Northeastern

Introduction to System Dynamics

Healthcare Systems Engineering Institute

Northeastern University, Boston, MA

06/11/2015

www.hsye.org

Center for Medicare & Medicaid INNOVATION

CHOT Center for Health Organization Transformation

VERC New England Veterans Engineering Resource Center

HSyE

System Dynamics

A modeling and simulation approach to understand the behaviors of complex dynamic systems

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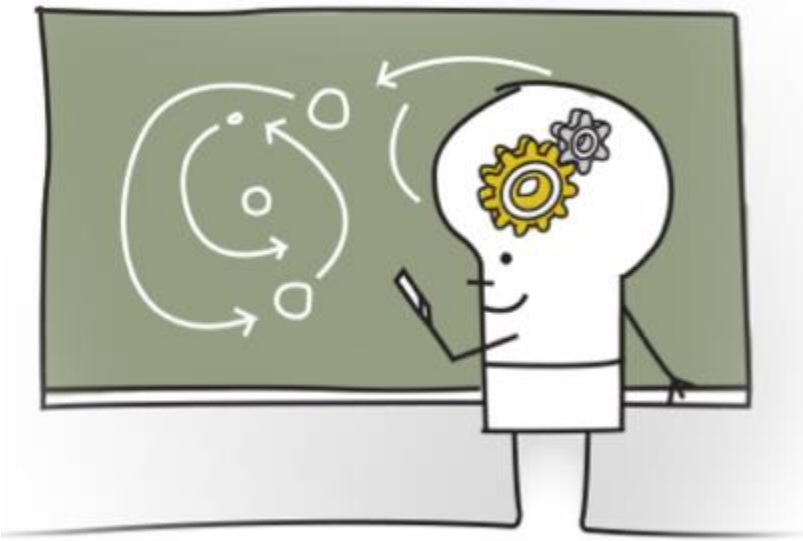
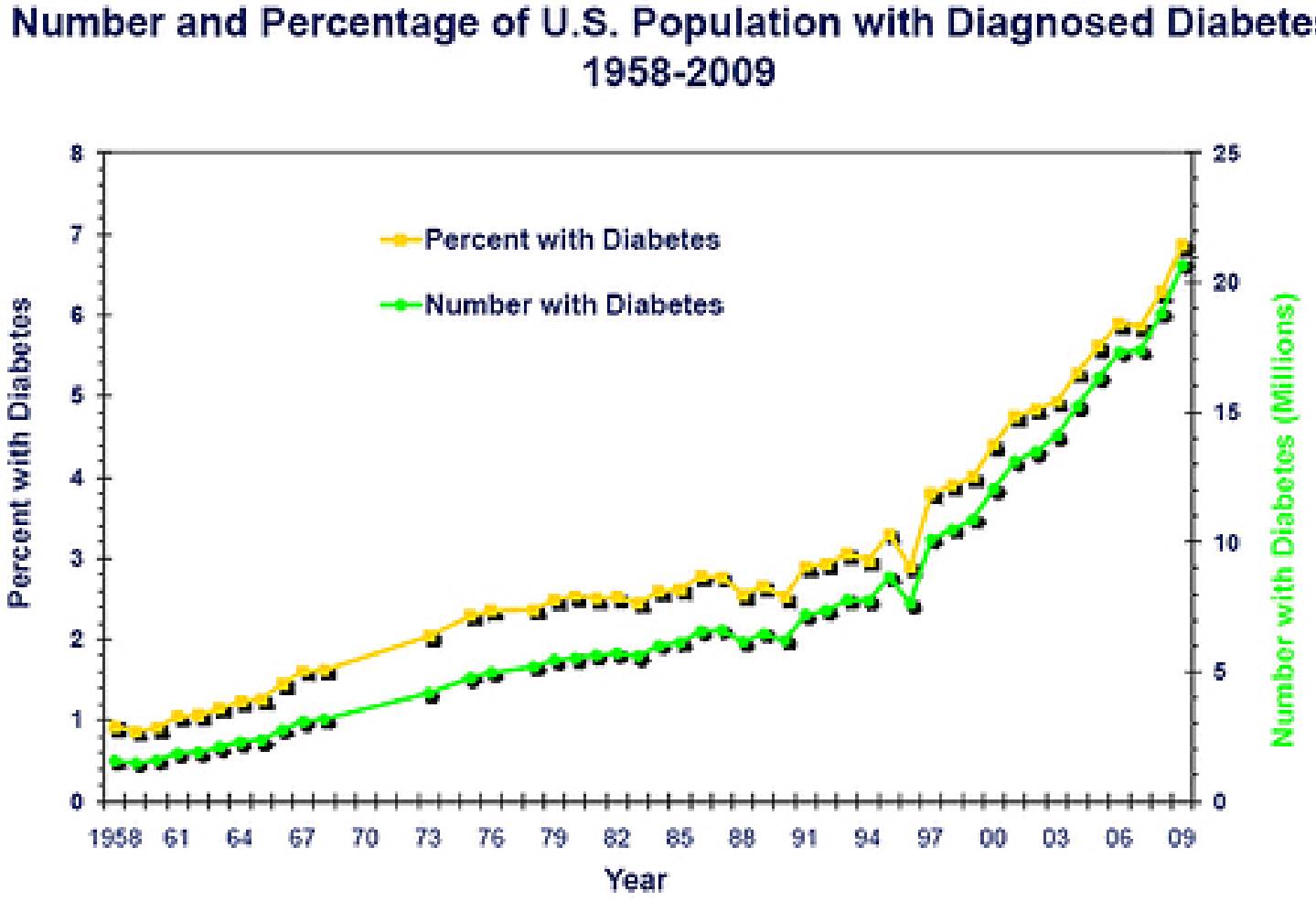
A modeling and simulation approach to understand the behaviors of complex dynamic systems



