Introduction to Systems Basic Principles

Application to hotel &
Hospitality Management
KAHTEA
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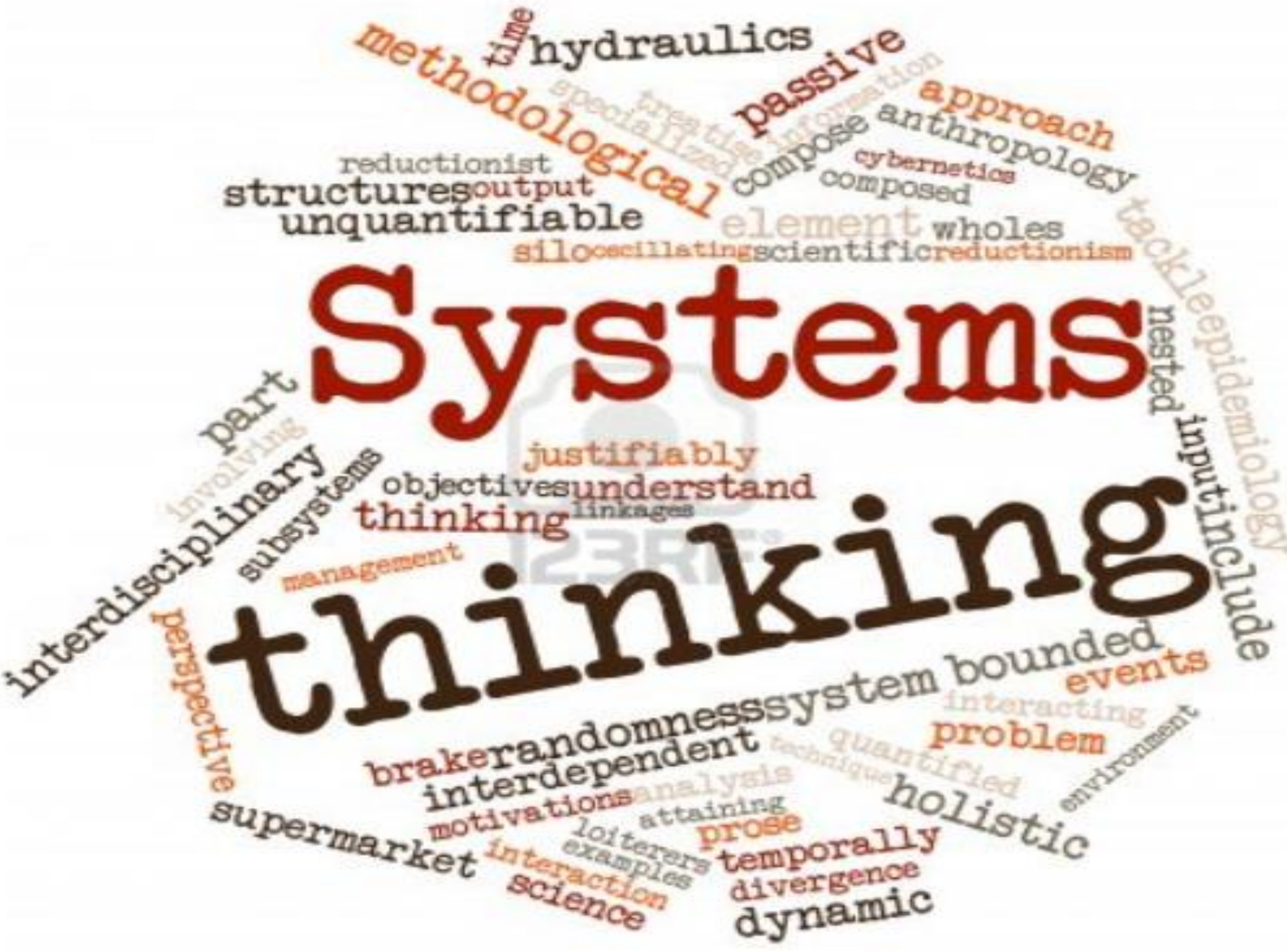
Systems
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divergence
dynamic

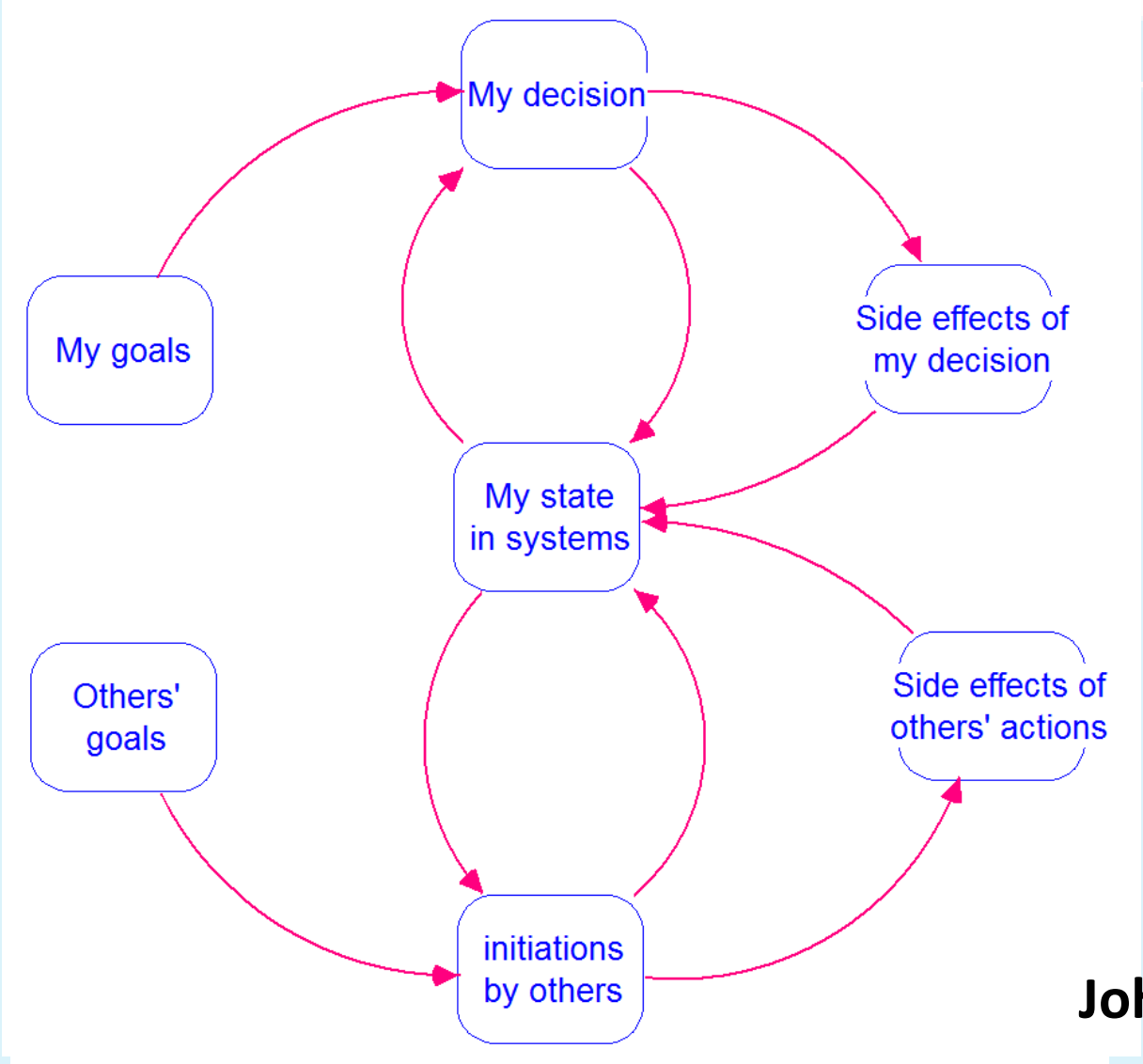
System, it's a matter!

- Family relationships, learning, & school systems
- Food-chain, ecosystem, & solar systems
- Pricing, inventory, & management systems
- Critical features of systems
  - A number of system components (factors)
  - Single-unit and/or multi-unit systems
  - Connected & interacting factors in other systems

Learning objectives

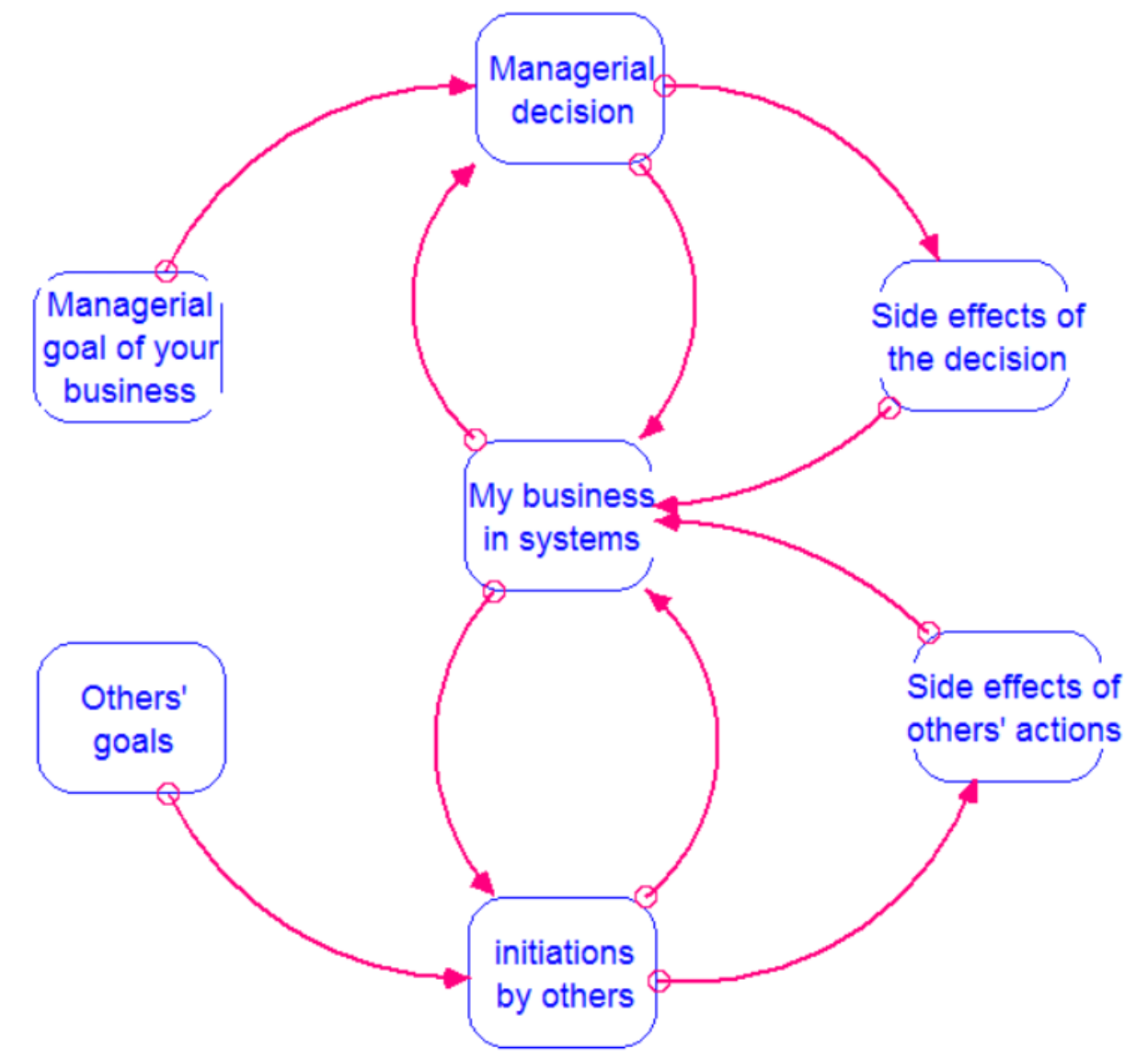
- System approaches being used to understanding the dynamic of operation
- Basic procedures of the modeling process
- Building a simple model using the basic elements of System Dynamics

We are embedded in a larger system



John Sterman

In business as well…



Family System

Factors sustaining family functions

- Incomes
- Expenses
  - Shopping
  - Paying bills
  - Gasoline
  - Insurance
  - Medical costs
  - Eating out
- Time demand
  - Cleaning
  - Cooking
  - Family hours
  - Leisure
  - Fixing
  - Mowing
  - Riding
- Feeling
  - Pleasure
  - Sorrow
  - Anger
  - Arousal
  - Happiness
  - Enjoyment
  - Upset

Connected & Nested

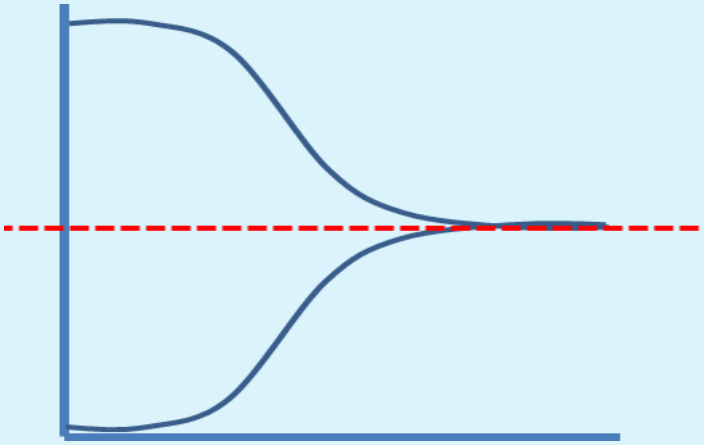
Thinking in Systems

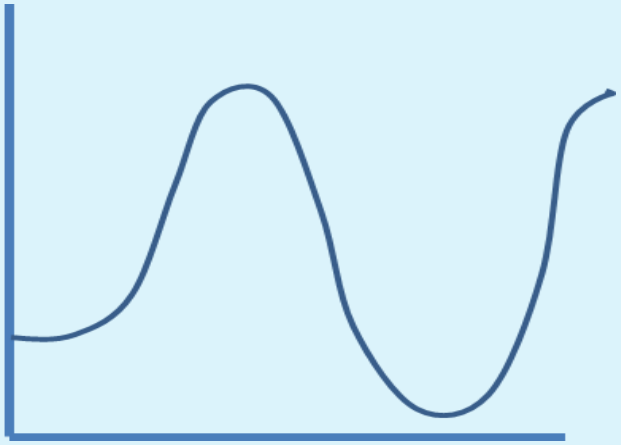
- System: A set of variables interacting and interconnected that sustains functional relationships over time.
- System science: A area of study that quantitatively investigates the behavior of complex dynamic systems.

(Ruth & Hannon, 2001).

Factors in a system (Fisher, 2007)

- Interrelated: Behaviors of the system are a result of interaction among several factors
- Feedback: The value of a factor can influence the behaviors of other factors in the system
- Non-linear relationship





Why systems approach?

- To visualize implications of connections between model components (factors).
- To simplify representations of a hypothesized situation that may happen in reality.
- To help us reason about the implications of our understanding.
  - To identify the cause of system behaviors
  - To anticipate future behaviors of interest factors
  - To develop strategies to produce desired outcomes

Systems thinking skillset

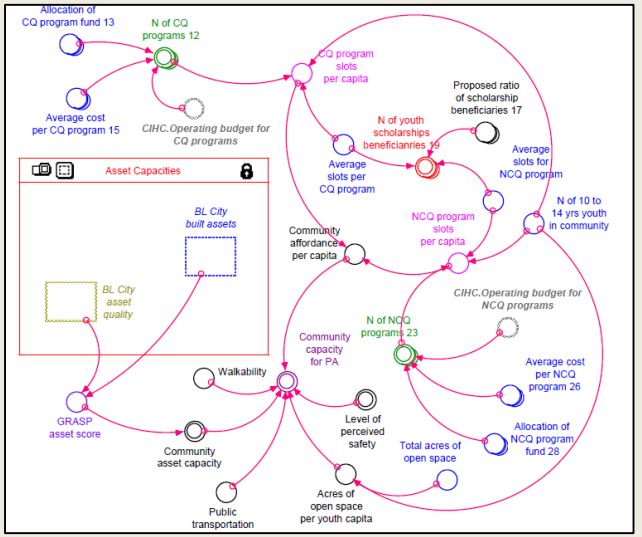
- Dynamic thinking: Over time thinking
- Feedback thinking: Circular causality
  - Causal loop diagrams (Balancing & Reinforcing)
- Operational thinking: Use stocks and flows to represent systems' structure
- Non-linear thinking: Include tipping points, diminishing returns, etc.

Required Mechanical Skills

- Create stock & flow diagrams
- Define equations
- Create graphs and tables
- Set time and rage specs
- Run simulations
- Conduct sensitivity analysis
- Print and save models

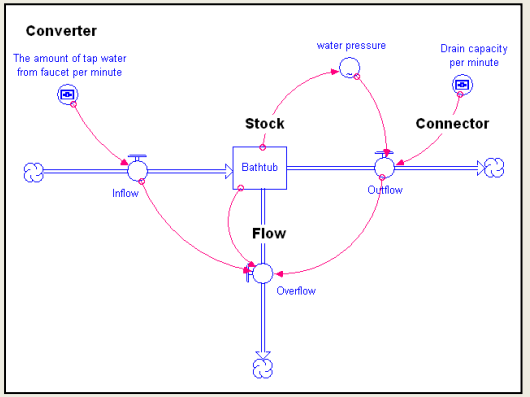
STELLA®

http://www.iseesystems.com/



One of dynamic system software programs that allows us to:

- Visually develop a system
- Simulate how a system operates
- Illustrate impact of any change over time.



