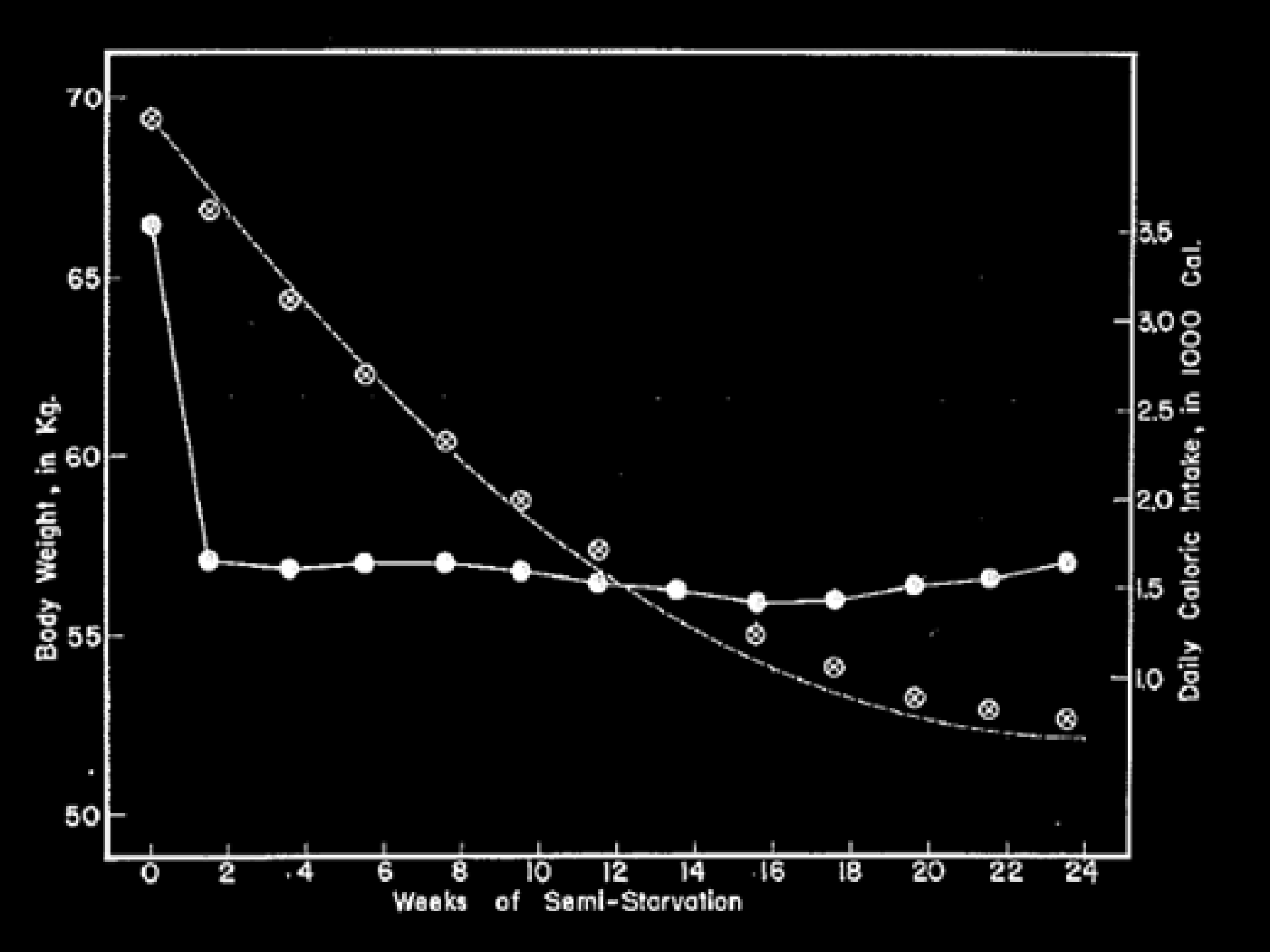


Fig. 2.—Body-weight curve for Levansin.

$$W = 3.20\ (10)^{-0.143T} - 0.324T + 57.43$$


70
65
60
55
50
Body Weight, in Kg.
3.5
3.0
2.5
2.0
1.5
1.0
Daily Caloric Intake, in 1000 Cal.
0
2
4
6
8
10
12
14
16
18
20
22
24
Weeks of Semi-Starvation

Wishnofsky's Rule: 1958

Caloric Equivalents of Gained or Lost Weight

MAX WISHNOFSKY, M.D.