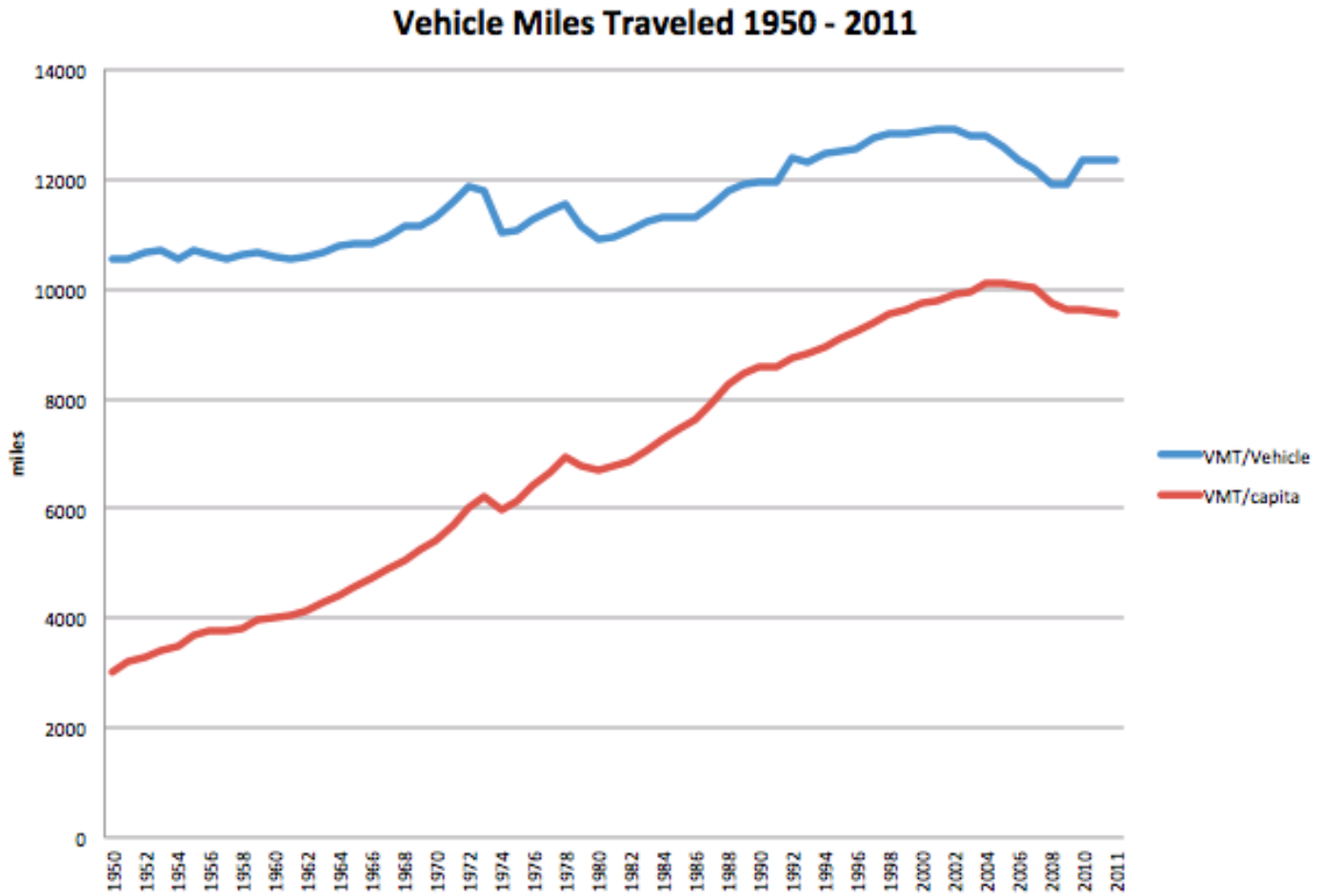
Example Problems

- Healthcare



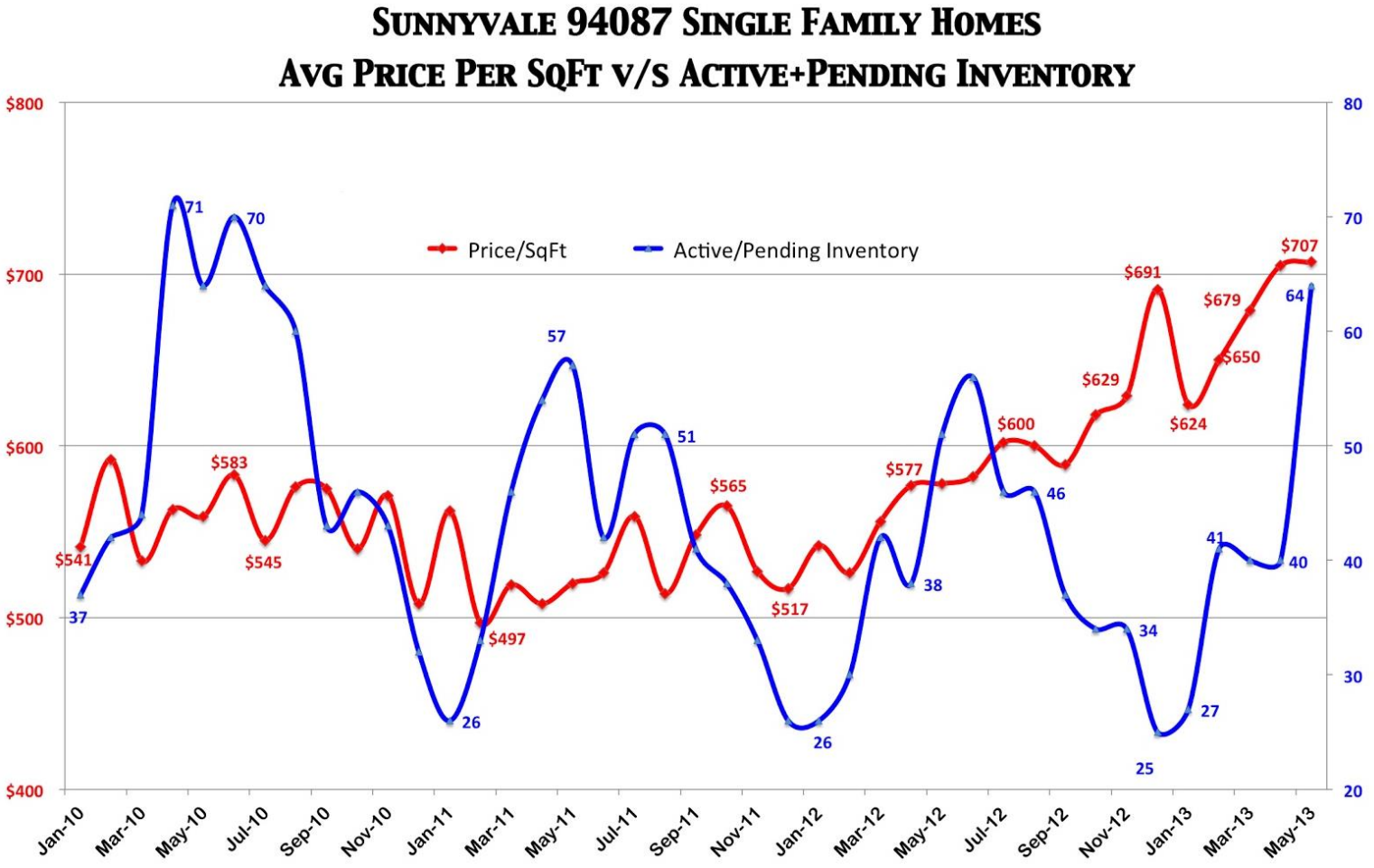
Example Problems

- Energy



Example Problems

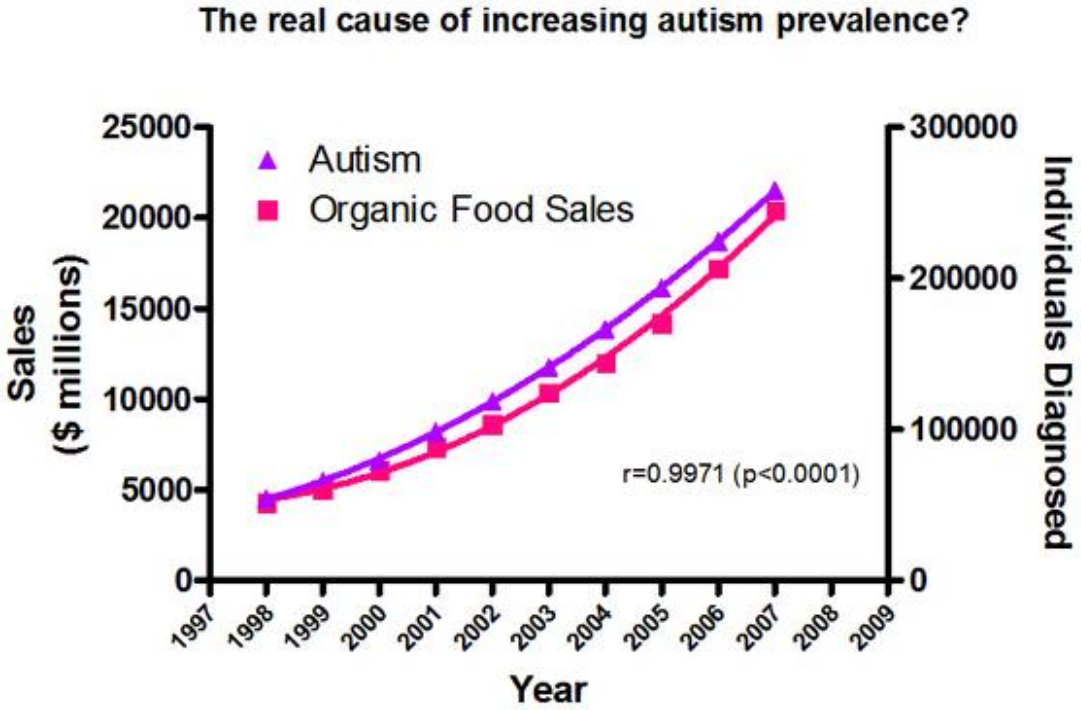
- Business



Principles of Systems Thinking

1. Direct Causality

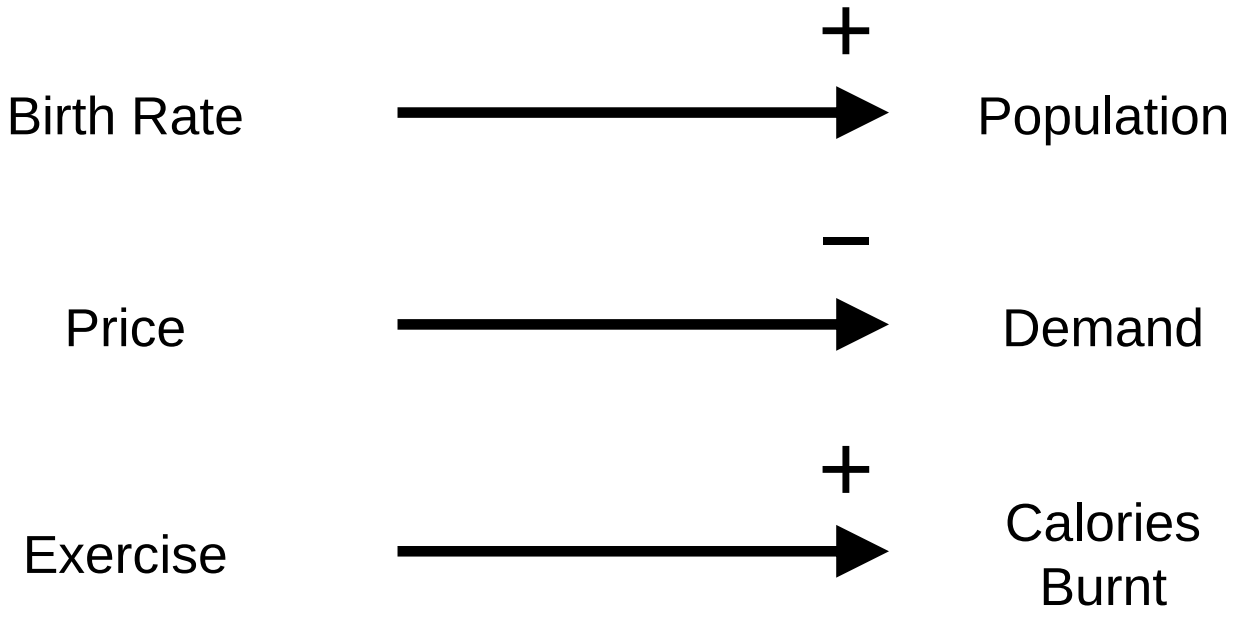
   As opposed to mere correlation



Eating Organic Food → (+) Autism

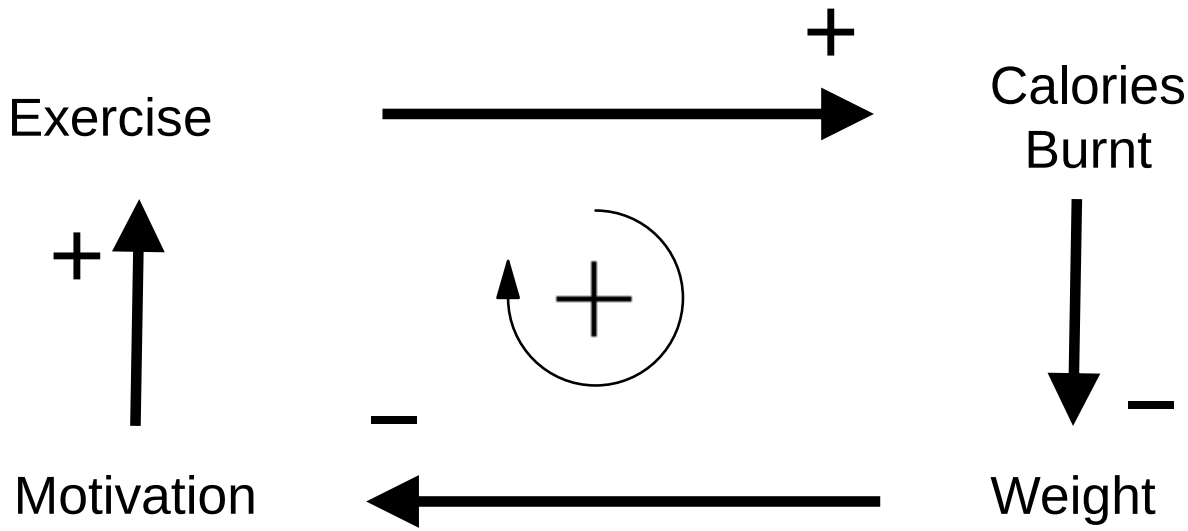
Principles of Systems Thinking

1. Direct Causality



Principles of Systems Thinking

1. Direct Causality
2. Circular Causality



Principles of Systems Thinking

1. Direct Causality
2. Circular Causality
3. Endogenous Focus

- Whole internal structure is the main cause of behavior, not some external forces

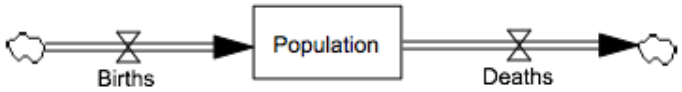
- Does not mean that external forces does not have influence

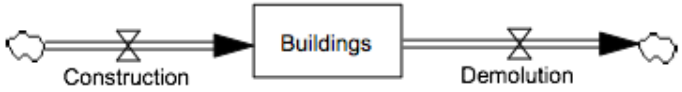
Stocks and Flows

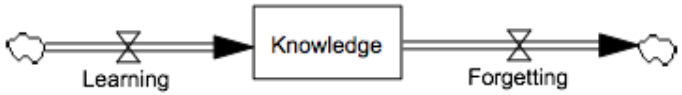
- Stocks: represent level of accumulations over time

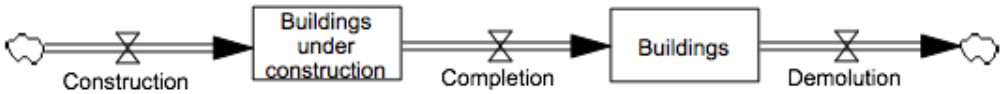
- Flows: represent the rate of change of stocks

Stock and Flow Examples









The Math Behind..

$$d/dt\ Stock = Inflow - Outflow$$

$$Stock(t) = Stock(t-dt) + dt*(Inflow(t) - Outflow(t))$$

Software

- Vensim
- STELLA
- PowerSim
- AnyLogic

Vensim Software

- Free download for educational purpose at

http://vensim.com/free-download/#current-version-63

- How to build a model on Vensim?