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Complementary model types

- Model: Simplified representation of selected aspects of a real system
- Static models
  - Understand connections between system factors
  - Do not a significant reaction of systems' feedback
  - Aid in reasoning structure of system
- Dynamic models
  - Aid in understanding consequences over time on designer's choices & forecasted outcomes

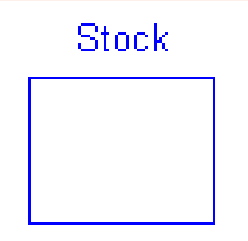
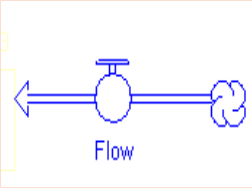
Dynamic models

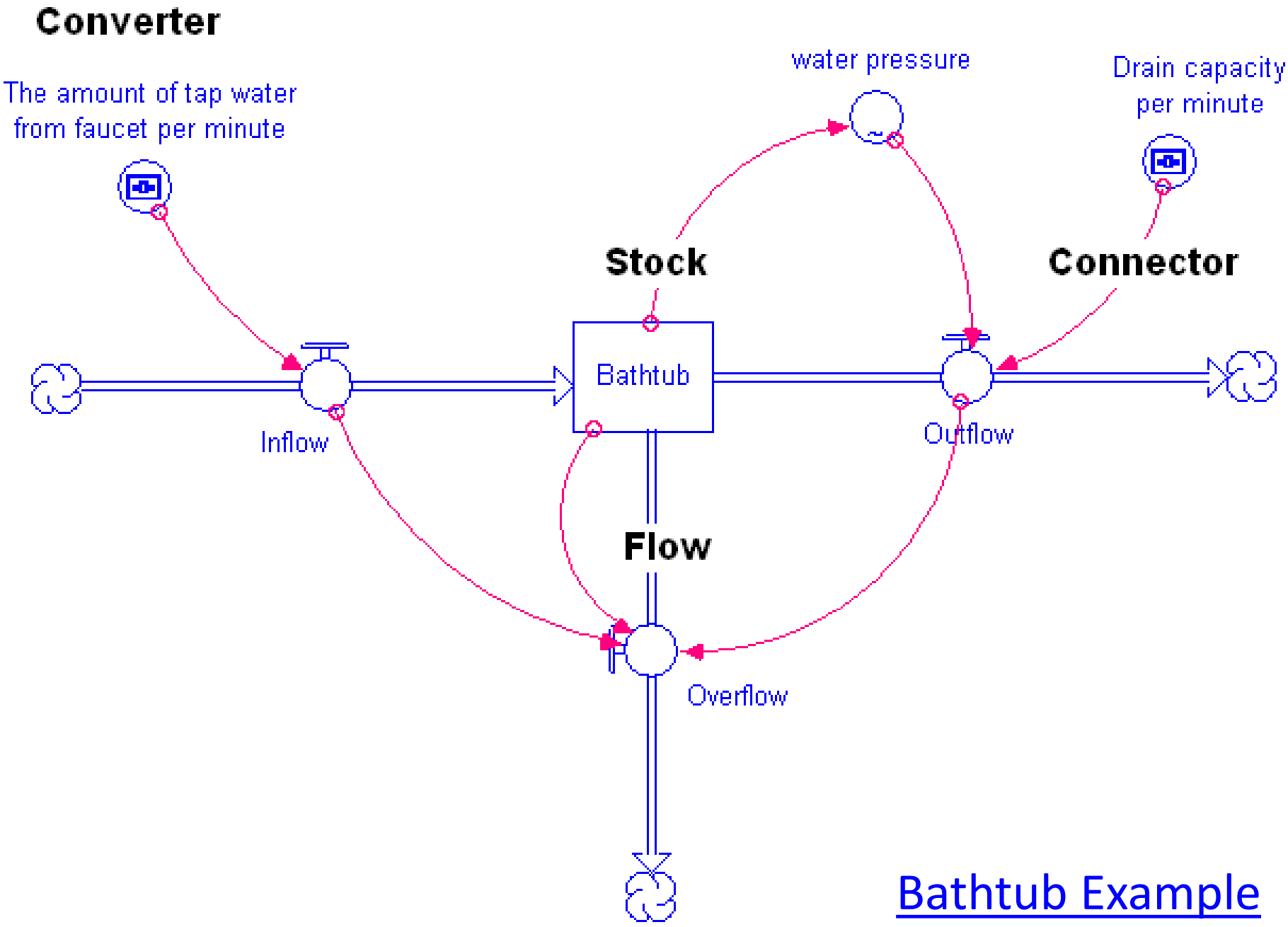
What makes any system dynamic?

feedbacks and time delays

- Provide a way to examine diverse consequences of changes in one factor of the system on the whole system
- Models help us to identify
  - Ways of positively changing system structure
  - Improved ways of scientists and managers working together to plan, implement, and evaluate strategies

Four Components

	Stock (reservoir): A state variable that can increase and decrease over time through either inflows or outflows (Bathtub containing water)
	Flow: A control variable that represents the action or change in a stock (Water valve & Drain valve)
	Converter: A translation variable that holds information about the system. It affects the rate of the flow or the value of another converter
	Connector: An information arrow that delivers information from one variable to another.



Bathtub Example

Check Point (1)
- Population in a Community -

• birth rate	• Converter
• immigrating	• Flow
• Number of people	• Stock
• dying	• Flow
• being born	• Flow
• immigration rate	• Converter
• death rate	• Converter
• population density	• Converter

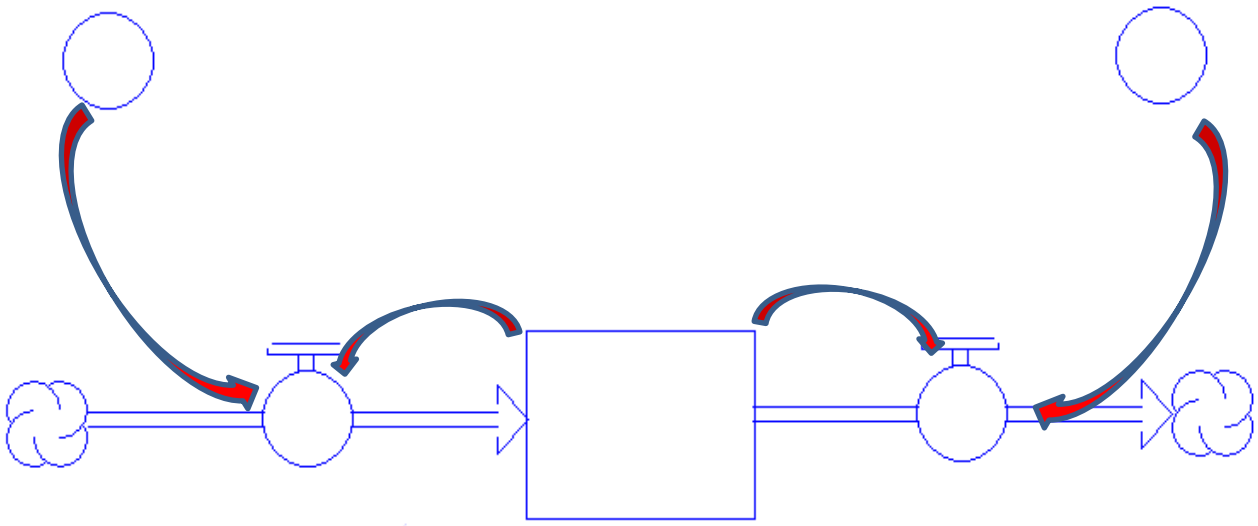
Population Model

Stock, Flow, or Converter?

Population
(Stock)

birth
(Flow)

birth rates
(Converter)



death
(Flow)

death rates
(Converter)

Check point (2)

- Dollars in bank account — Stock
- earning — Flow
- interest rates — Converter
- spending — Flow
- children allowance — Converter
- gift money — Converter
- foods & groceries — Converter
- paying monthly bills — Flow
- gas — Converter
- utilities — Converter

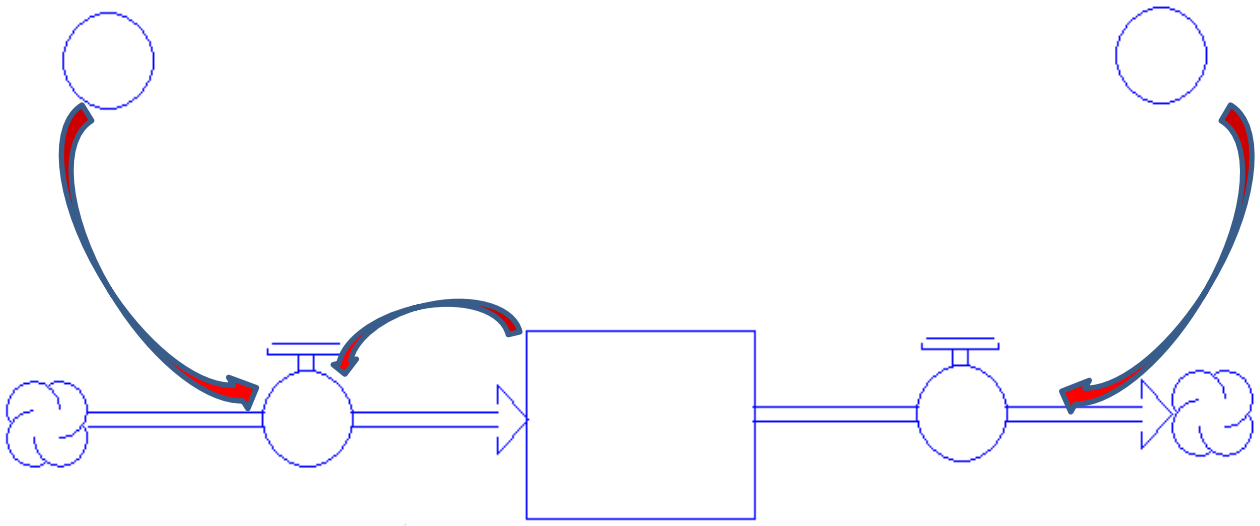
My bank account

Stock, Flow, or Converter?

$ on my account
(Stock)

earning interests
(Flow)

interest rates
(Converter)



paying fees
(Flow)

payment per month
(Converter)

Modeling Dynamic Systems

1. Define the problem (patterns of behaviors)
   - Establish the purpose of the modeling
   - Define a boundary of the problem
2. Identify critical stocks and flows
3. Gather main factors (converters) that influence the flow
4. Draw causal loop diagrams (CLD)
5. Determine logical and mathematical relationships between identified factors

Several more steps

6. Simulate the model and examine the results
7. Revise modeling to represent it better
8. Simulate and examine
9. Revise it
10. Simulate and examine
11. Revise it
12. …

There is no such a perfect model

1. Define the problem (filling water)

- What do you want to know?
- What is the purpose of the modeling?

- ✓ Understand how it stop filling water in a bottle
- ✓ Examine how long it would take to fill water a bottle.

2. Define stocks & flows

- Stock(s): Some entity that can be accumulated/depleted over time by inflow/outflow.

Stock: Water level
(volume of water/liters)
(Mass of water/grams)

Inflow: filling water
(milliliters/min)
(grams/min)

Outflow: none

Note: The unit of each stock should be the same as its corresponding flows.

3. Identify auxiliary factors (converters)

- Things that affects the rate of the flow or the value of other converters.

Stock: Mass of water (grams)

Inflow: filling water (grams/min)

- Converters
  - target water level
  - gab b/w target level & water in the stock
  - amount of water per minute from the faucet

4. Causal Loop Diagrams (CLD)

- Provide us a broad picture of the model
- Help us to understand the relationships (direction & causal) between critical variables
- Feedback: A closed path of action & information

Four Elements of CLD

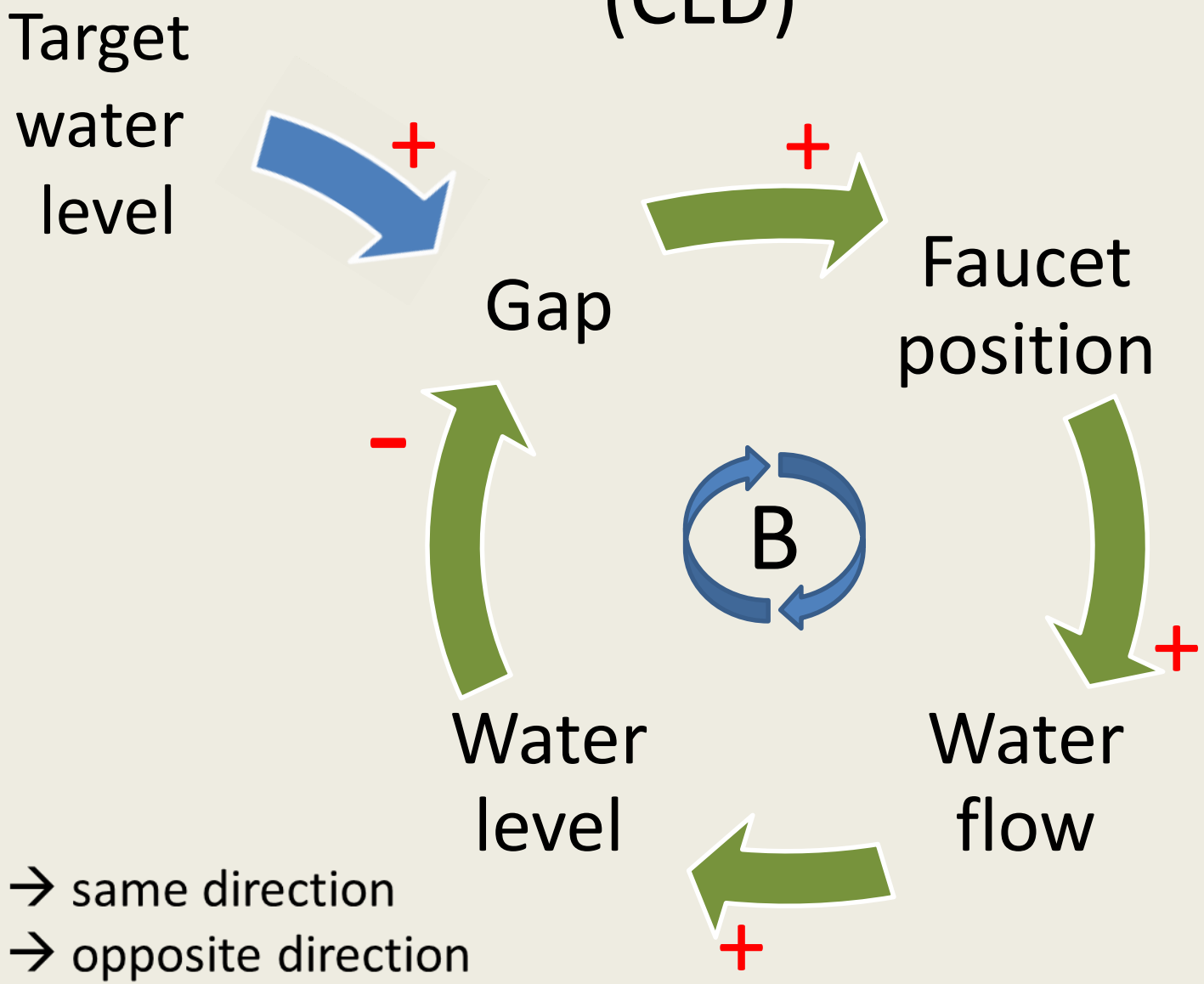
- Variables: Represent sequences of cause & effect
- Arrows: Indicate which variables affect other variables.
- Symbols: Show a direction of the influential relationships

  + (S): same direction / - (O): opposite direction

- Central symbols: Indicate types of the loop

  R: Reinforcing / B: Balancing

Filling water in a bottle (CLD)