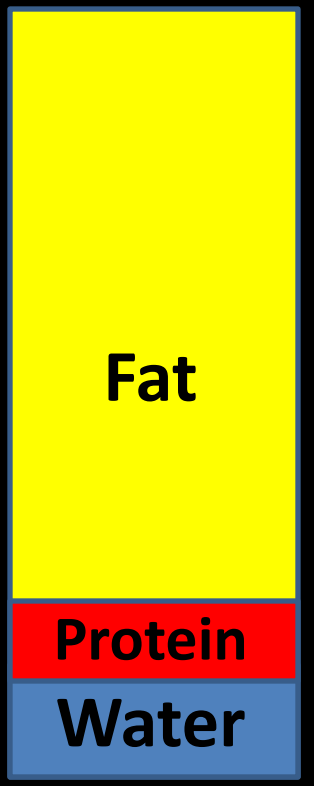
WHAT is the caloric equivalent of one pound of body weight, gained or lost? To put the question in other words: How many calories in excess of the amount necessary to maintain caloric equilibrium will produce a gain of

obese patients under the especially rigid conditions of the metabolic service for an average period of 59 days. The average diet provided 58 g of protein, 14 g of carbohydrate, and 8 g of fat, with a total value of 360 cal. They state:

pound of body weight lost. The conclusion can be drawn that 3,500 is the caloric value of one pound of body weight lost.