The Problem

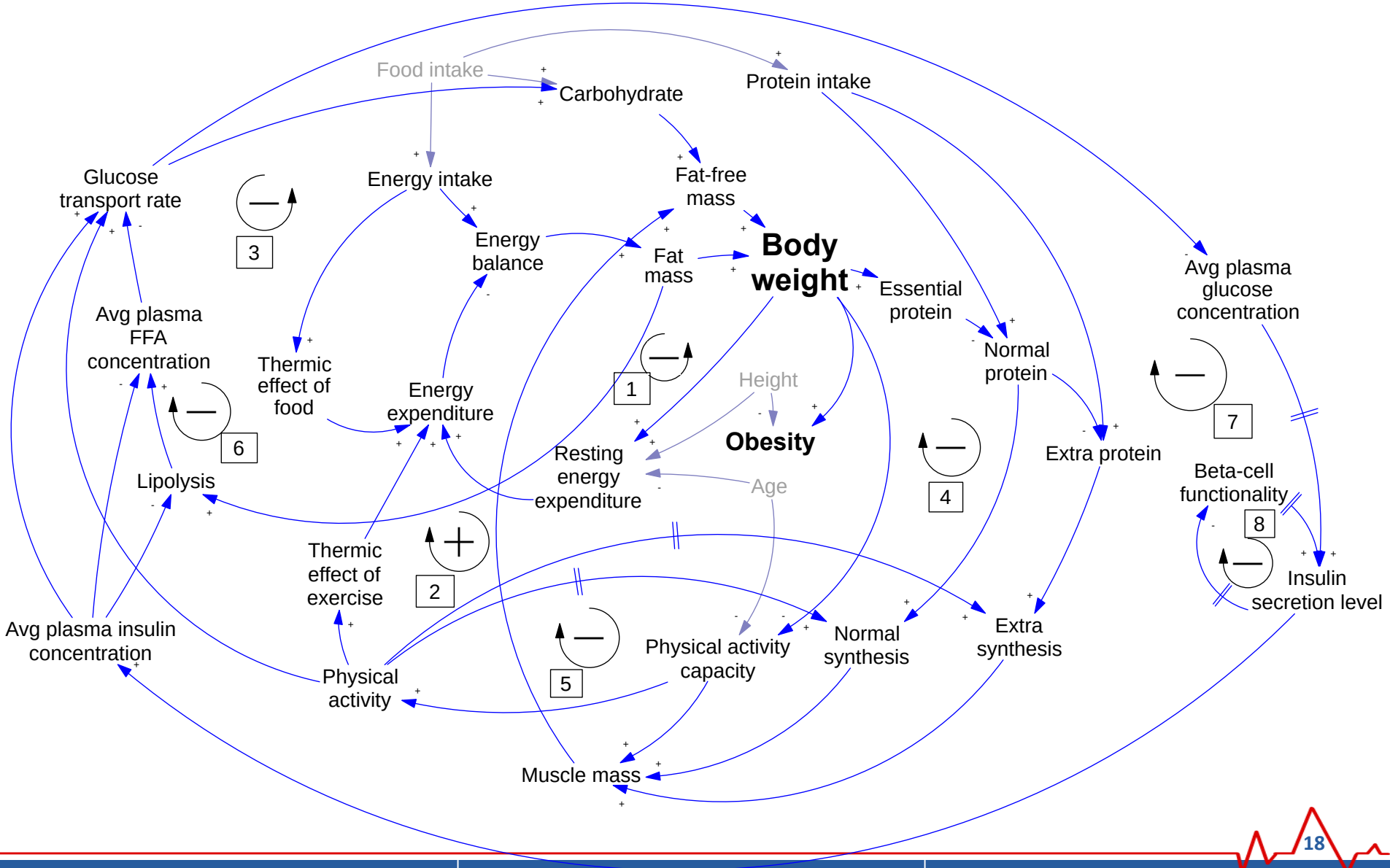
- An endangered rabbit population in an isolated island
- No arrivals/departs, births and deaths only
- No constraints (food, predator, etc.)

Sample Study

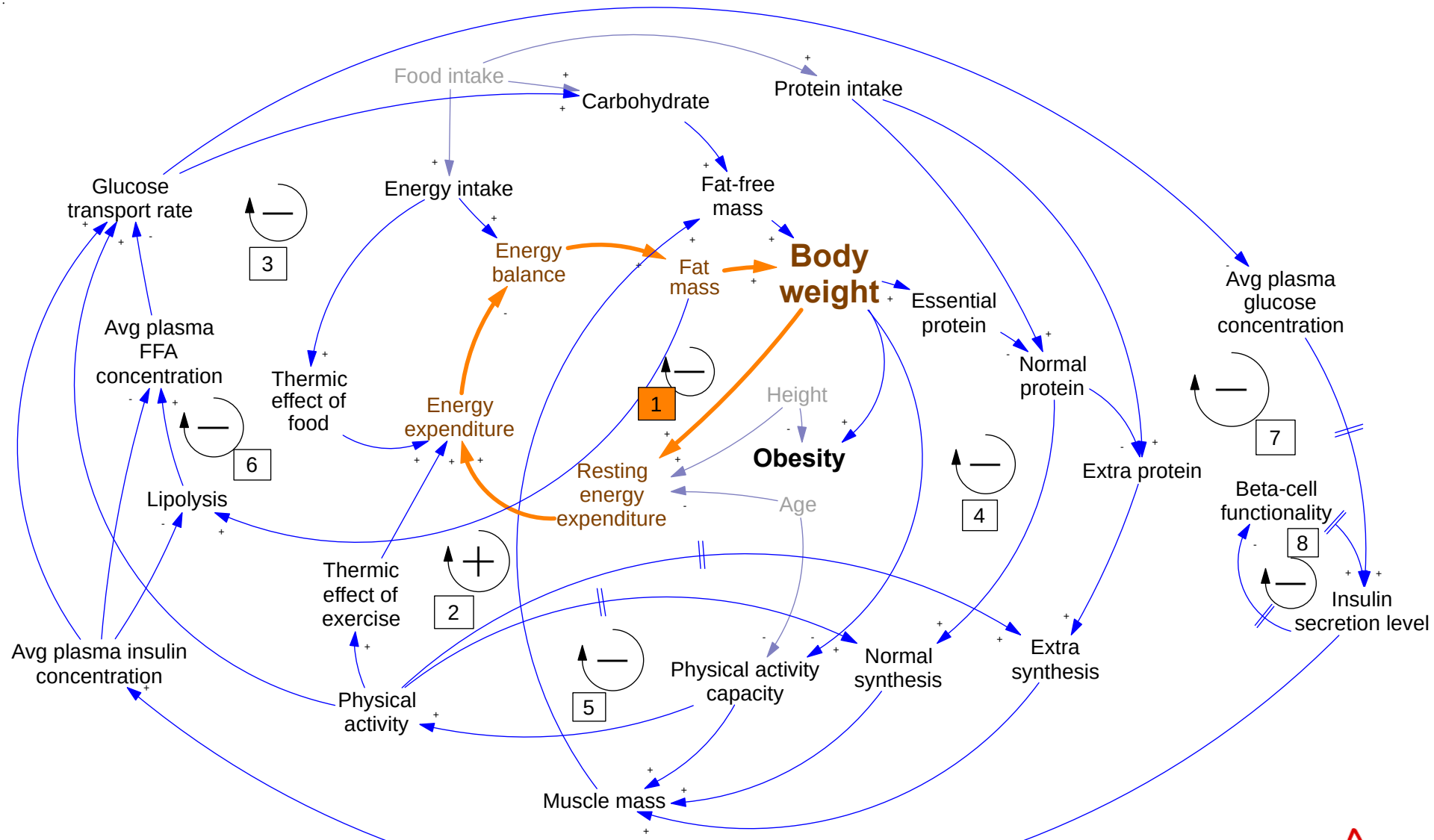
- Research Objective

Long-term dynamics of developing insulin resistance and type II diabetes with specific focus on obese people