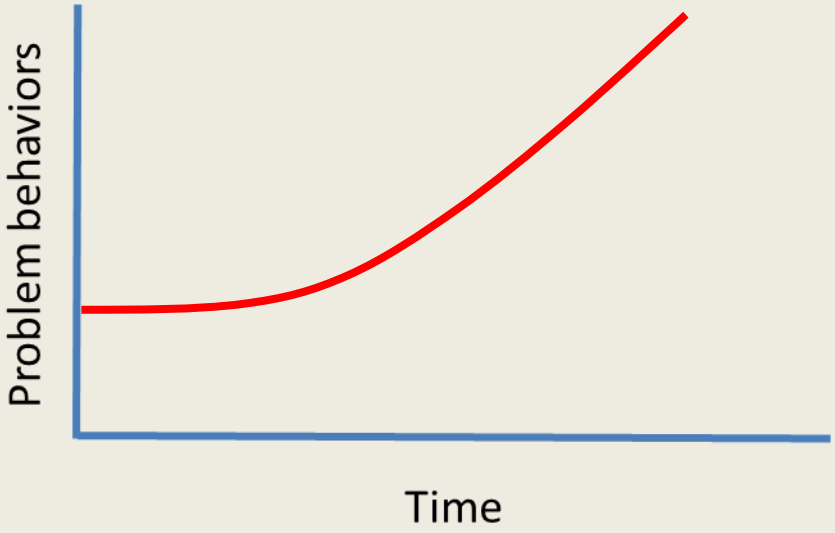
Parents of children with ASD

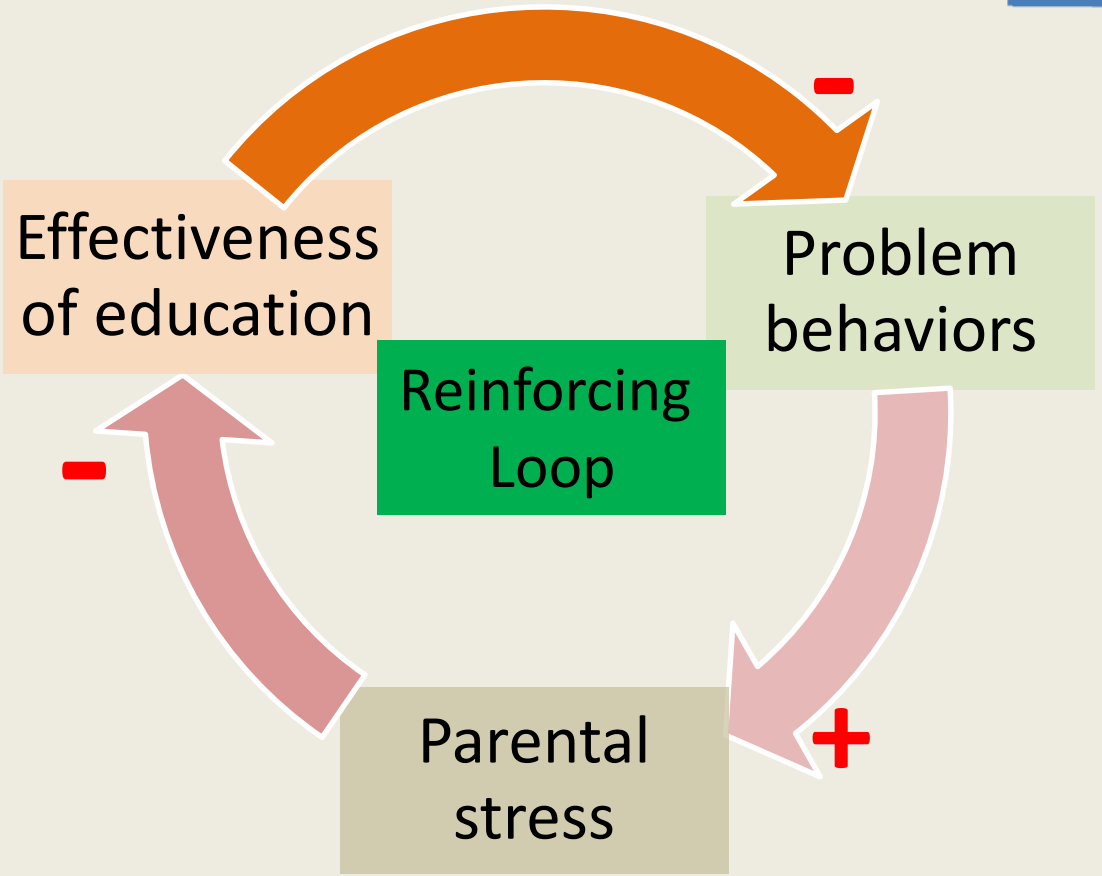
(Autism Spectrum Disorders)

- Problem Behaviors: Inappropriate behaviors, endless duties, helping & caring of their child
- The primary source of parental stress
- The greater they are stressed out, the less parental care is effective (effectiveness of Edu)
- Therefore, the problem behaviors of the child with ASD will be even worse.

+ → same direction

− → opposite direction

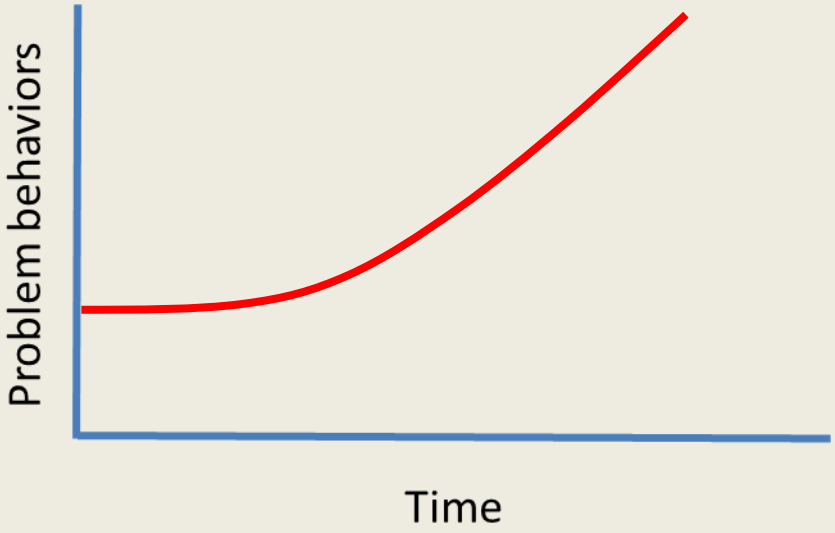


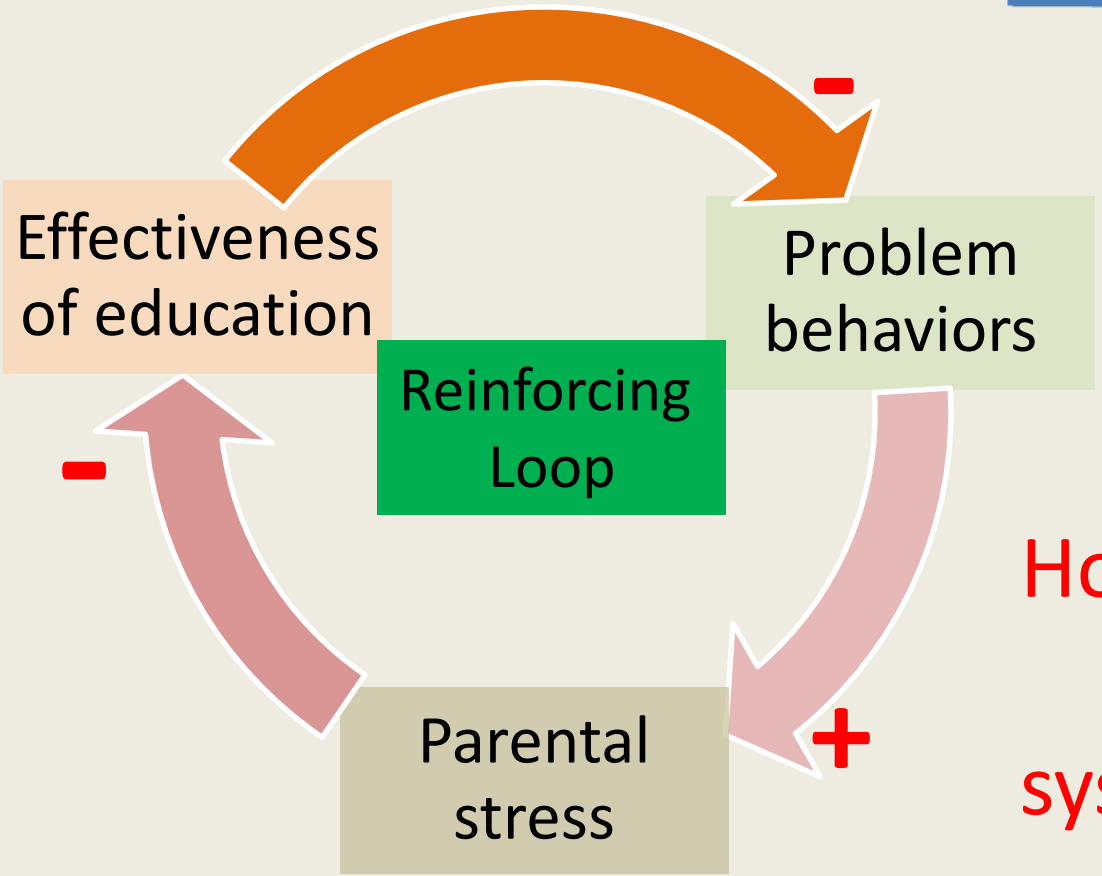


Family of children with ASD

+ → same direction

− → opposite direction

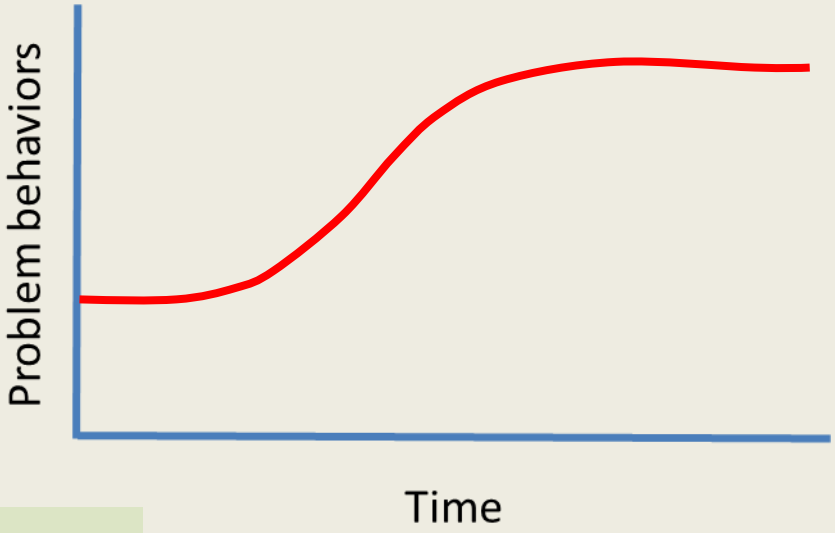


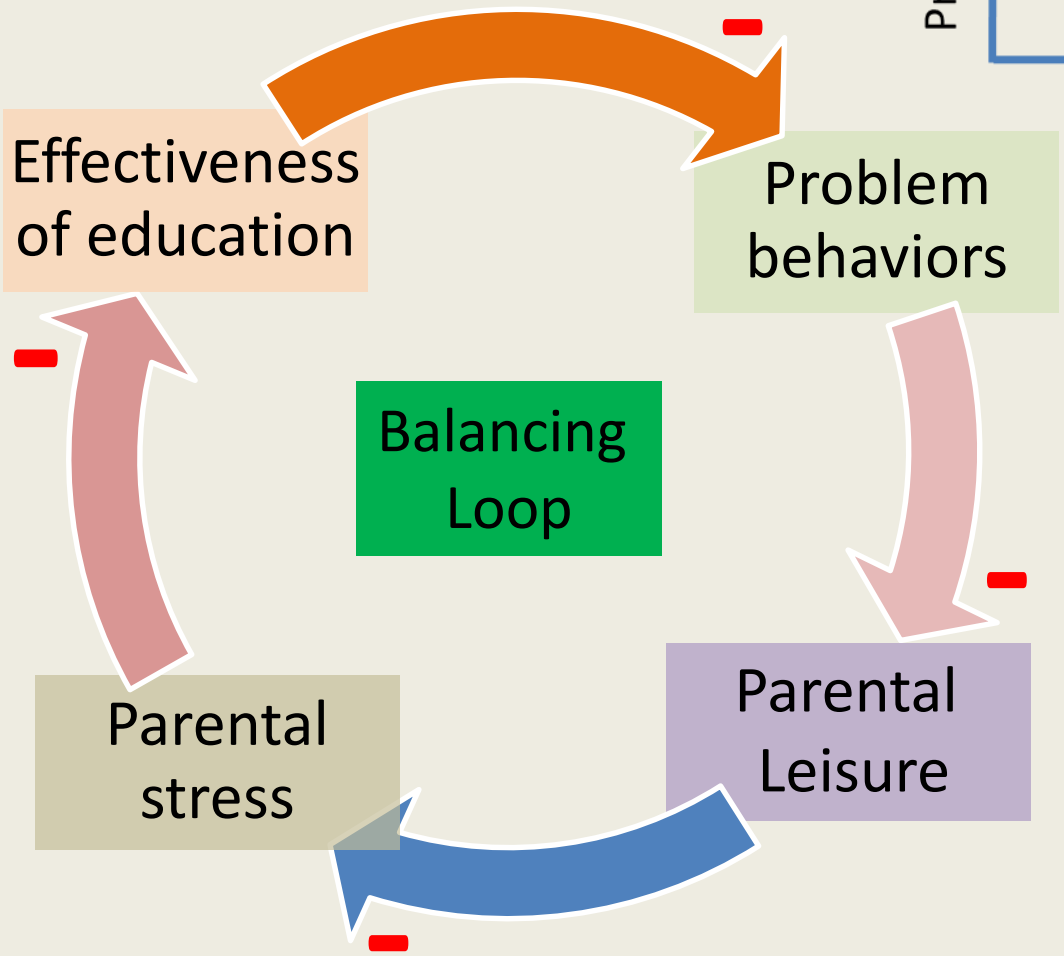


How can we change the patterns of systems' behaviors?