$$\Delta W = W_0 - \Delta EI \times (1/3500) \times T$$

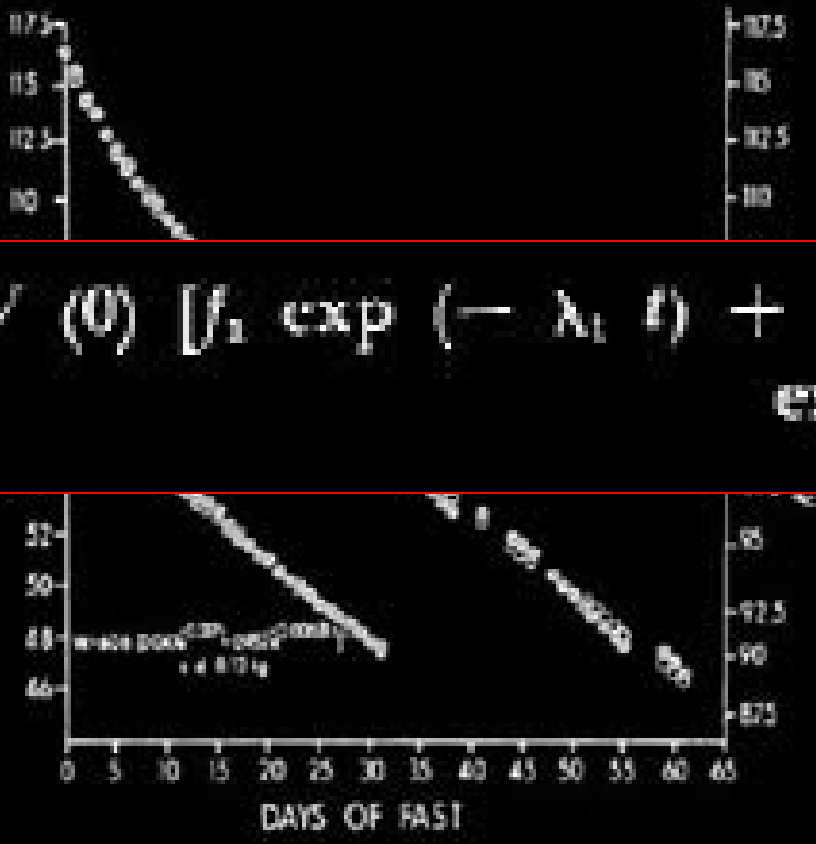
ADIPOSE TISSUE



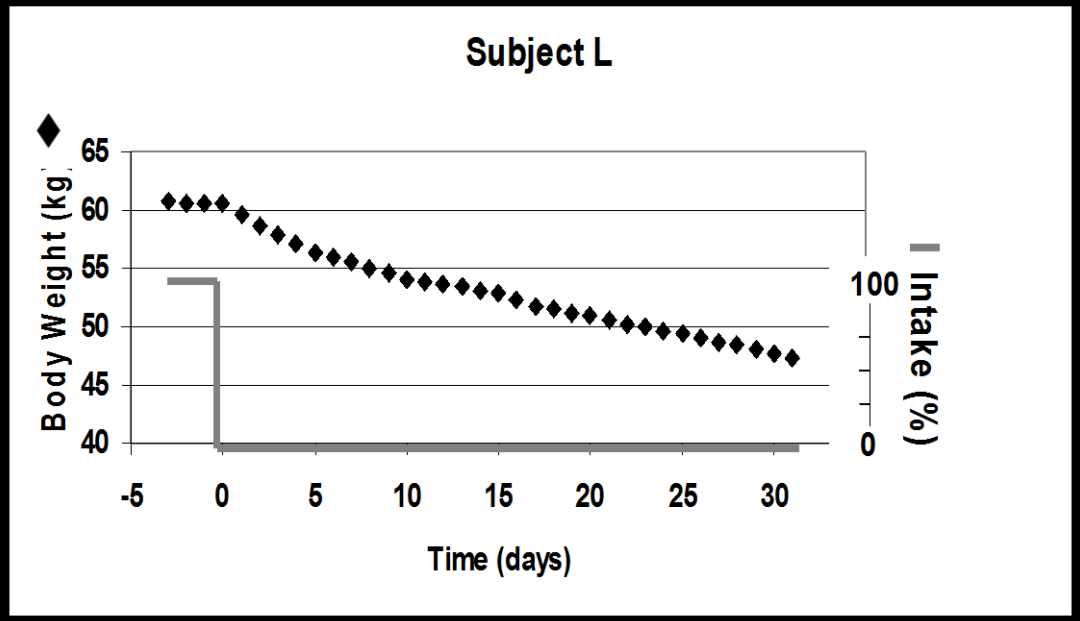