Causal-Loop Diagram



Major Loops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Glucose transport rate
Energy intake
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3
Energy balance
Fat mass
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Essential protein
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Avg plasma FFA concentration
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Normal protein
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Obesity
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Beta-cell functionality
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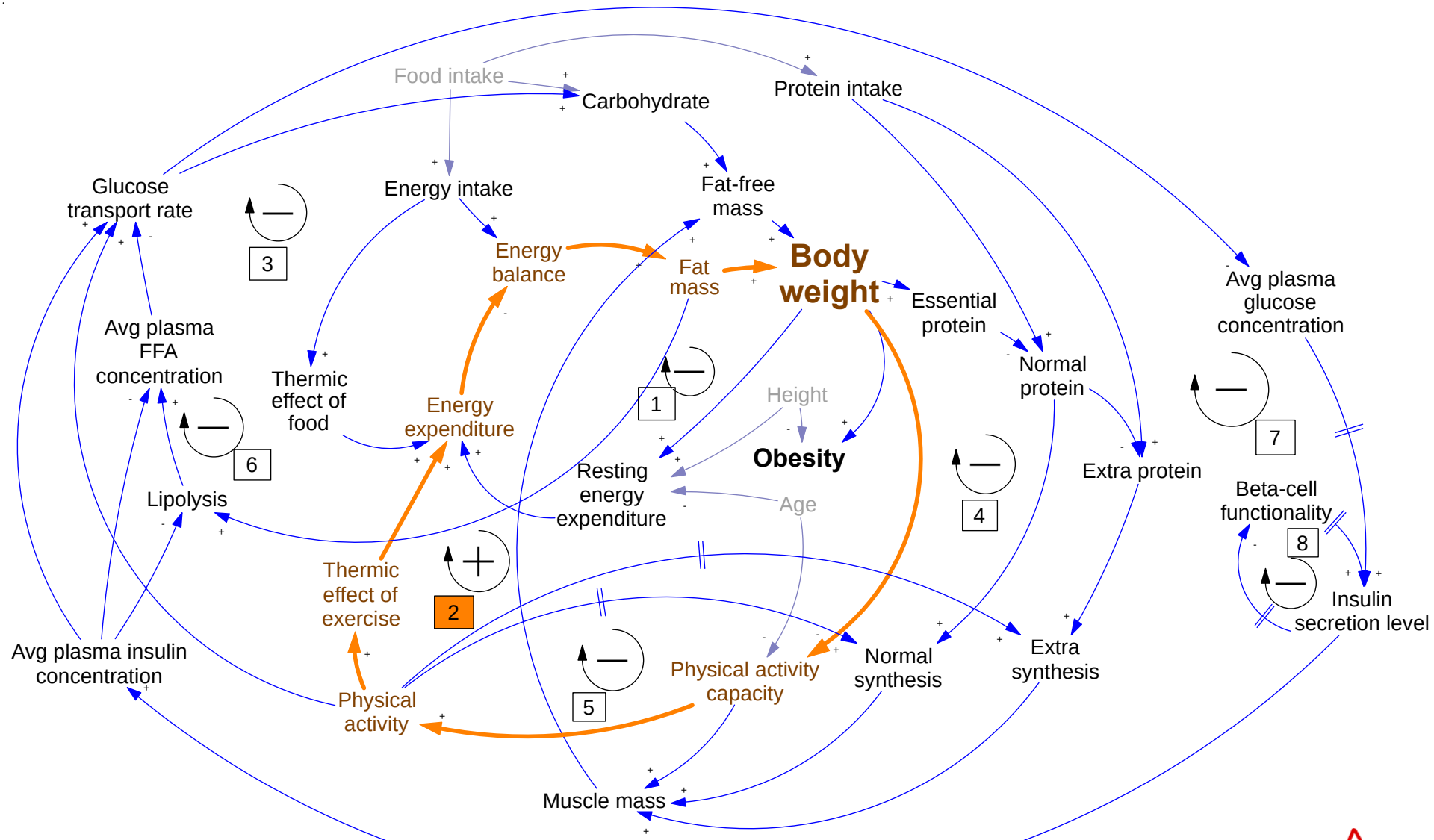
Extra synthesis
Muscle mass