+ → same direction

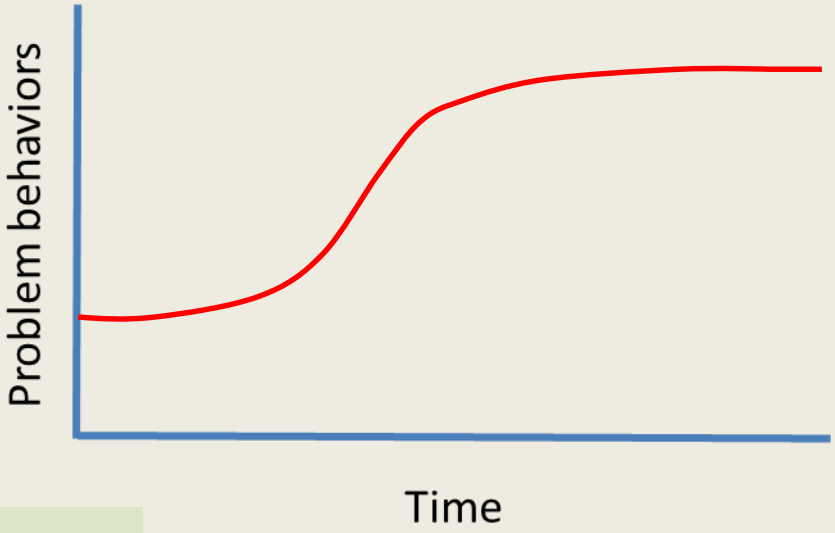
− → opposite direction

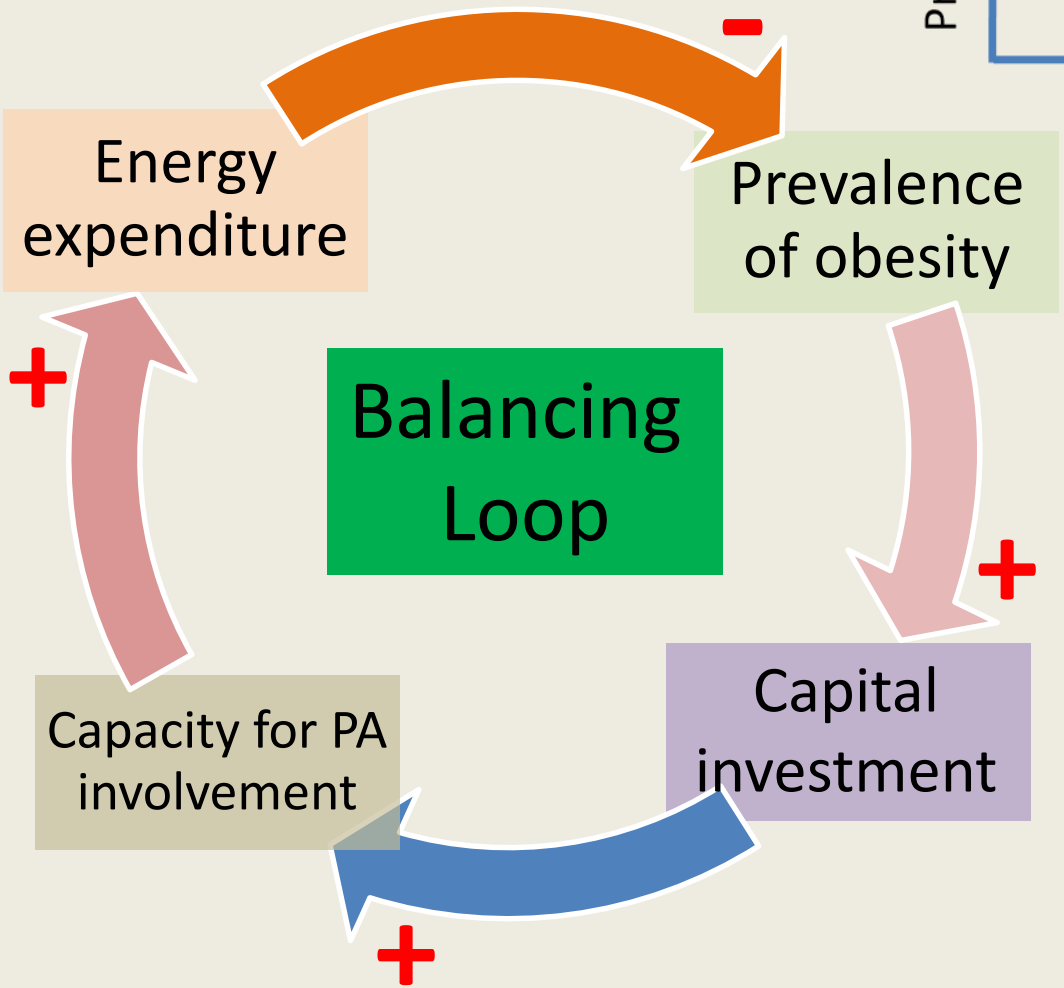




Changing systems' behavior

Childhood obesity issue



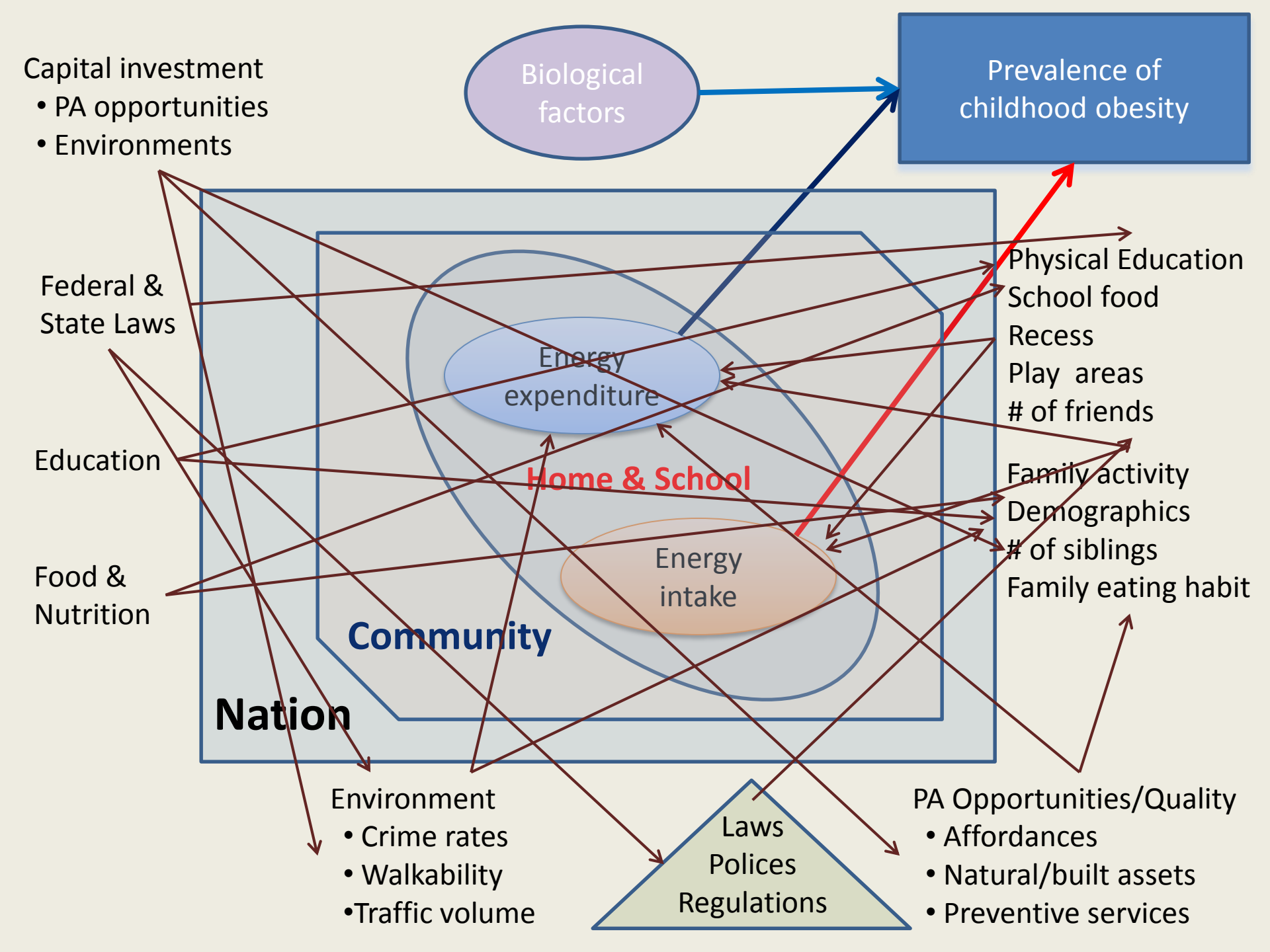


+ → same direction

- → opposite direction

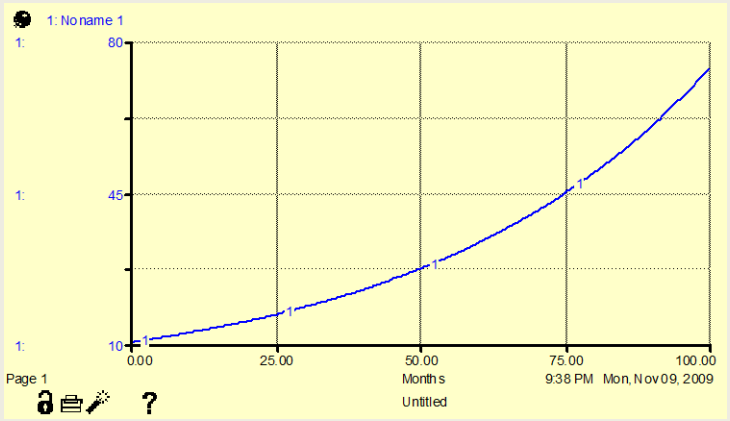
Are we?

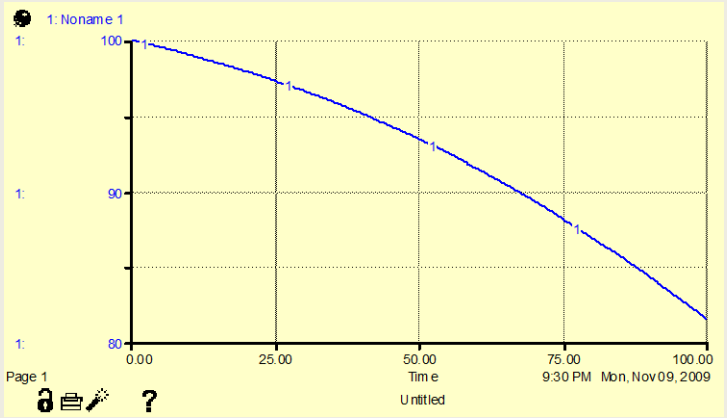
What is wrong?


Capital investment
• PA opportunities
• Environments
Biological factors
Prevalence of childhood obesity
Federal & State Laws
Education
Food & Nutrition
Physical Education
School food
Recess
Play areas
# of friends
Family activity
Demographics
# of siblings
Family eating habit
Energy expenditure
Home & School
Energy intake
Community
Nation
Environment
• Crime rates
• Walkability
•Traffic volume
Laws
Polices
Regulations
PA Opportunities/Quality
• Affordances
• Natural/built assets
• Preventive services

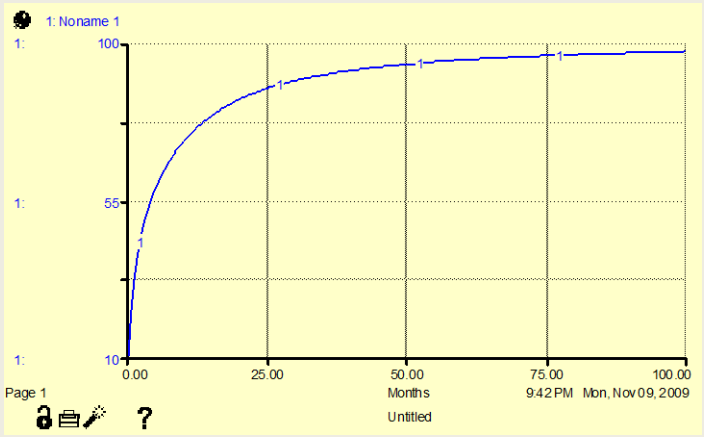
Some patterns of behaviors

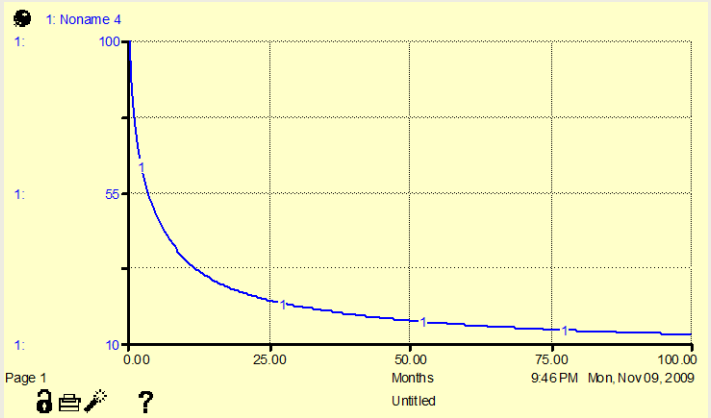
Reinforcing Loop





Balancing Loop





Show me what you've learned

- Make groups of three
- Select a (simple) problem of interests
- Discuss & write a short story explaining the causes & effects of the problem
- Develop a CLD (Causal Loop Diagram)
- Identify possible solutions of the system
- Create reference graphs depicting the anticipated systems' behaviors (time by a factor of interest)

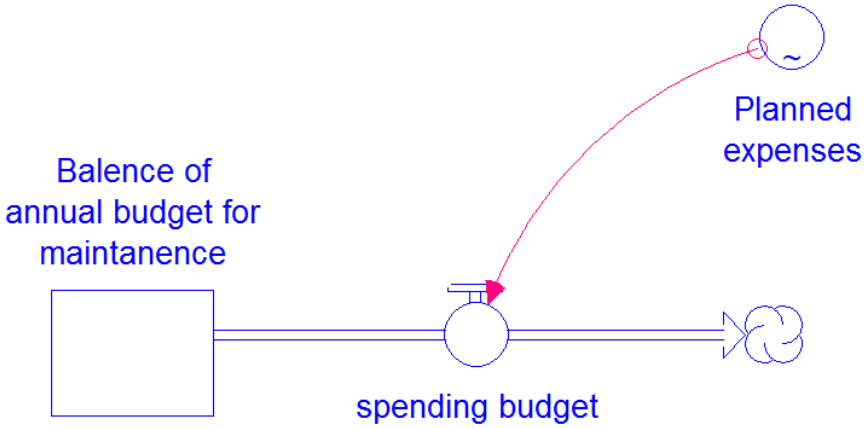
Four Basic Models & Building a simple model using a modeling tool (STELLA)

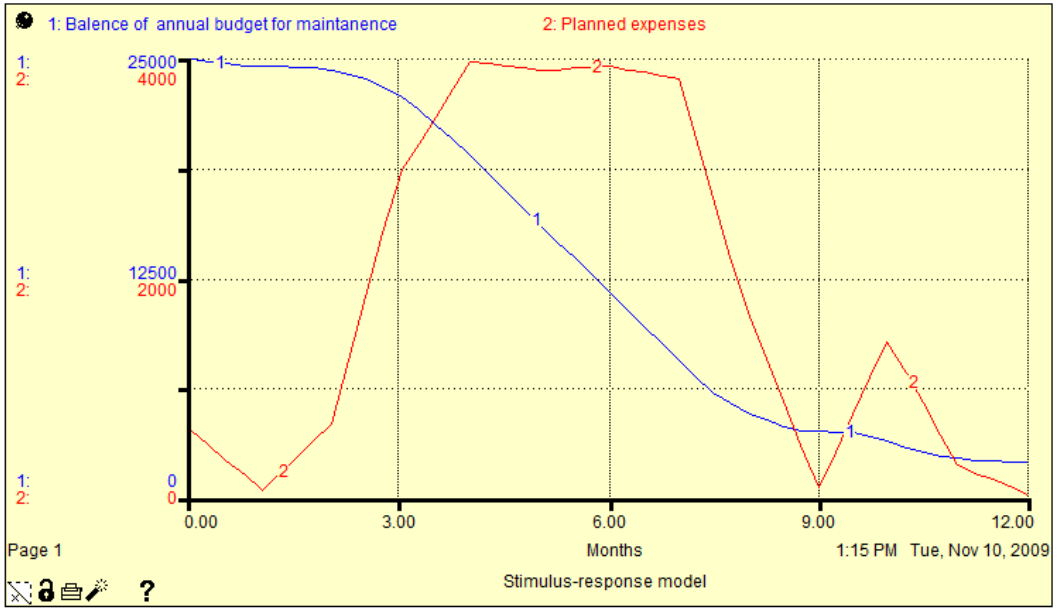
Learning objectives

- To understand four (4) basic models of dynamic system modeling
- To understand the concepts of feedback & time delay in dynamic system
- To build a simple dynamic model

1. Stimulus-Response Model

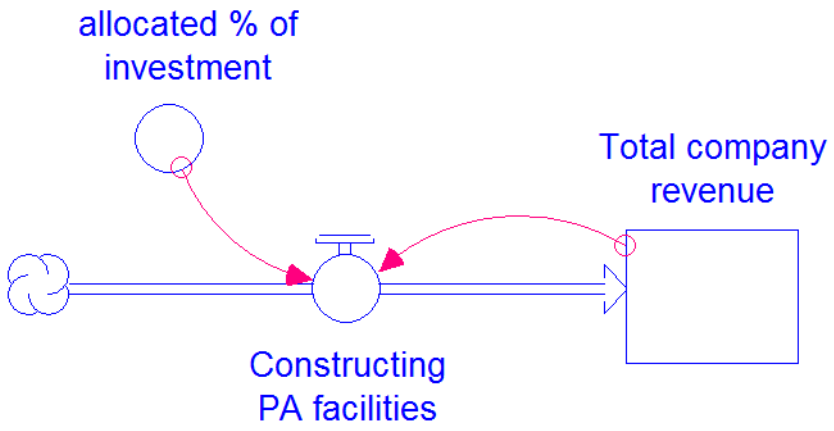
The change in the stock is independent of the current volume of the stock, but is influential in the volume of its inflow & outflow.

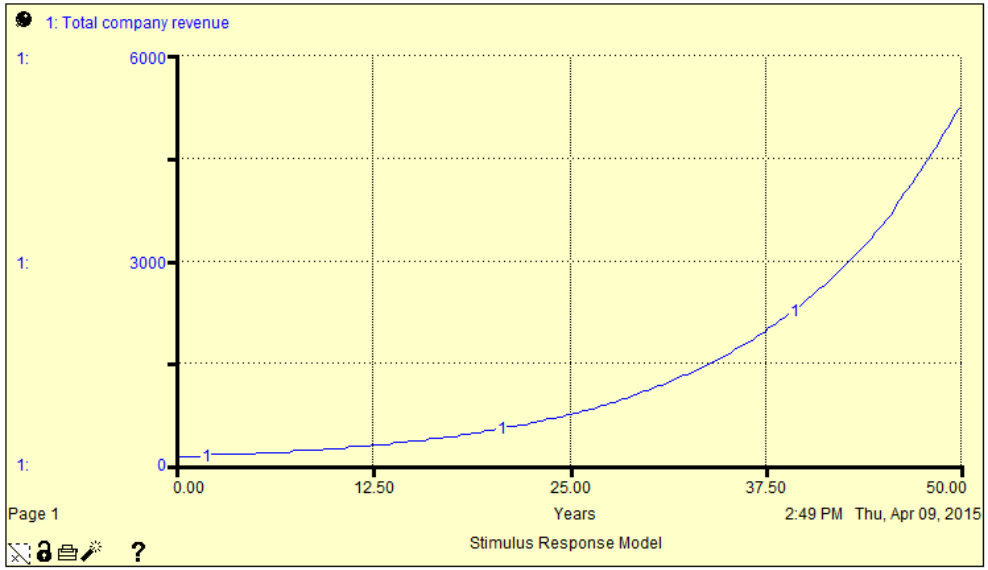




2. Self-reference model

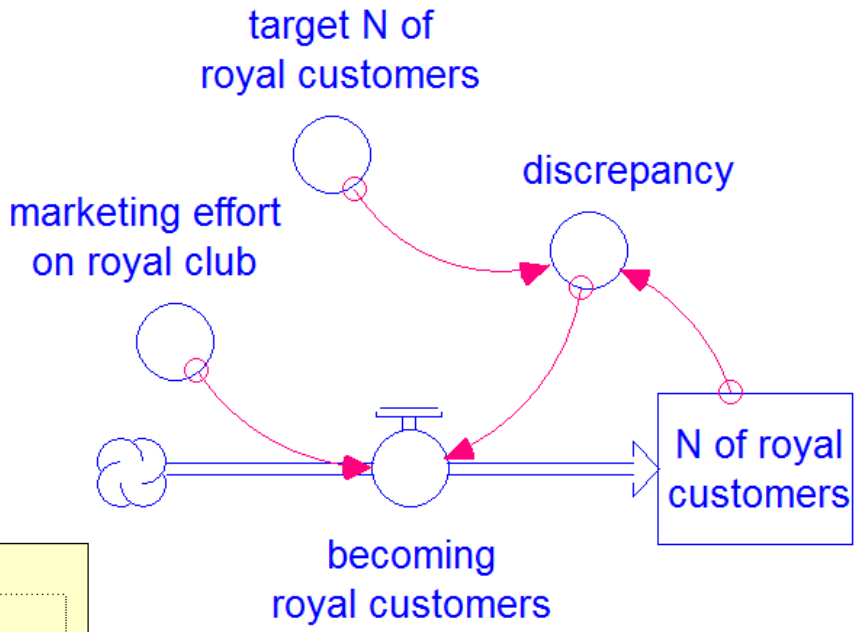
The change in the stock depends on the volume of the stock itself.