Weight Loss during Fasting: Implications for the Obese[1,2]

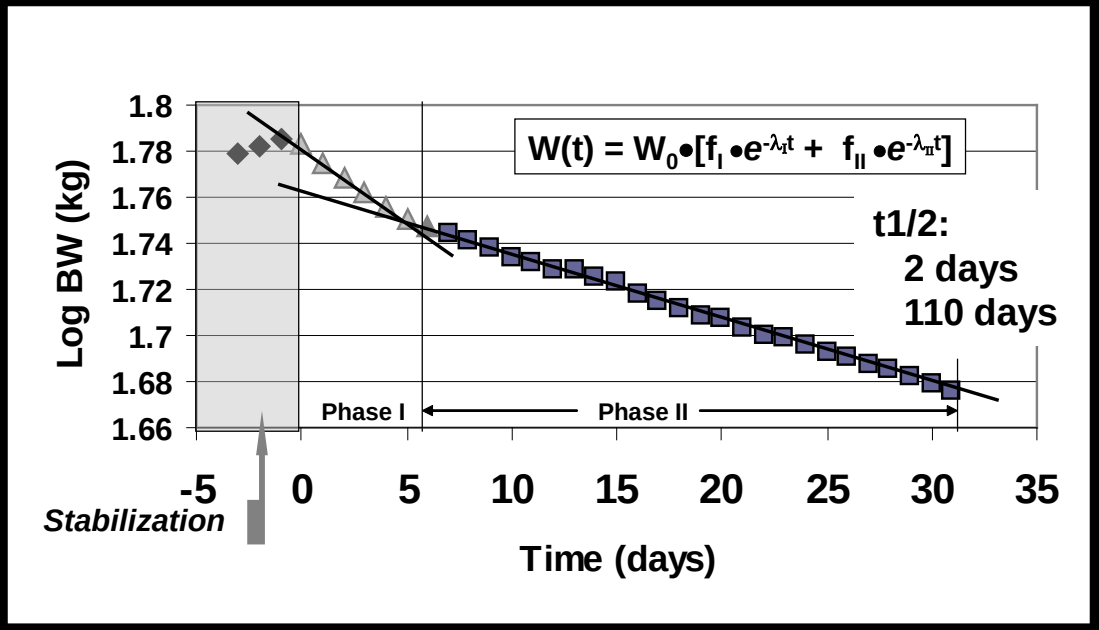
GILBERT B. FORBES,[3] M.D.