Major Loops..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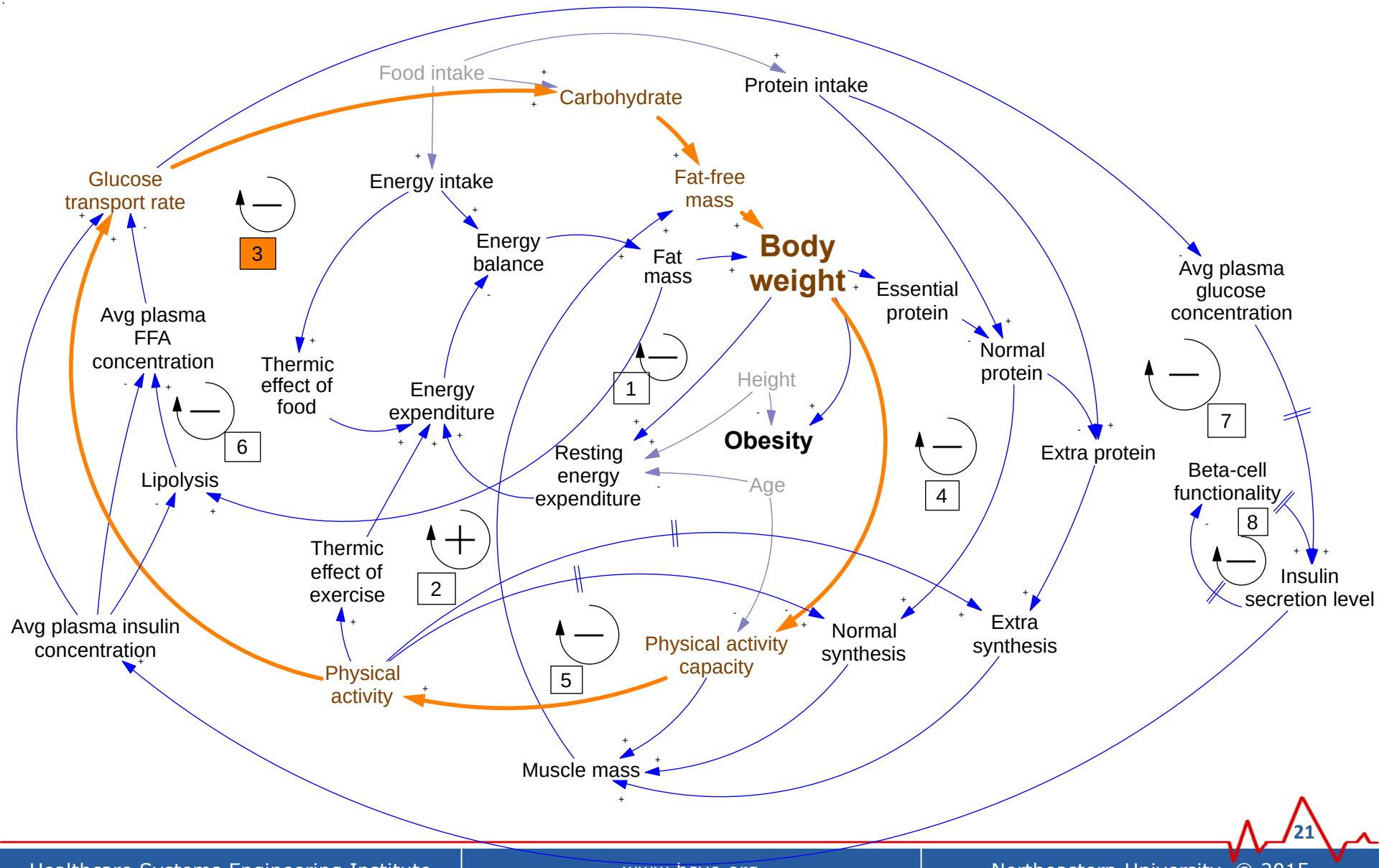
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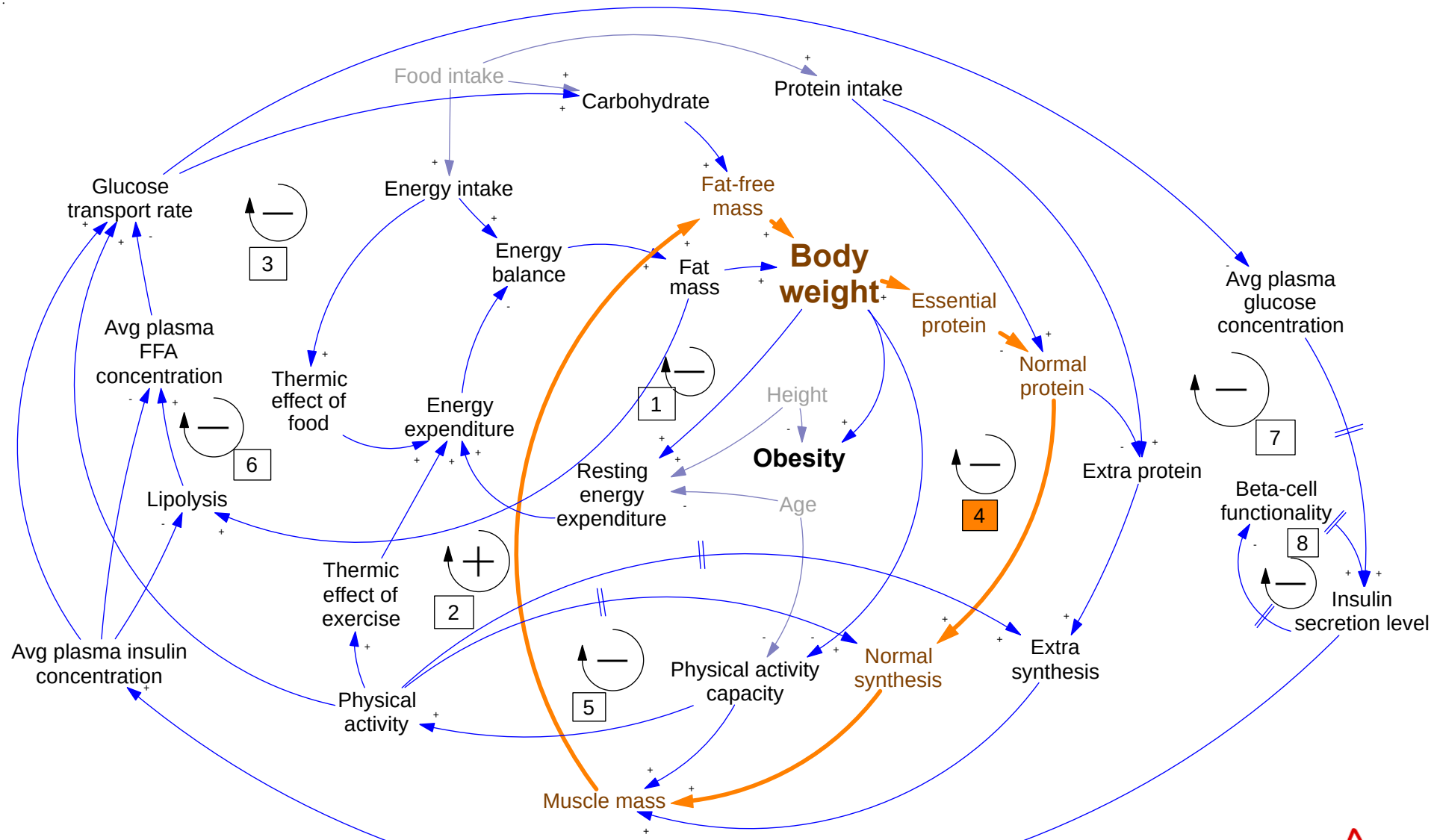