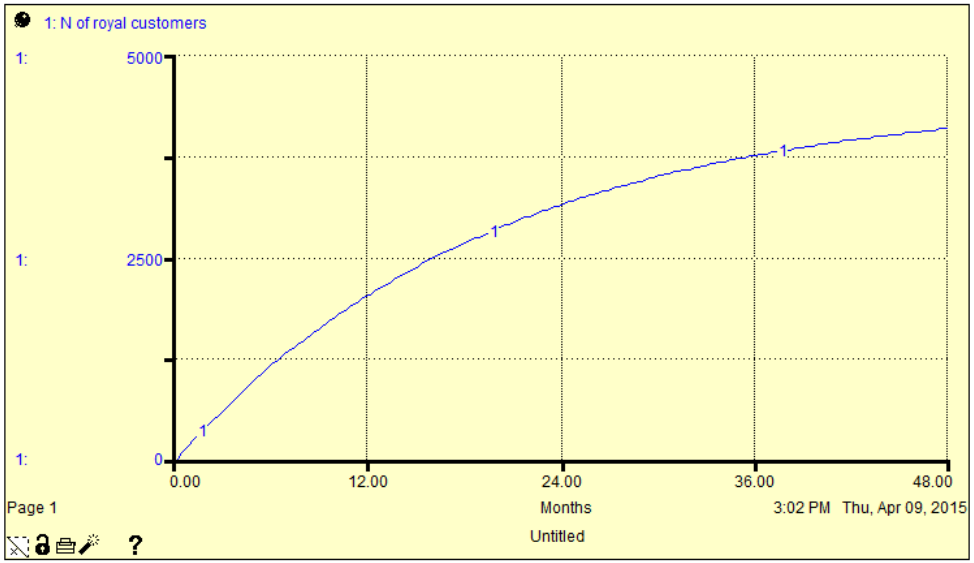




3. Goal-seeking model

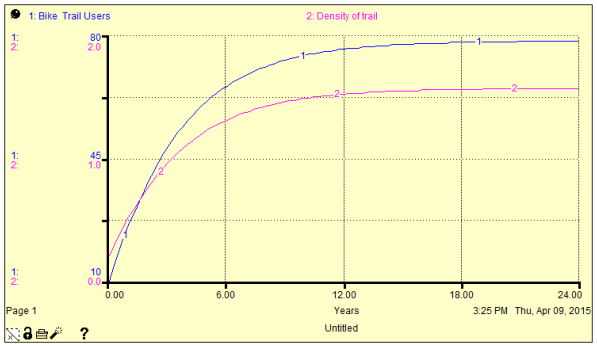
The current level of stock drives toward the predetermined target level of the stock.





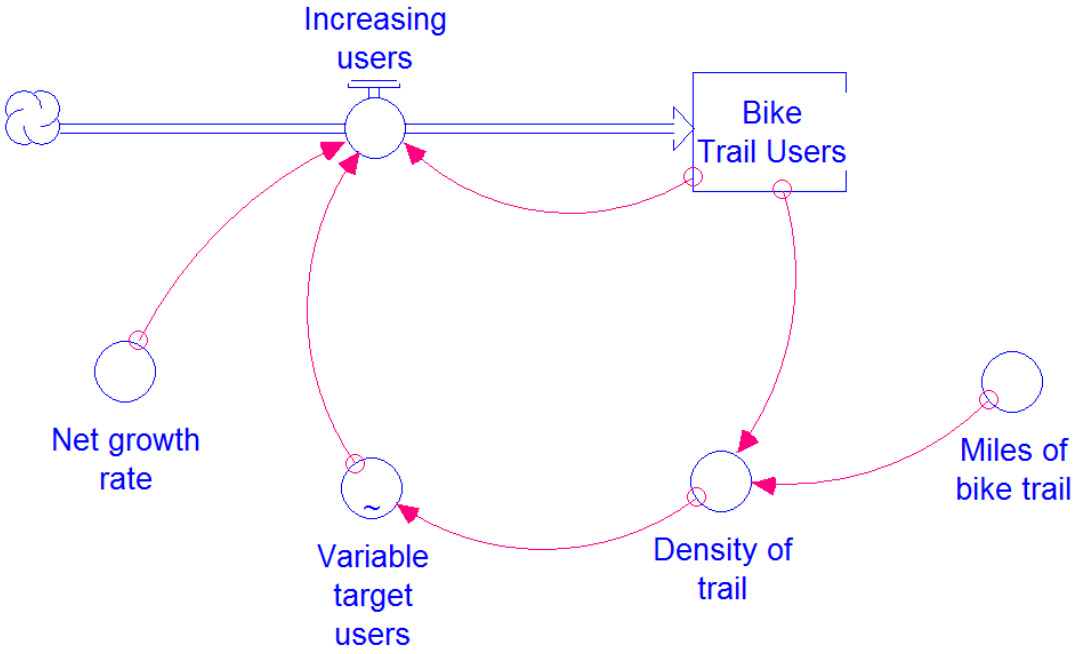
4. Goal-setting model

The factors in systems are involved in setting a goal that may control those factors in turn.



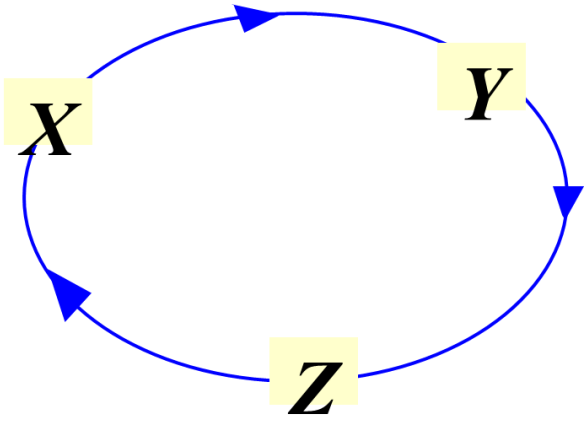
Density

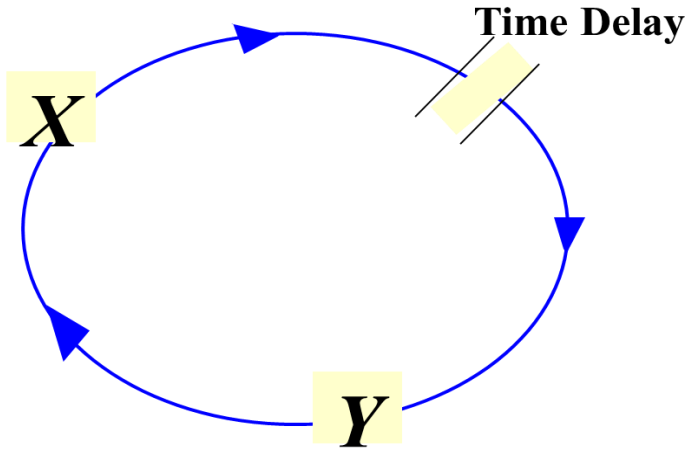
Users



Feedback loop & time delay

- Feedback: A factor “X” affects the other factor “Y”, and it in turn affects “X” as a result of a chain of causes and effects.
- Time Delay: The time between the action and the result of this action.





Developing a dynamic model

STELLA software

Drawing a simple model using the basic elements of System Dynamics

Population dynamic (Modeling)

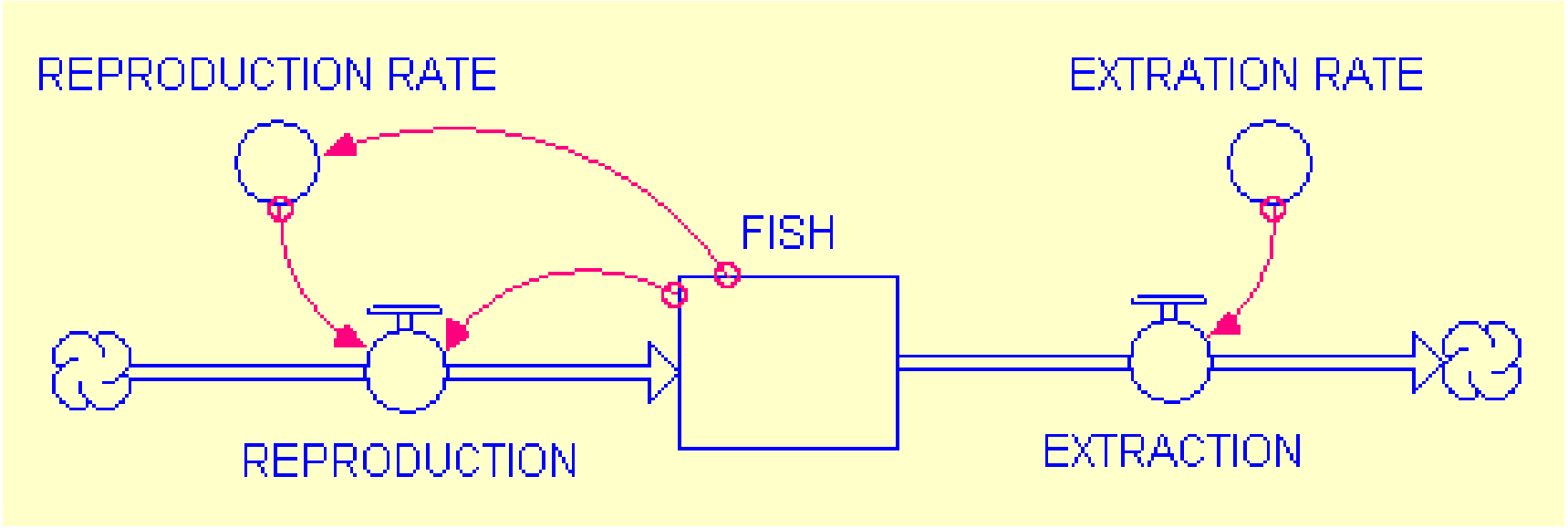
- Stocks: Children cohort, Childbearing cohort, & Elderly cohort
- Flows: being born, growing, aging, & dying
- Converters: birth rate & death rate
- Feedback: the number of childbearing cohort → new birth → the number of childbearing cohort
- Time delay: New born child can be a childbearing adult after twenty years later.

Examples: A pond with 200 fish

- Assume we have 200 fish stocked in a pond.
- Reproduce rate of 5% per year
- None of the fish in the pond die
- How many fish will be in the pond after 20 years?
- What-if?
  - What if the reproduction rate varied with the current number of fish population (from 0% to 10%)?
  - What would happen if you decided to sell fish at a constant rate of 3% per year.

Simple dynamic model (Example)

- Model develop with STELLA software.



The Fifth Discipline. Peter Senge, Currency Doubleday, 1994, Chapter 5.

Apply this model to your field…

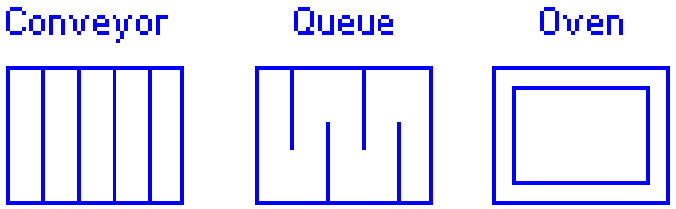
- Assume you are managing a restaurant.
- Currently you have 200 loyal customers
- By your effort, we can increase the number by 5% annually for the first 5 years
- However, you may consider the maximum capacity of the restaurant (increasing rate would vary & should have a target # of customers).
- Unfortunately, you loose 3% of customers each year.

One More Practice?

- I went to a bank to open my bank account. A teller said that I will have 8% of ARI (annual rate of interest) based on the $ amount on my account. However, each month I had to pay $1.50 monthly fees. In addition, I had to maintain the account balance (greater than $0) to avoid paying a penalty charge. The charge would be 15% of your debts. It seemed to be unfair, but I opened my account and deposited $200.
- Let's pretend you forget your bank account, & haven't checked the balance for 5 years. What would happen?
- What would my balance be after five years (120) later?
- How much do I need to deposit to avoid paying any charges?

Conveyor, Queues and Ovens

- There are four versions of stocks
  - Conveyor: A conveyor belt. Material gets on the Conveyor, rides for a period of time, and then gets off.
  - Queue: A line of items awaiting entry into some process (i.e., grocery store checkout line)
  - Oven: Think of a oven. Open its door, put stuffs in, bake, and unload them.



One more exercise

- Consider you recently open a coffee store where people enter, put in an order, and wait for a product before they leave.
- Two persons can order at a time, and currently two employees are taking orders. It takes about 1 minutes to take a order, and 30 seconds (.5 minutes) to prepare the order by 3 batistes.
- You have 0-3 groups of customers in every minute, and the average group size is about 2. Currently you have four customers in a line to order.

Sensitivity analysis

- Reliability of the Systems Dynamic Modeling
- Test uncertain parameters that cannot be collected from real observations
- Examine the effect of changes in a parameter(s) on system behaviors
- Addition data collection is required if the output(system behavior) is significantly affected by the variation of the parameter.

Sensitivity analysis (Sterman, 2000)

Involves a change in model parameters to examine system behavior patterns (i.e., points and levels of equilibrium / Periods and amplitudes of oscillations.

- Numerical sensitivity: Sensitivity of output values
- Behavior mode sensitivity: Sensitivity of output behavior
- Policy sensitivity: Desirability or suitability of an existing policy
- Behavior pattern sensitivity

Customer Experience Model

Dynamic models help us to…

- ✓ Understand model structure of a complex system
- ✓ Represent hypothesized causal relationships between factors
- ✓ Evaluate changes on outcomes of interest over time
- ✓ Examine consequences of manipulations in one factor of the system on the whole system
- ✓ Plan, implement, and evaluate intervention strategies in collaboration between scientists and managers

However, models are not …

- View a model as an important but imperfect tool, see its output as a parable

- ✓ Attempt at perfect representation of "real-world" system
- ✓ Dependent upon complete data
- ✓ Replacement for traditional analyses
- ✓ Black boxes for decision making

Osgood, N (2010)

Educational Campaign: Active Youth Initiative (AYI) Causal Loop Diagram

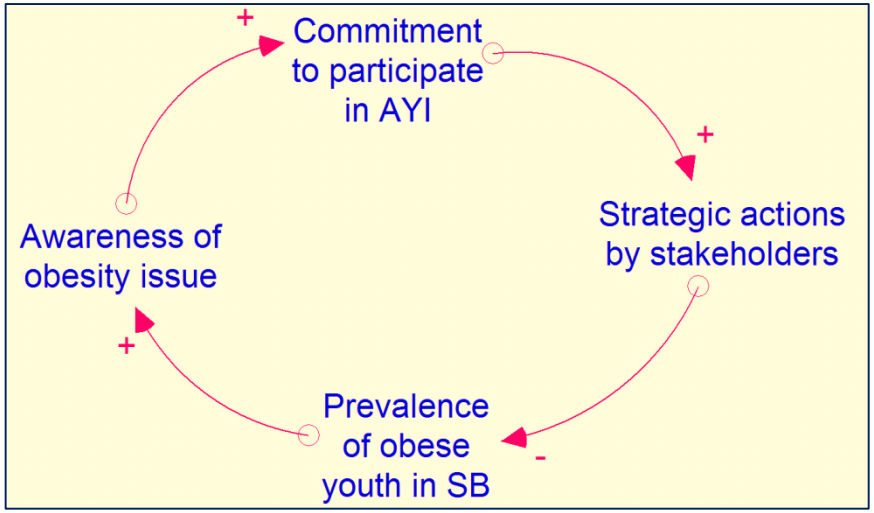
Kiboum Kim, PhD

A warrant for action

The City of South Bend, IN will initiate a campaign to increase active living among 10-14 year old youth in the next four years through a multi-agency, city wide Active Youth Initiative (AYI). This campaign will be spearheaded by the SBPRD. AYI intends to increase active living among the most vulnerable South Bend 10-14 year old youth as well as reduce the prevalence of obesity among this population by 3% over a five year period. AYI will accomplish this with the following:

1) increasing awareness by 15% among South Bend stakeholders (parents, youth serving agencies, public health and medical services, business and industry, and civic leaders);
2) increase the level of intention by 25% of SB stakeholders to officially join in the AYI campaign;
3) increase by 10% of support for AYI in the form of staff time, funding, asset use, or affordances directly related to the target population;
4) become directly involved as a member of AYI Board of Directors [NOTE: could be Steering Committee, Advisory Board, etc.]