1970

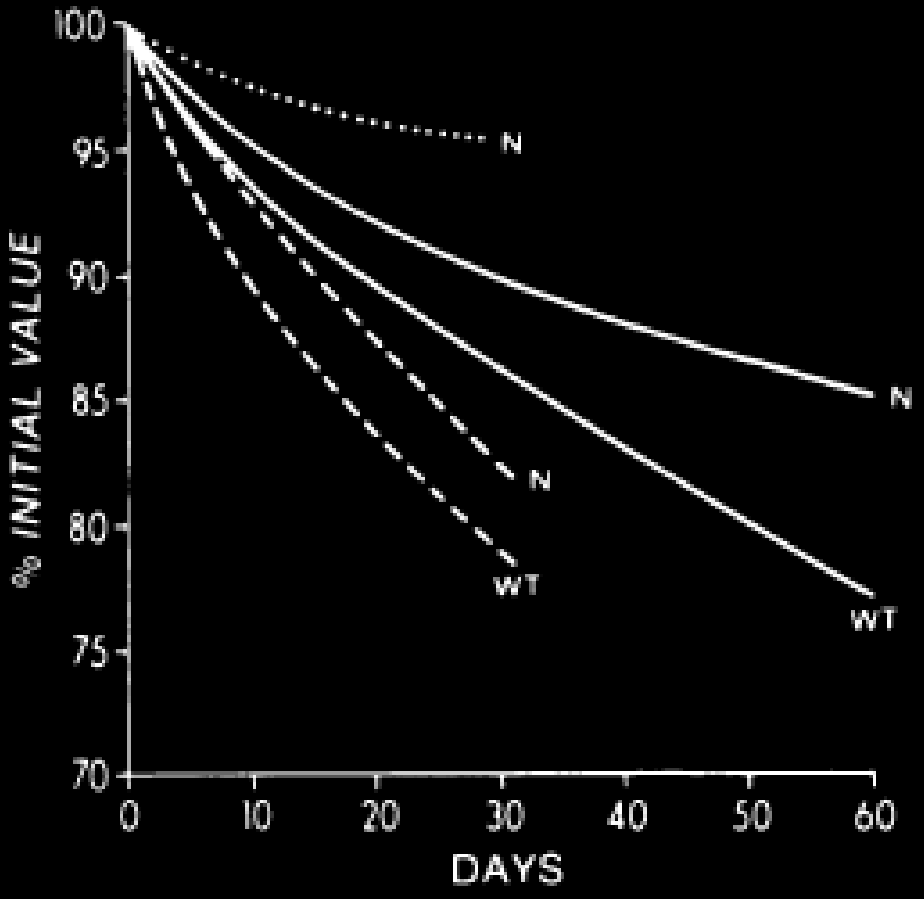


$$W(t) = W(0)\,[f_1 \exp(-\lambda_1 t) + f_2 \exp(-\lambda_2 t)]$$

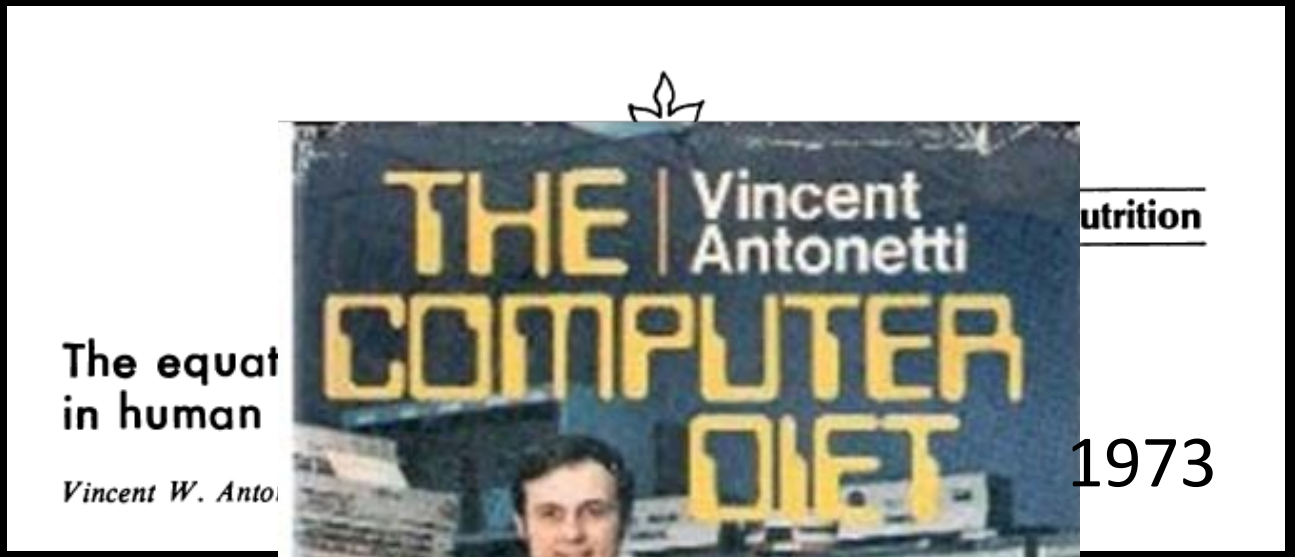

Subject L
Body Weight (kg)
65
60
55
50
45
40
100
0
Intake (%)
-5
0
5
10
15
20
25
30
Time (days)


Log BW (kg)
1.8
1.78
1.76
1.74
1.72
1.7
1.68
1.66
W(t) = W0•[fI •e-λIt + fII •e-λIIt]
t1/2:
2 days
110 days
Phase I
Phase II
-5
0
5
10
15
20
25
30
35
Stabilization
Time (days)