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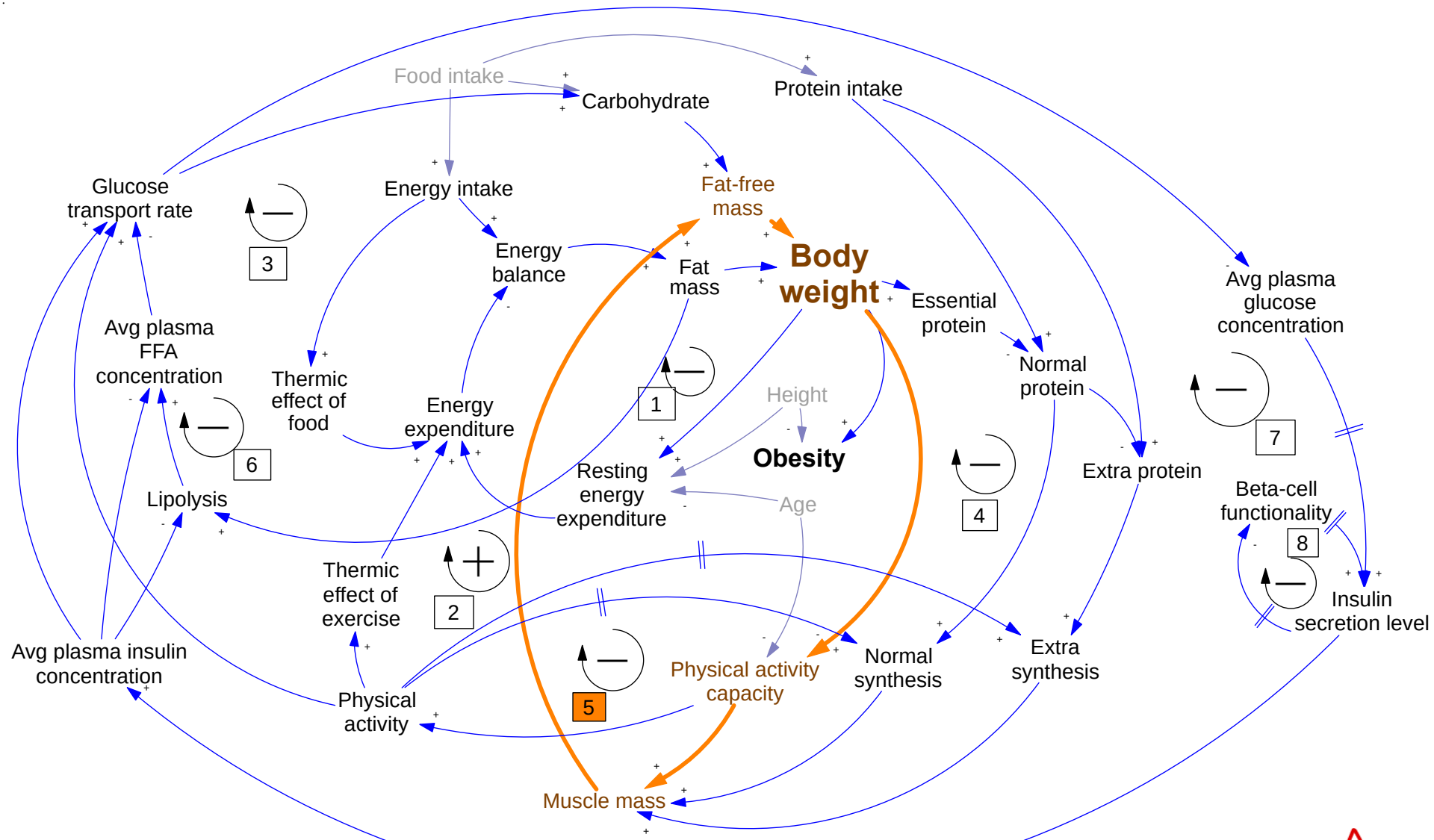
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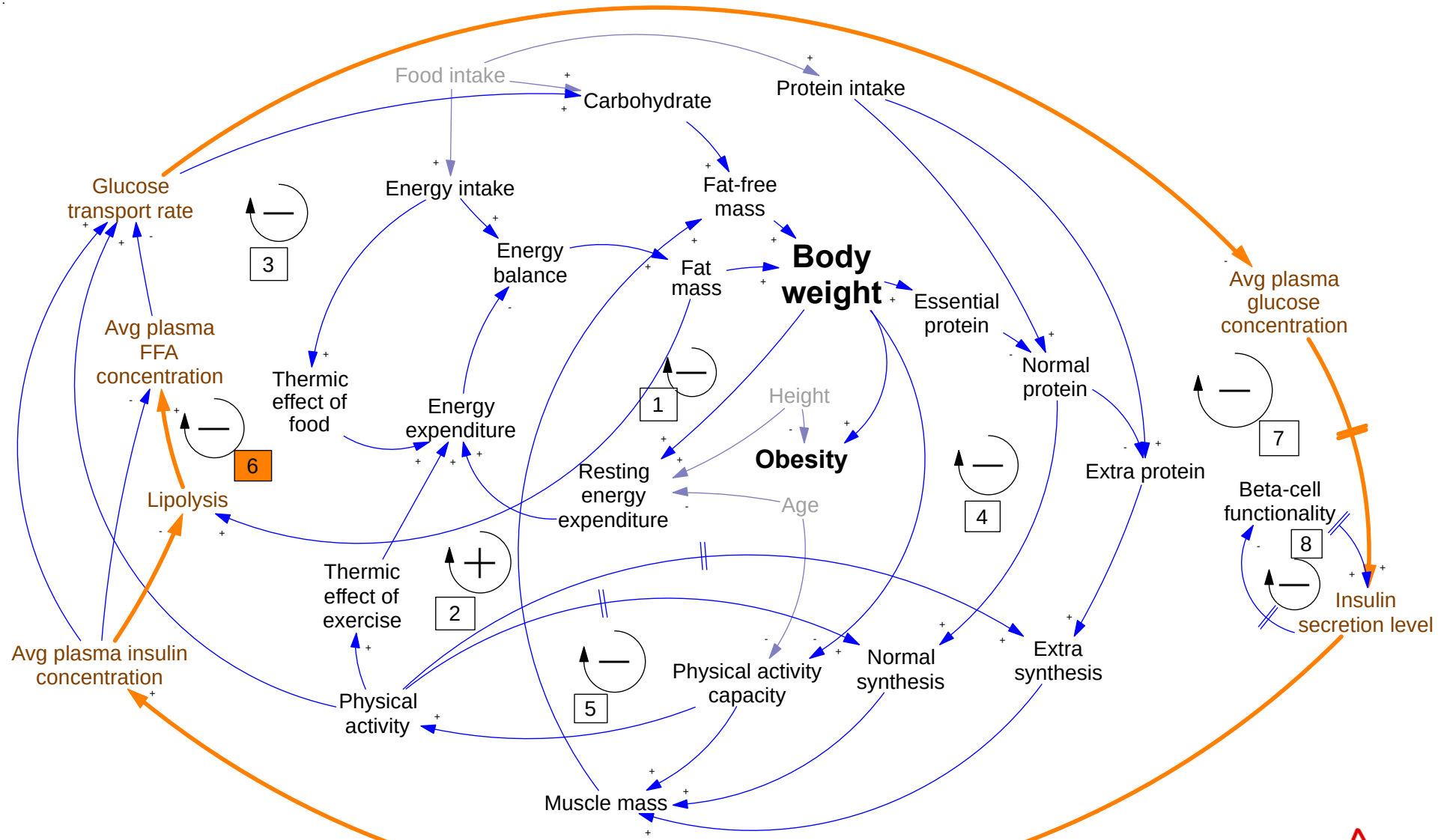
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