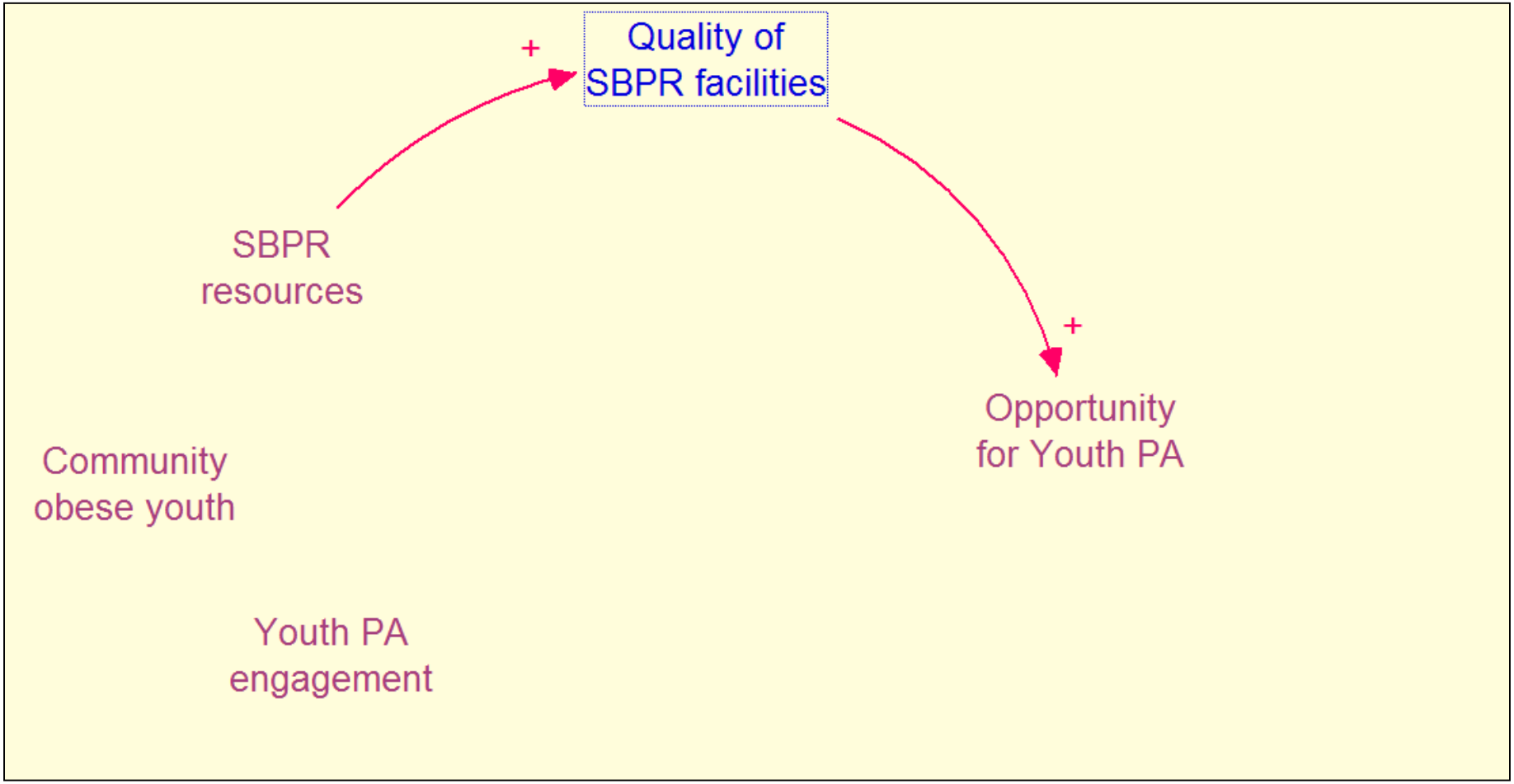
The SB Active Youth Initiative (AYI) CLD: A dynamic educational campaign



"+" represents a same direction.
As "A" increases (decreases), "B" will increase (decrease).

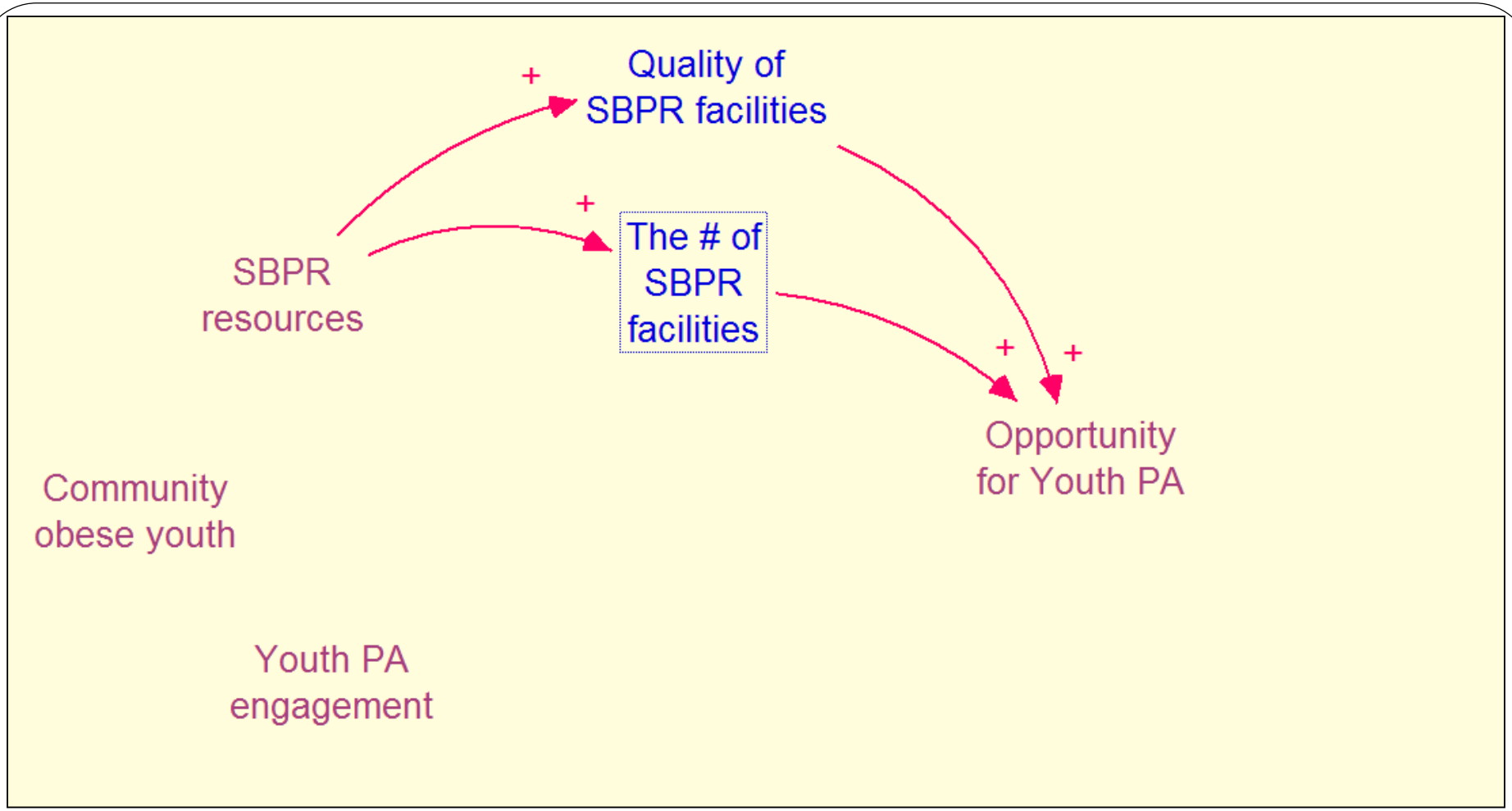
"-" represents a different direction.
As "A" increases (decreases), "B" will decrease (increase).

- ✓ The prevalence of obesity in SB youth rises over the next decade.
- ✓ Increased awareness of the issue is critical for all stakeholders in SB area.
- ✓ Commitment to the AYI by SB agencies, government, business, etc. a key to success.
- ✓ Intentional & collaborative actions by stakeholders directly affect youth, parents, health care costs and social capital.



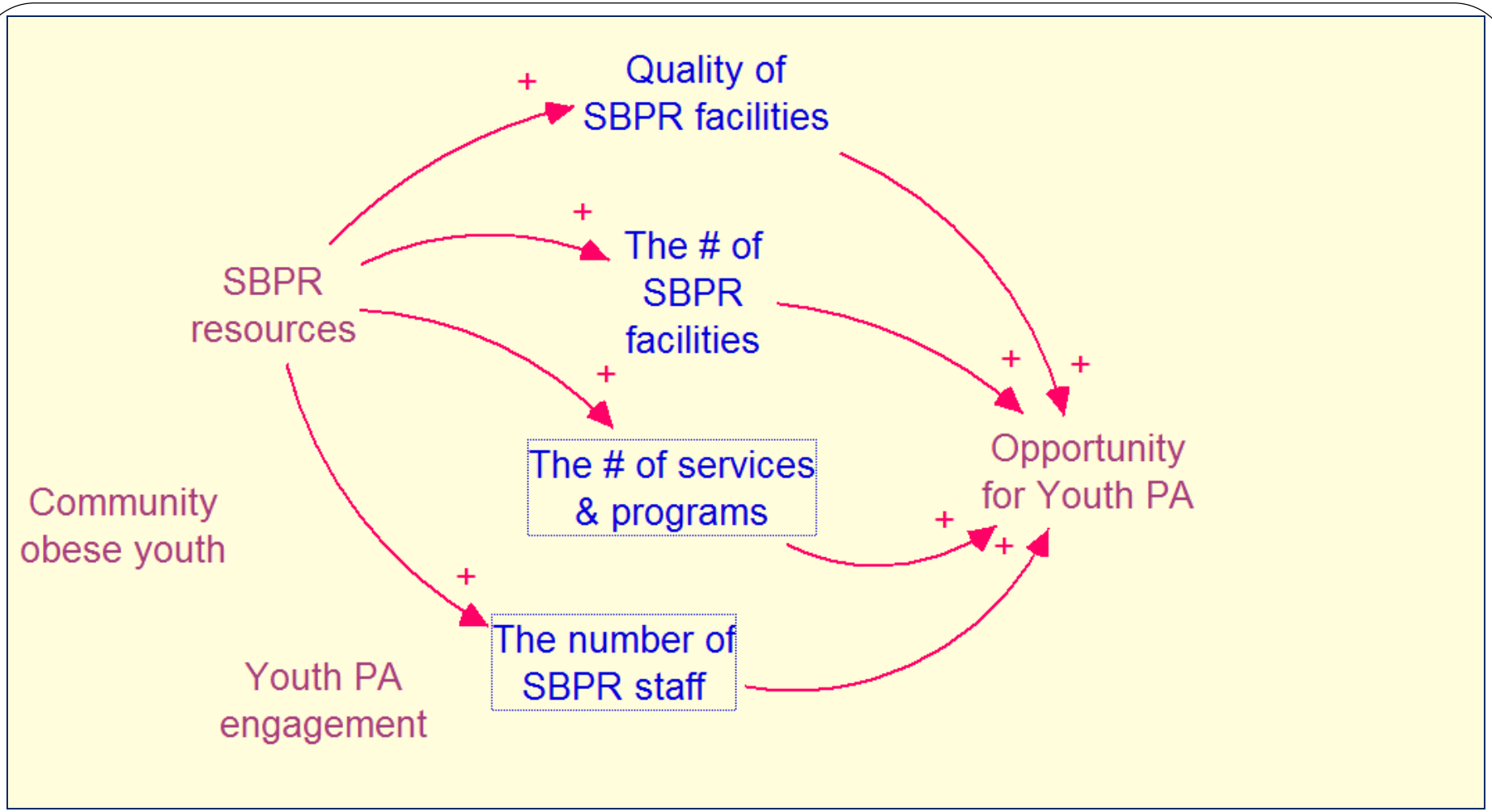
SBPR resources are utilized to provide youth with PA opportunities in several ways including:

1) improving facility quality



SBPR resources are utilized to provide youth with PA opportunities in several ways including:

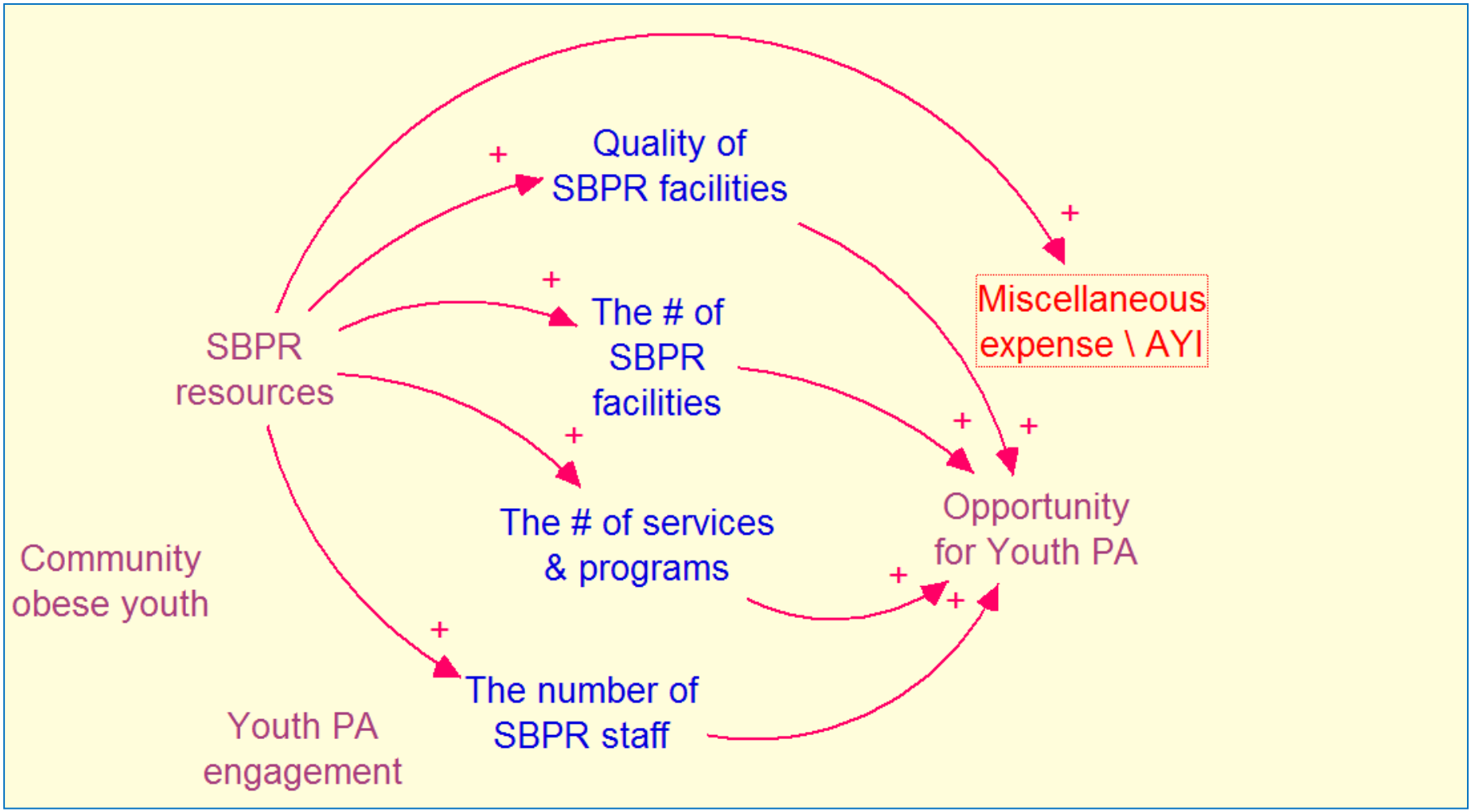
2) constructing a new building



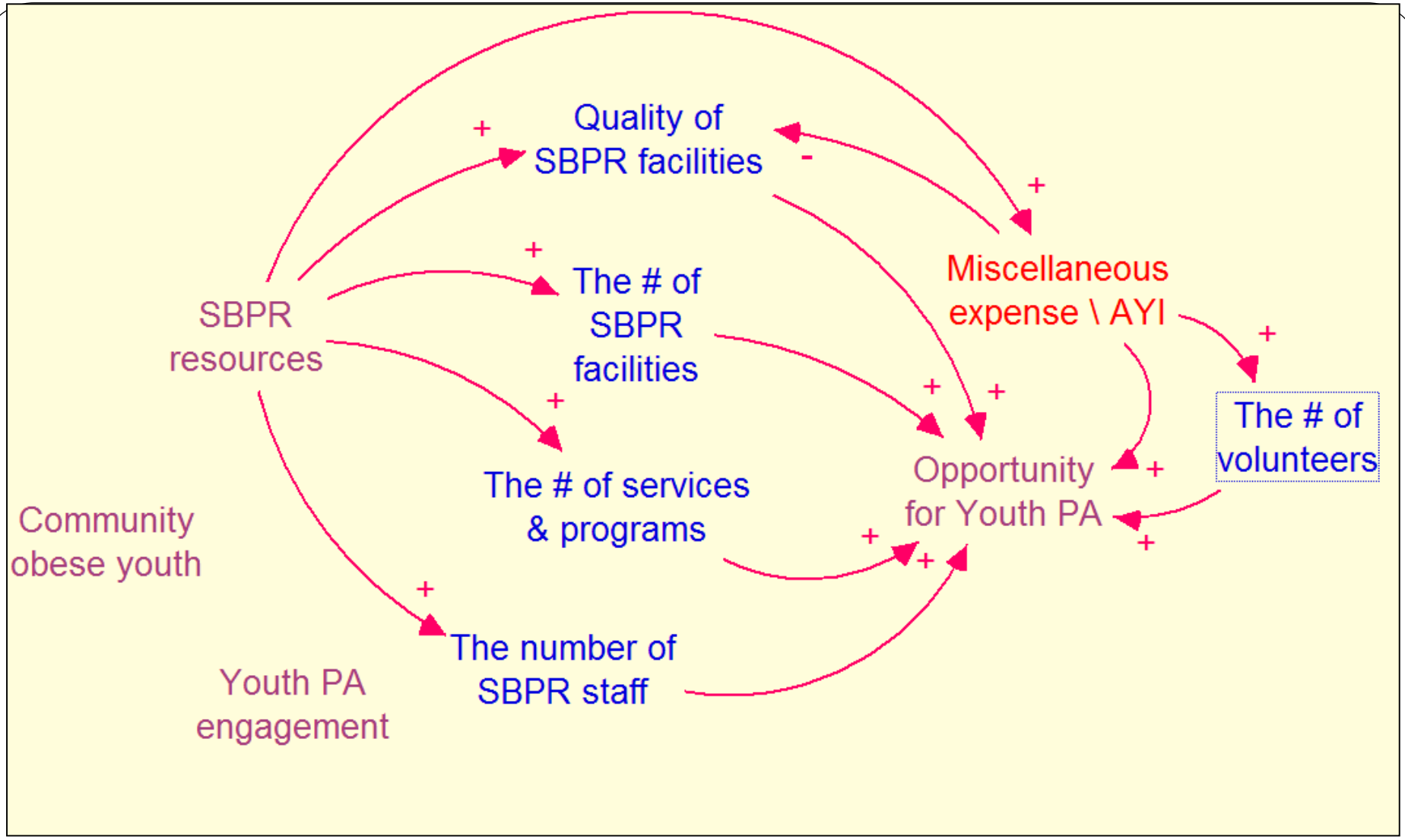
SBPR resources are utilized to provide youth with PA opportunities in several ways including:

3) Providing programs / services, and

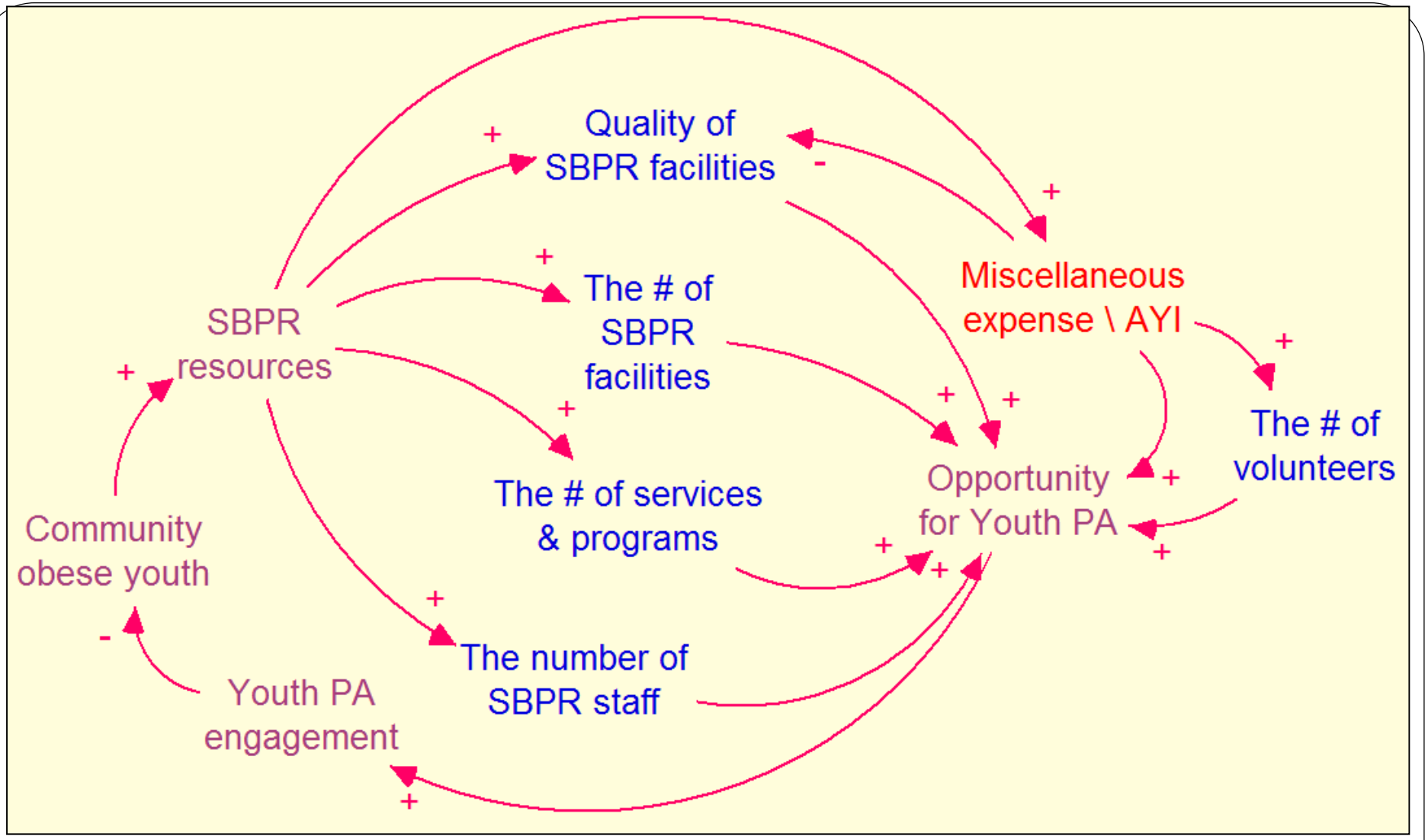
4) Staff salaries



In addition, there are small amount of portion designated for miscellaneous expense which may include a funding for initiating AYI.

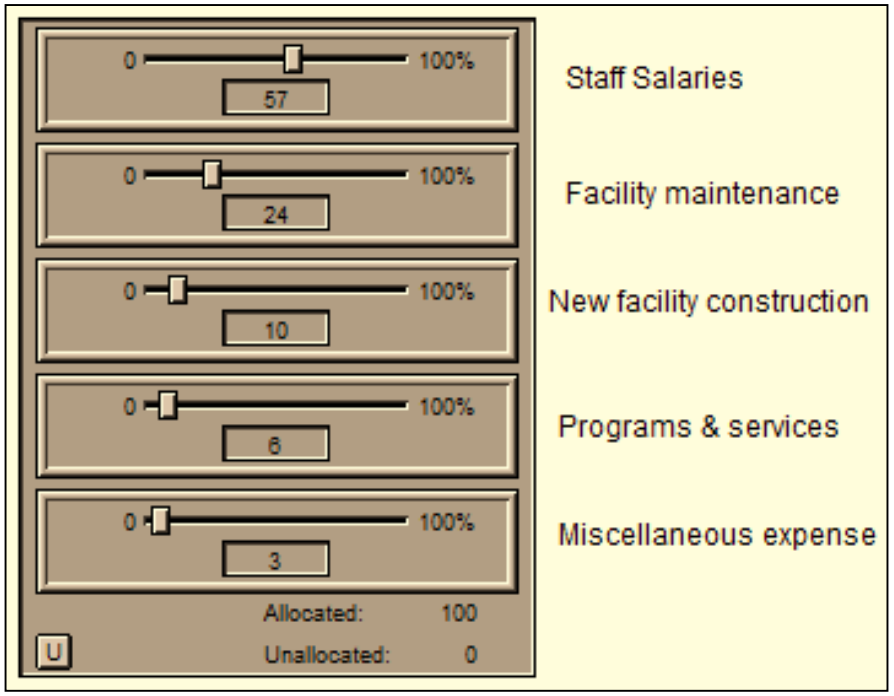


AYI will increase awareness among SB stakeholders, intention to join in the AYI campaign, and collaboration with private sectors as well as facilitating volunteer recruitment, which result in promote PA opportunities for community youth.



As increase in PA opportunities, youth may engage in PA more actively which contributes to preventing child/youth obesity in the community. The decrease in a threat to the child obesity will lead to budget cut in SBPR.

What if...?



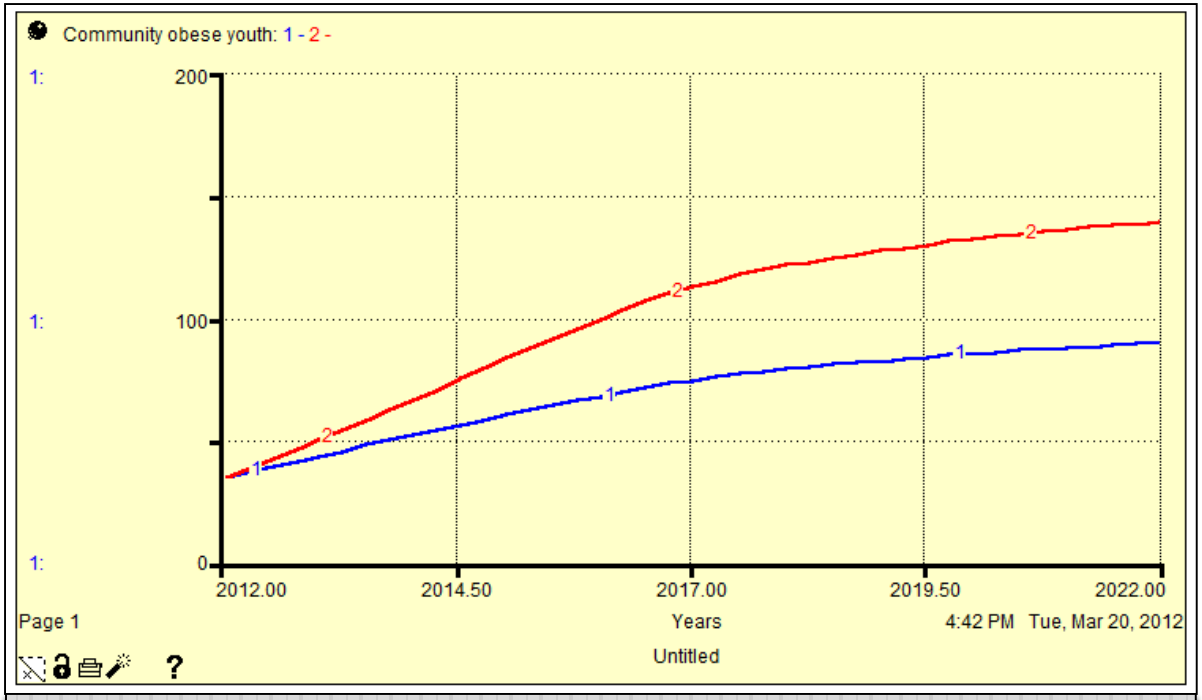
SBPR has a capability to allocate their resources to certain areas such as facility maintenance, staff salaries, building a new facility, programs and services, etc.

What if SBPR takes a 10% of the total budget (new facility construction) and invest these resources in other categories such as developing Active Youth Initiative (AYI) or providing more number of quality programs and services?

Theoretical simulation of youth obesity in South Bend

The red line represents no action is taken by SB stakeholders.

The blue line represents intentional and managed actions taken by SB stakeholders.



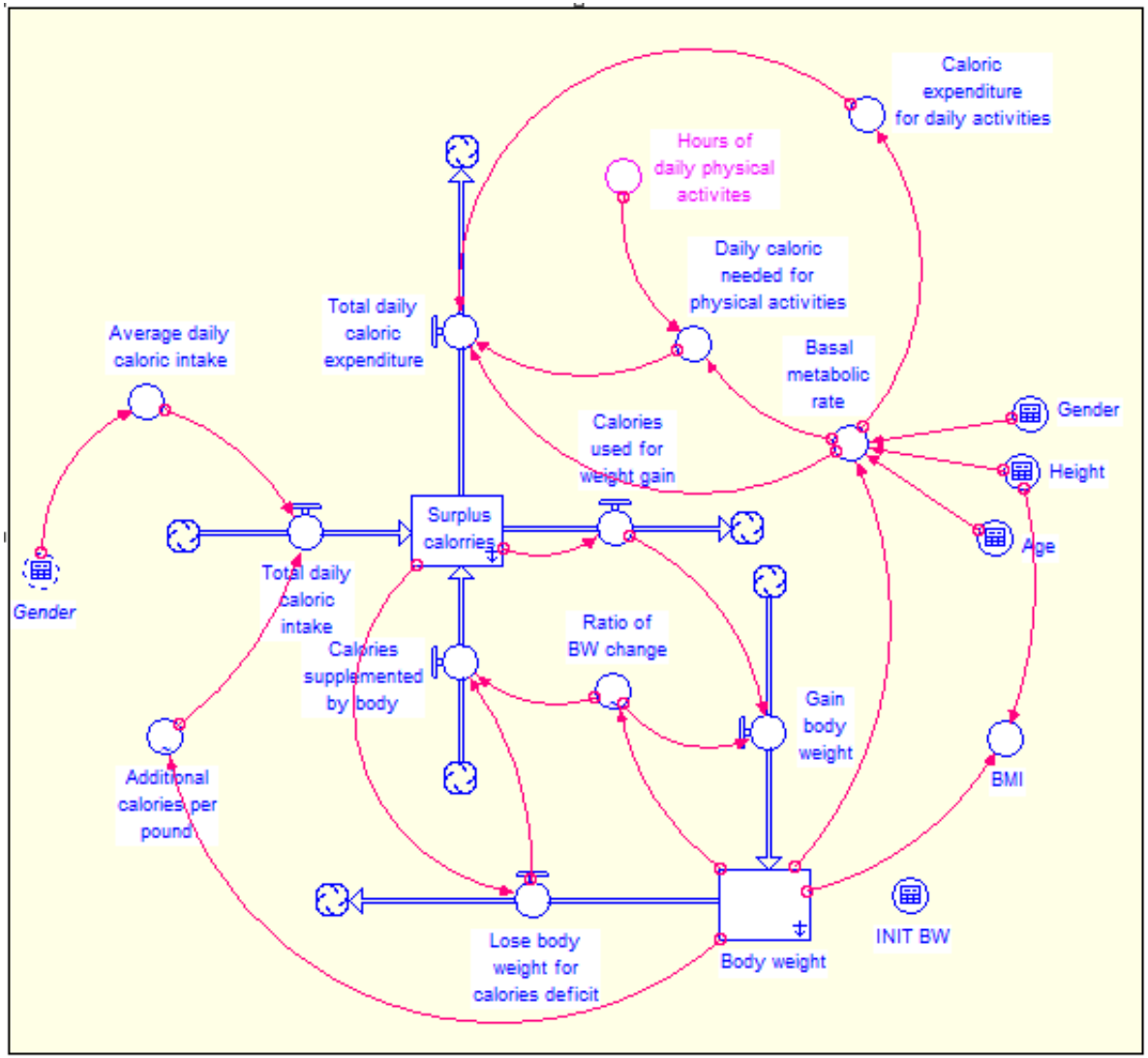
Trend in prevalence of obese youth over 10 years

NOTE: The gap between these lines represents the number of obese youth who will require additional health care, have reduced capacity to carry out daily life activities or work!

Systems simulation of weight change among South Bend youth

Kiboum Kim, PhD

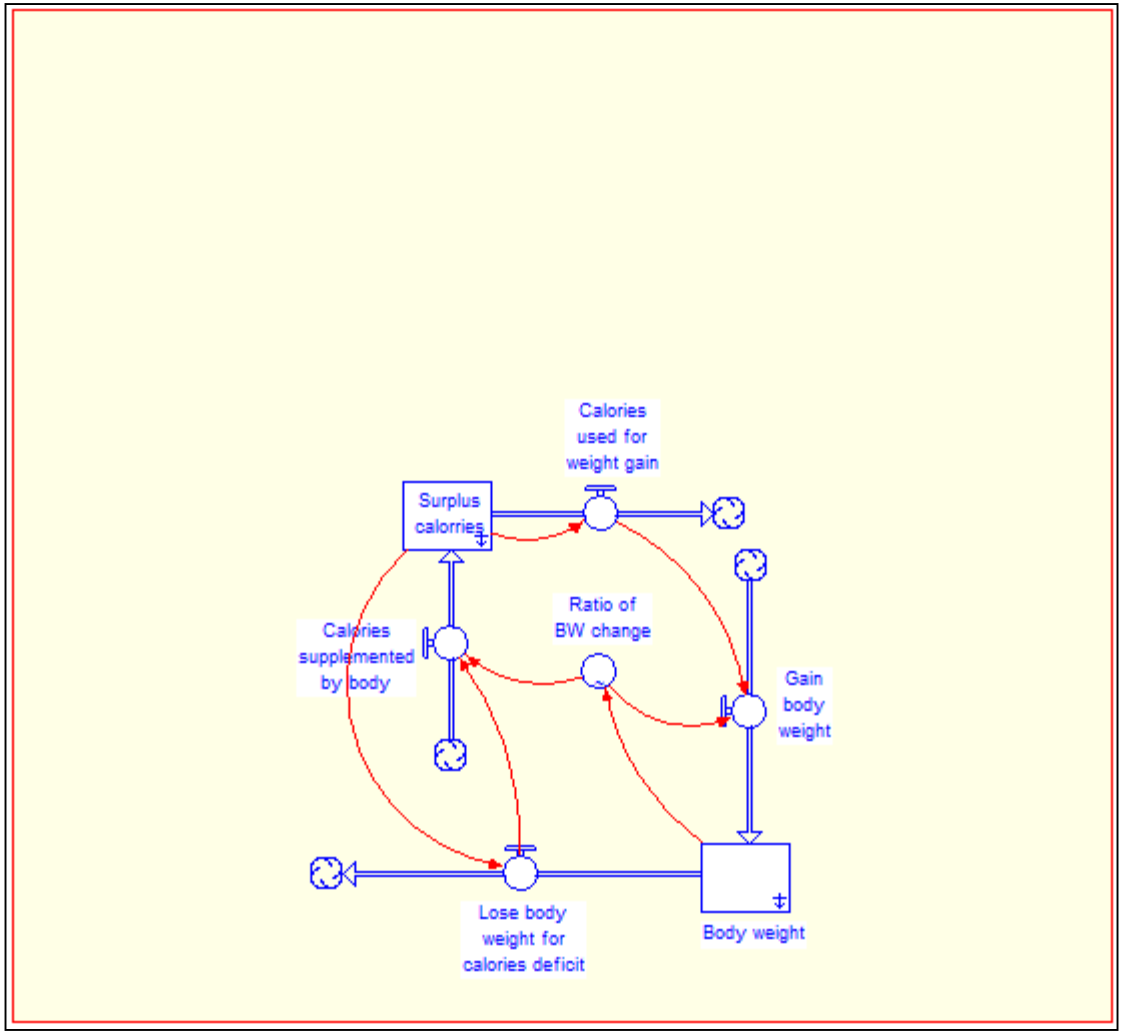
Body weight module



Illustrating the complexity of physiological factors that influence an individual's body weight.