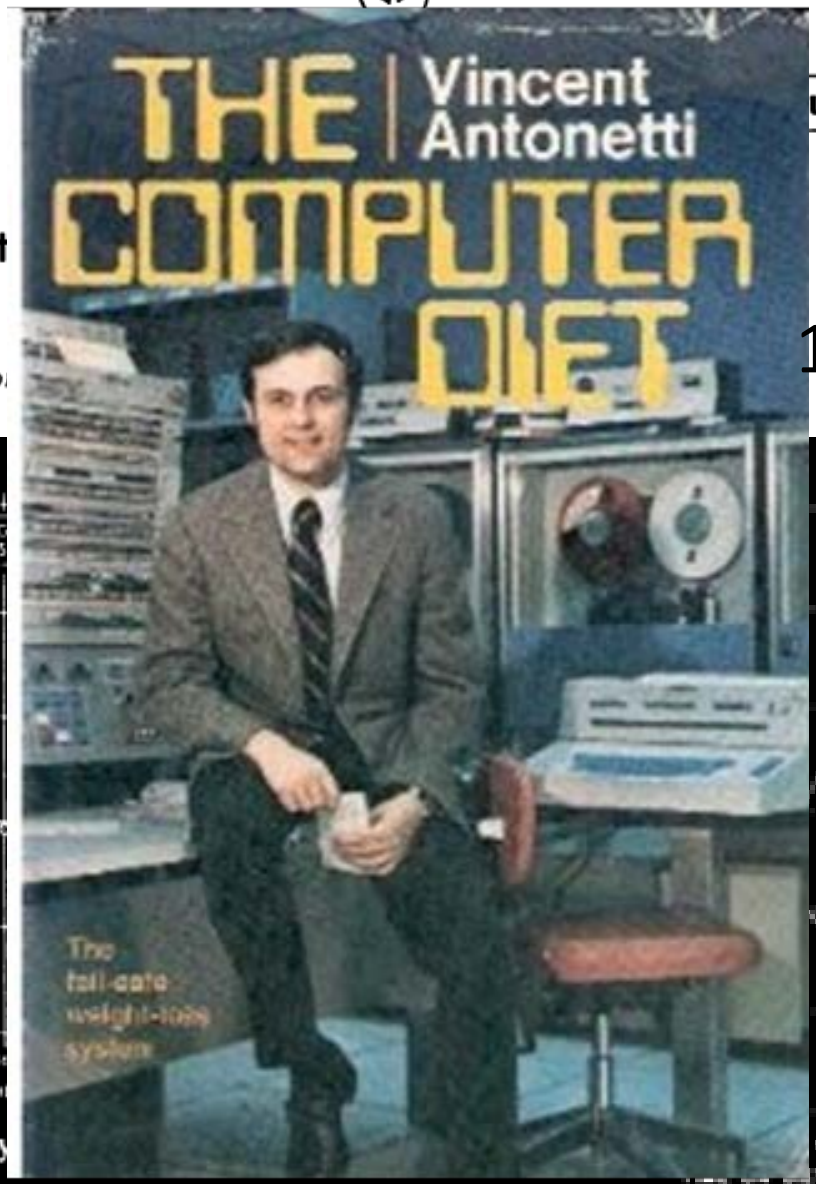
Protein Loss During Fasting



$$N(t) = N(0)[F_1 \exp(-\lambda_1 t) + F_2 \exp(-\lambda_2 t)]$$



1973



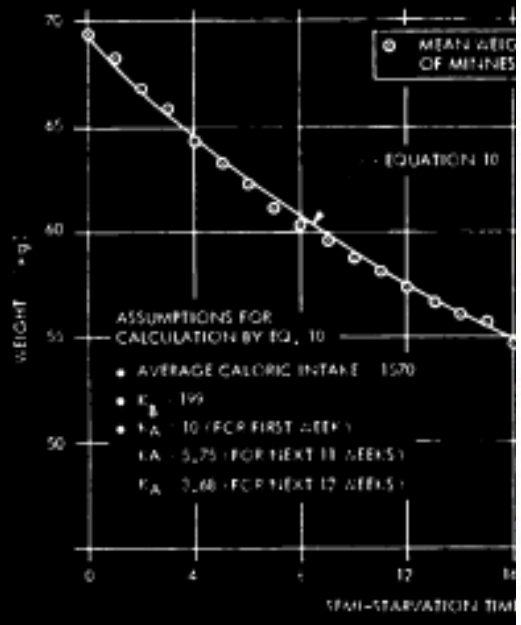


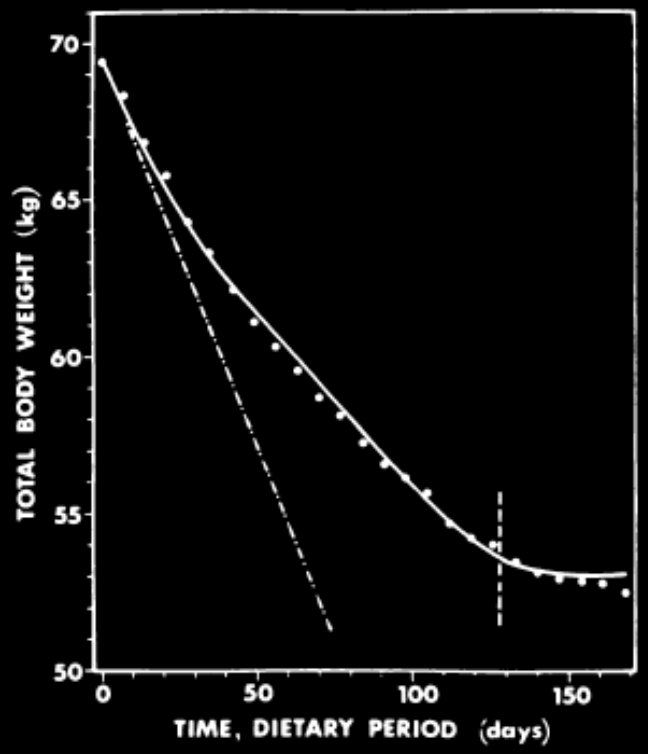
FIG. 5. Comparison of theory
experiment of Keys et al. (14).