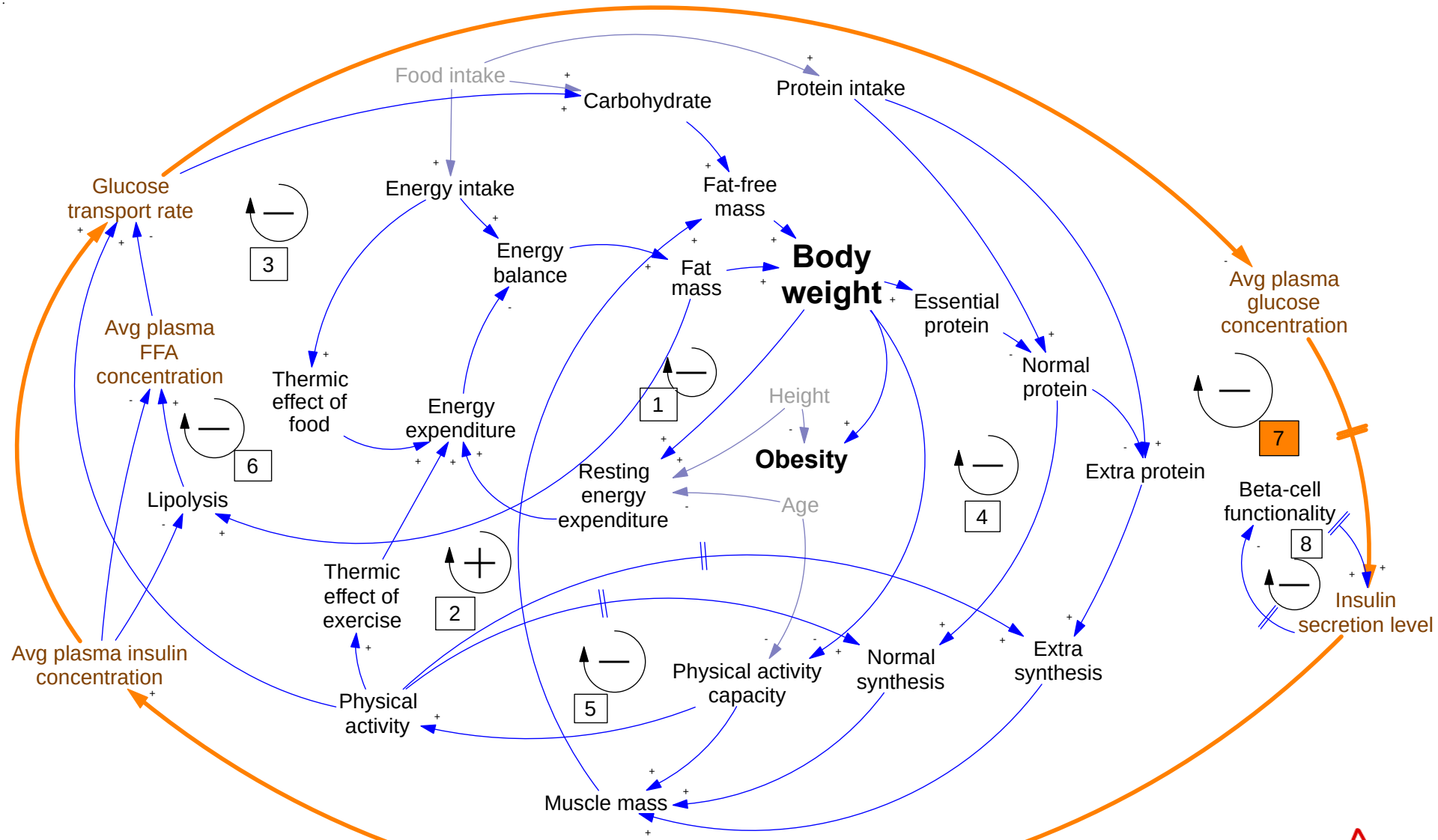
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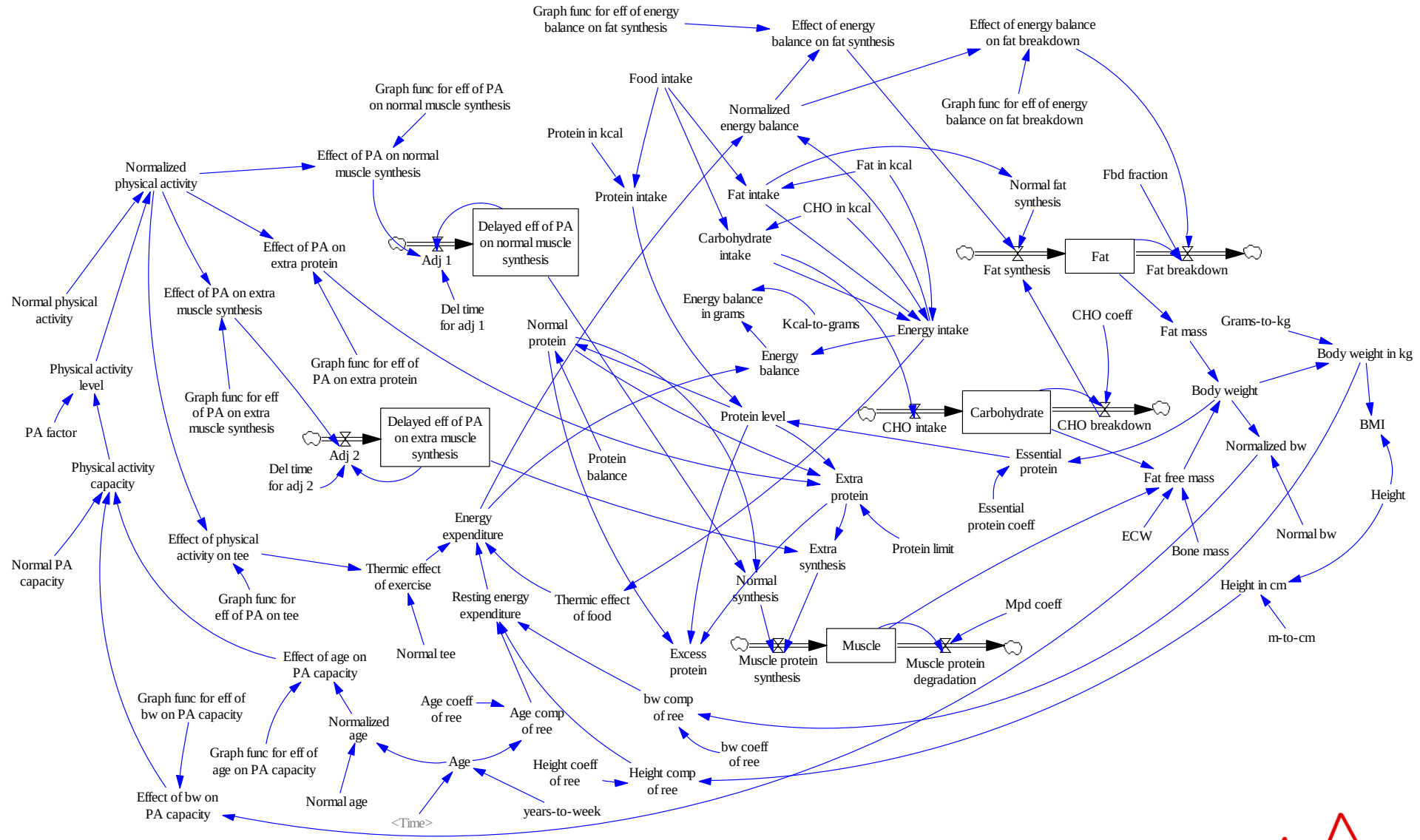
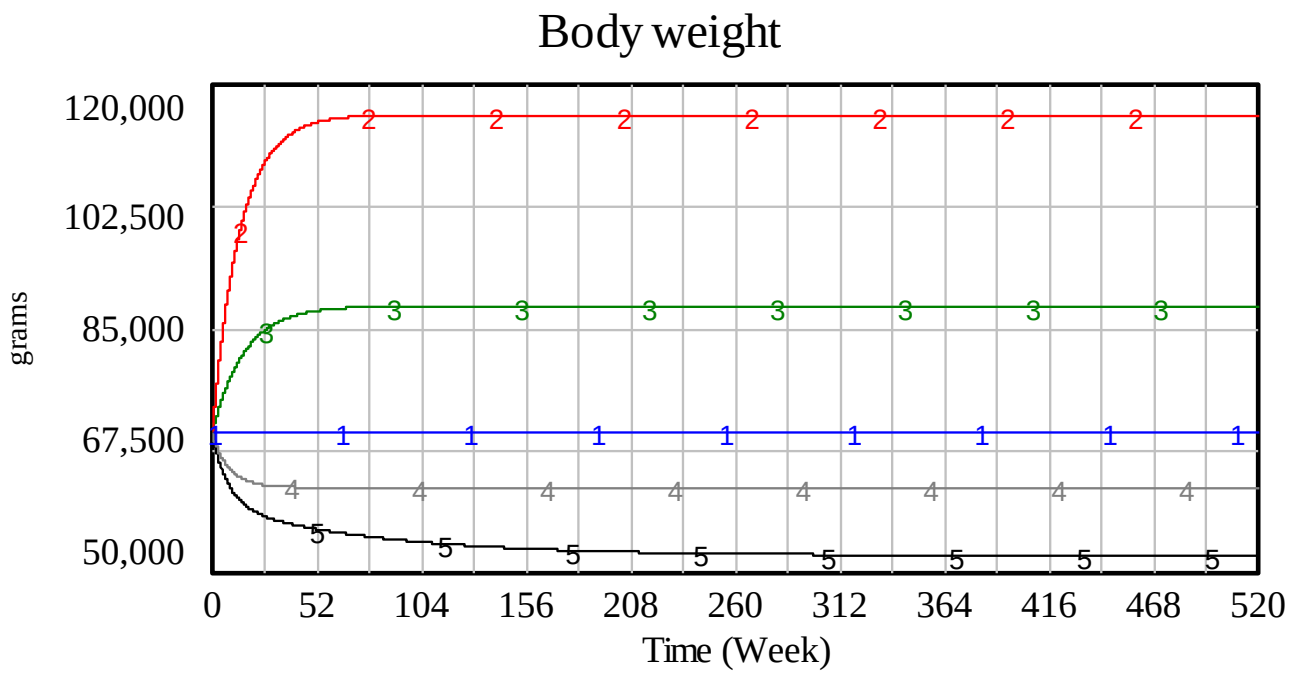
Stock Flow Diagram