- ✓ Many factors
- ✓ Individual differences
- ✓ Predisposition based on genetics, environment, cultural norms, etc.
- ✓ Change in BW is based on careful design & management

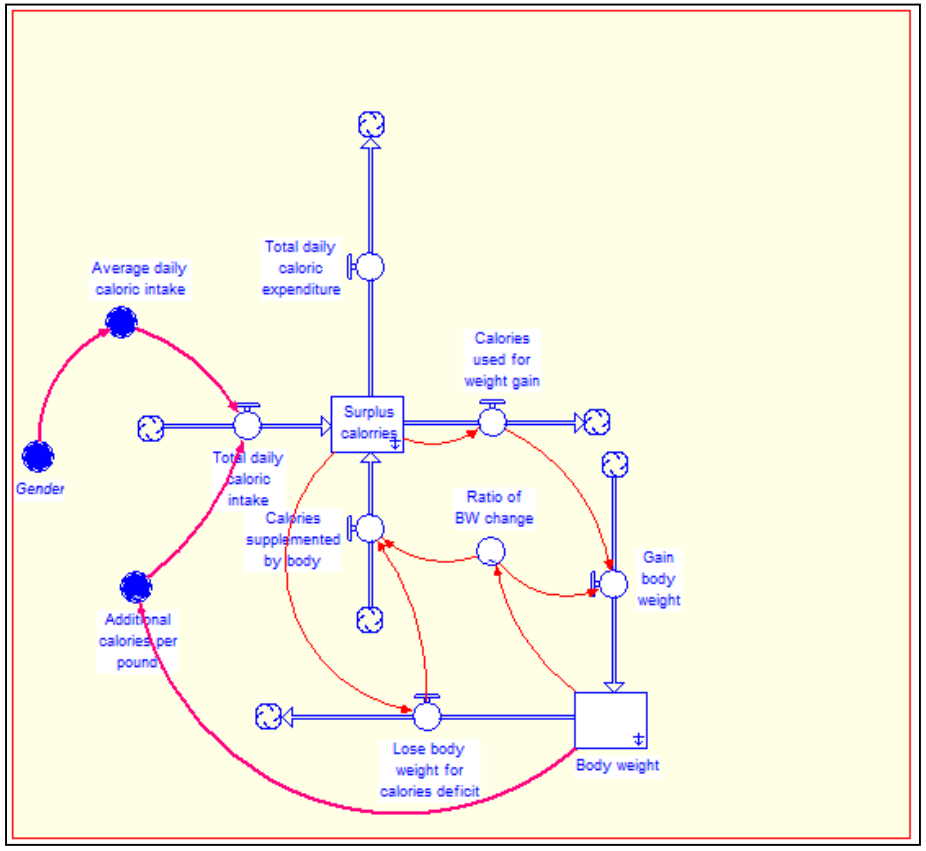
Body weight change



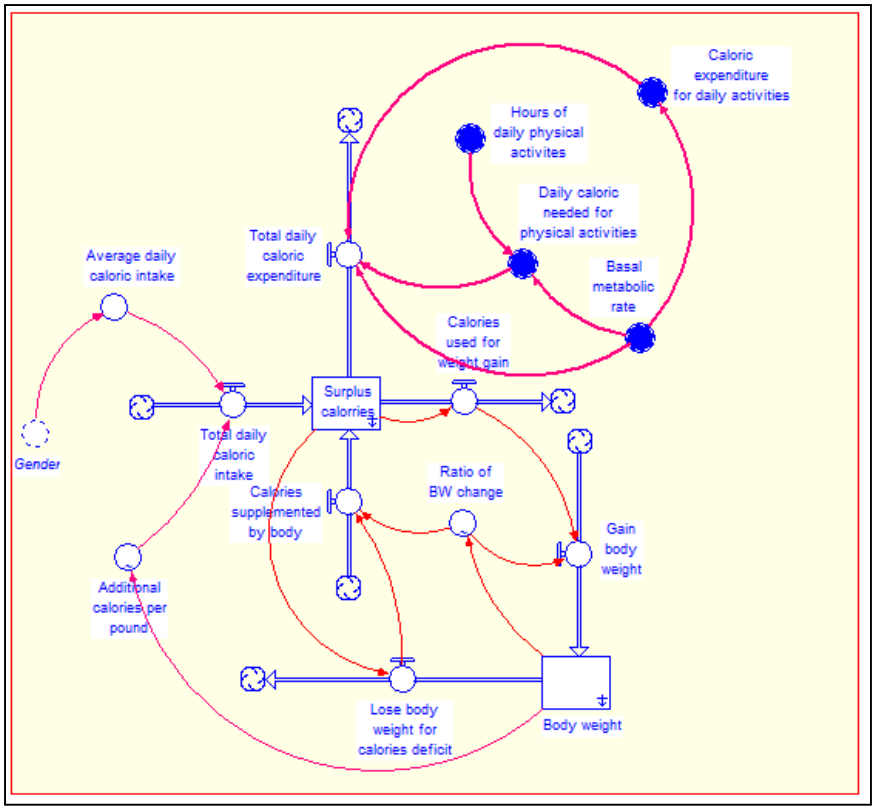
- ✓ When surplus calories are accumulated, a person gains BW.
- ✓ As the amount of surplus calories decreases to a daily target level, one may lose body weight over time.
- ✓ Requires adherence to a regimen

Surplus calories (intake & expenditure)

The amount of surplus calories is a product of the balance between calories intake and expenditure.

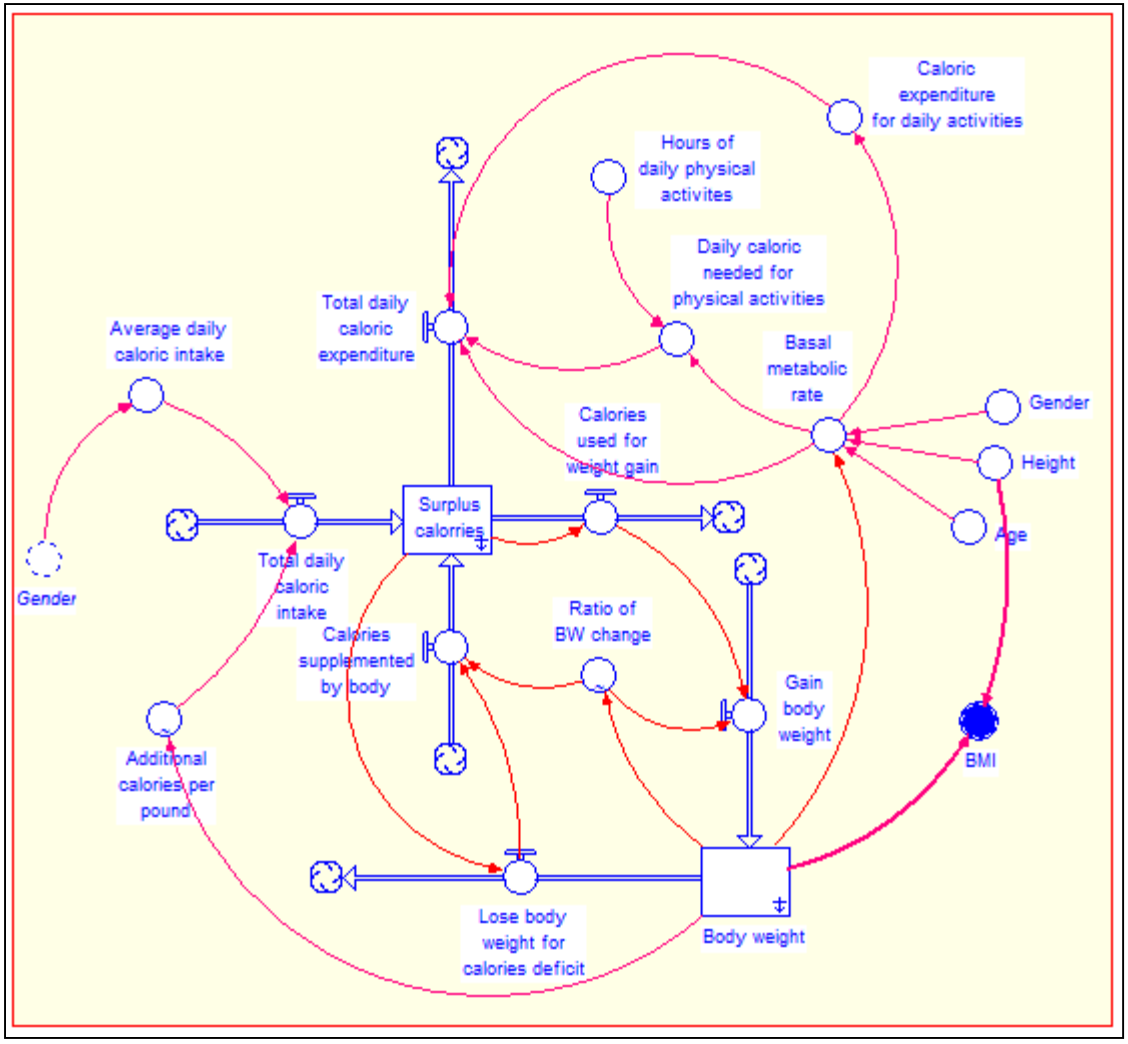


Caloric intake components



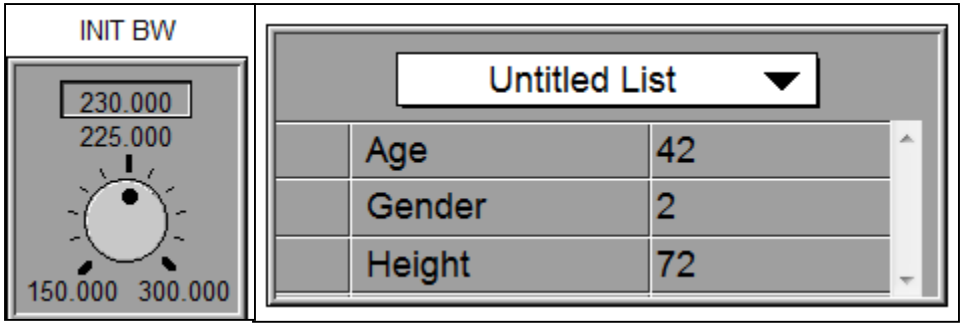
Caloric expenditure components

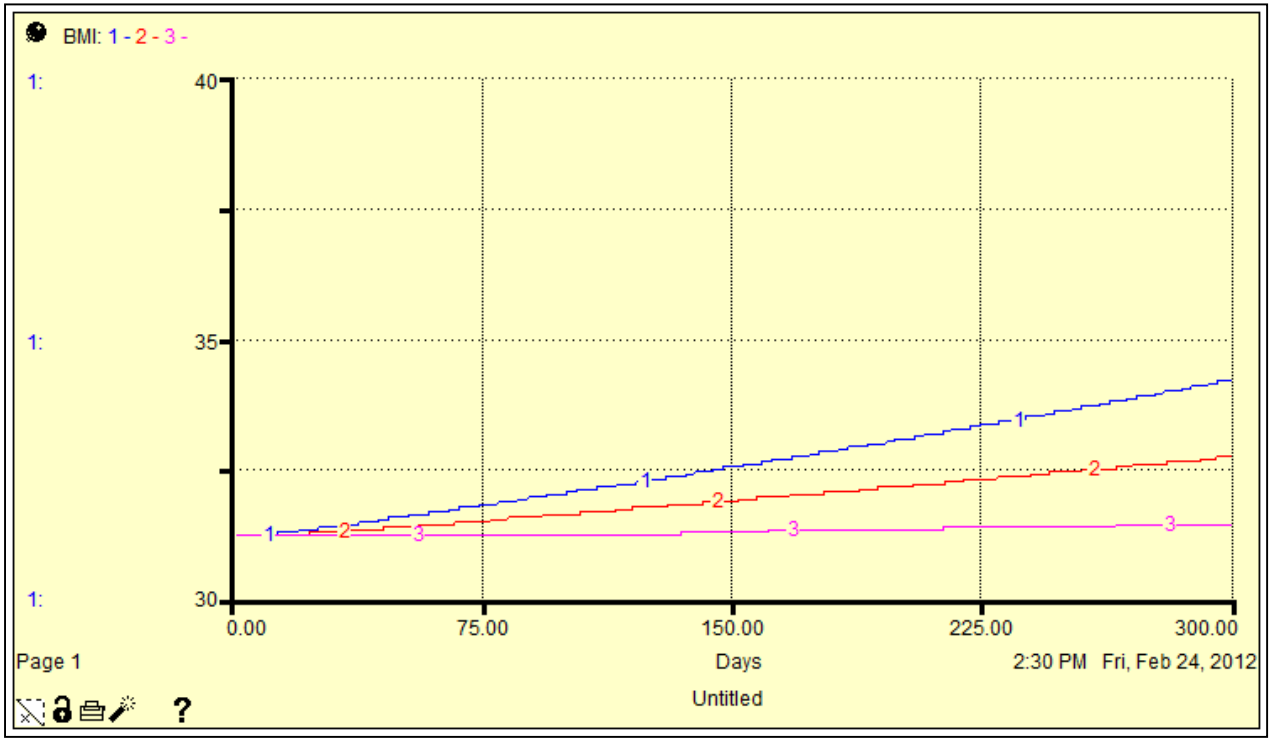
Basal Metabolic Rate



- ✓ The amount of calories required for daily life is associated an individual's basal metabolic rate (BMR).
- ✓ This is a function of gender, age, height, and body weight.
- ✓ The more body weight a person gains, the more BMR increases.
- ✓ Body Mass Index (BMI) is a universal measure

Model simulation (PA Influence)





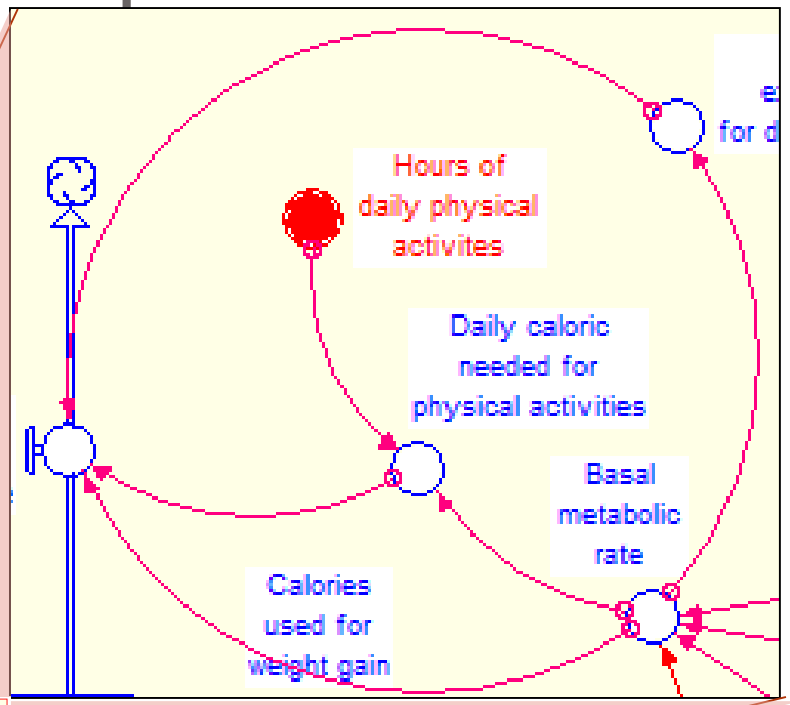
A simulation illustrating changes in an individual's BMI if engaged daily in physical activity:

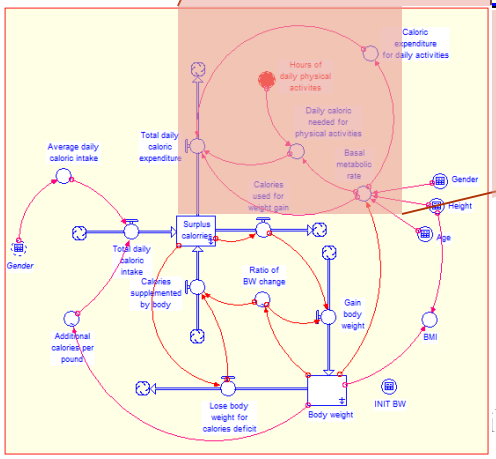
BLUE=0 minutes

ORANGE= 30 minutes

PINK= 60 minutes

Critical component in this module





By increasing the hours of daily physical activity, we increase caloric expenditure by youth. How?

Community efforts