perspectives in nutrition

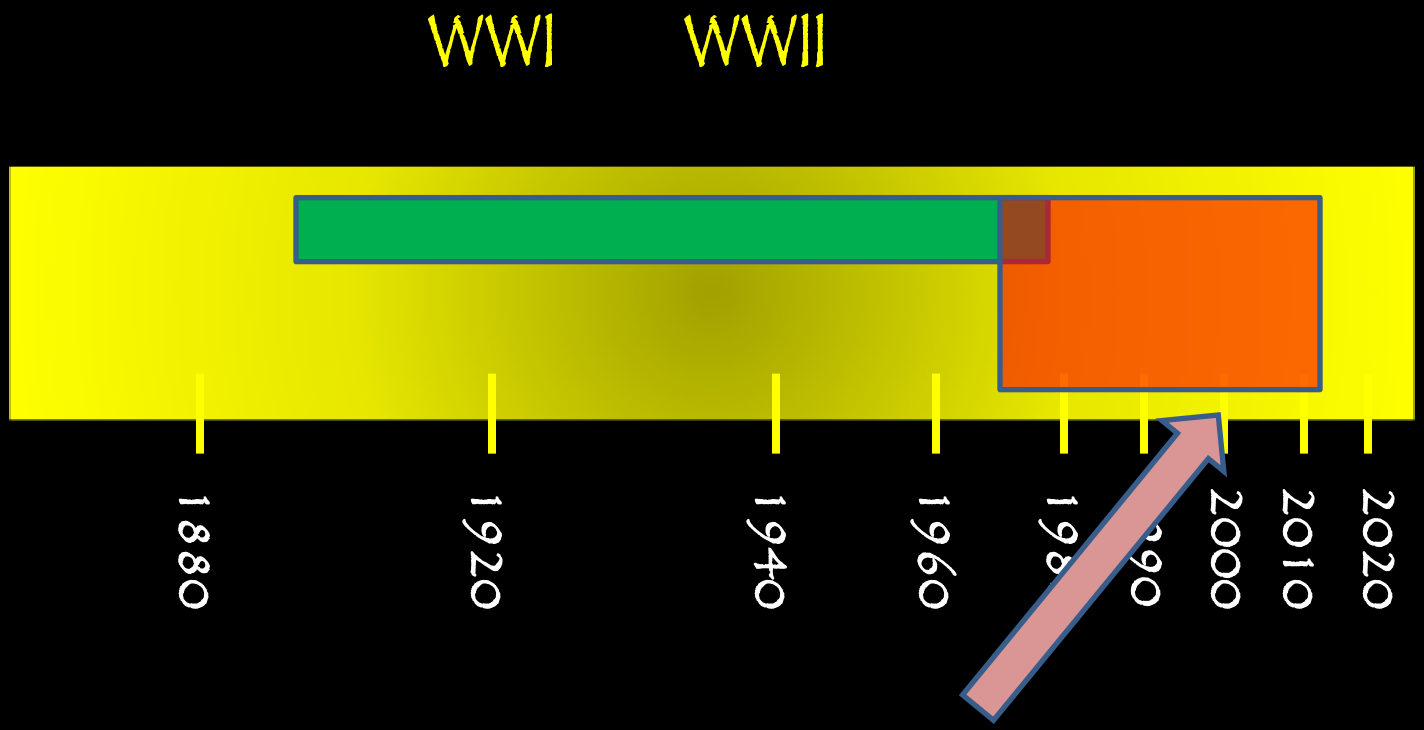
A two-reservoir energy model of the human body[1]

Seymour S. Alpert, Ph.D.

1979



$$\alpha\, df/dt + \beta\, dl/dt = \epsilon P - BMR(l) - W - \delta(f + l)$$



The quality of a scientific field depends on how well the mathematical models developed on the theoretical side agree with results of repeatable experiments.

Lack of agreement between theoretical mathematical models and experimental measurements often leads to important advances as better theories are developed.