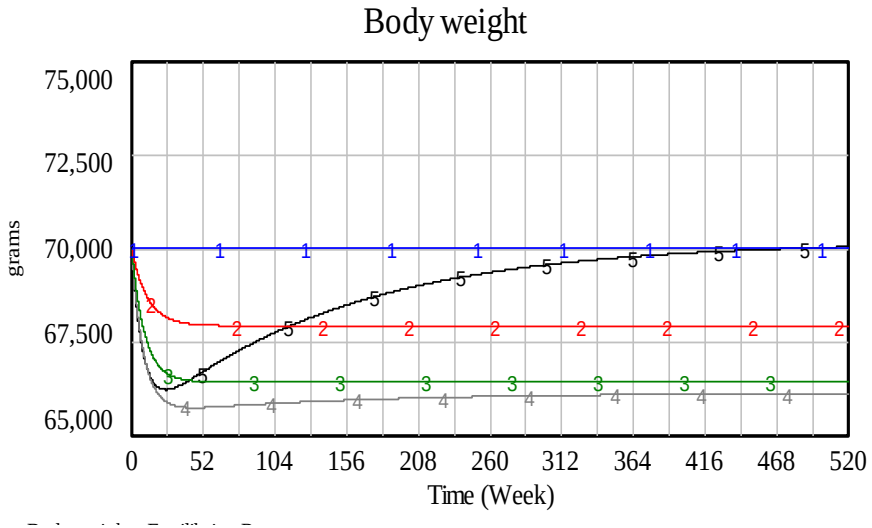
Some Behaviors

	Food intake for average man
1- Equilibrium	20,000 kcal/wk
2- Doubled Food Intake	40,000 kcal/wk
3- Excess Food Intake	30,000 kcal/wk
4- Insufficient Food Intake	15,000 kcal/wk
5- Half Food Intake	10,000 kcal/wk

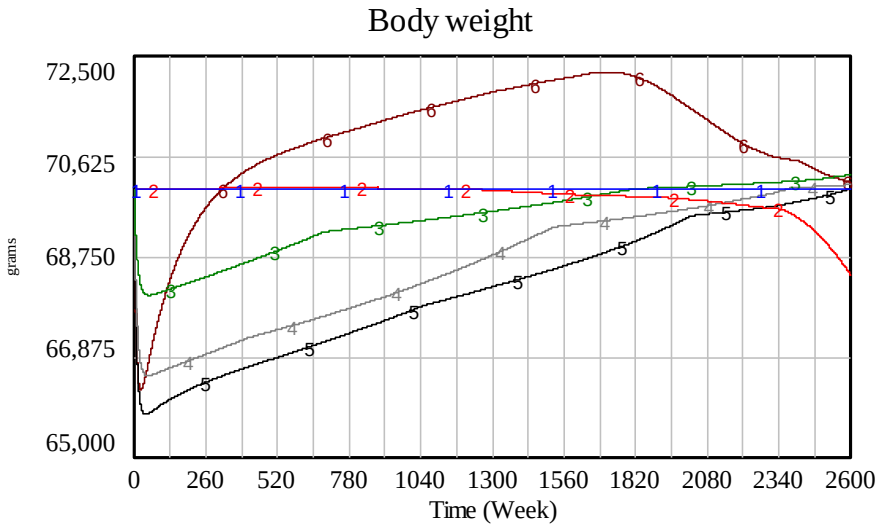


And Some More..

Base condition



With aging effect



	Energy expenditure through physical activity
1- Sedentary	2478 kcal/wk
2- Lightly active	4130 kcal/wk
3- Moderately active	6090 kcal/wk
4- Very active	8050 kcal/wk
5- Extra active	11,060 kcal/wk

Goodman, 2009

Questions?