Complexity models

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Models

- Models are simplified representations of the thing of interest; metaphors
- Models have strengths and limits; they trade off generality, precision, realism
- Various models lend themselves to quantitative and/or qualitative use

System characteristics

Simple, complicated

- Homogeneous
- Linear
- Deterministic
- Static
- Lack feedback loops
- Not adaptive or self-organizing

Complex

- Heterogeneous
- Non-linear
- Stochastic (probabilistic; some degree of randomness)
- Dynamic
- Feedback loops
- Tipping points (system behavior changes)
- Adaptive, self-organizing
- Emergent properties

Complex systems

- Complex systems cannot be managed; rather, we interact with them in ways that bring about outcomes as close to what we want as possible
- Complex system models:
  - Lend themselves to organization of facts in terms of principles;
  - Suppress a certain amount of detail
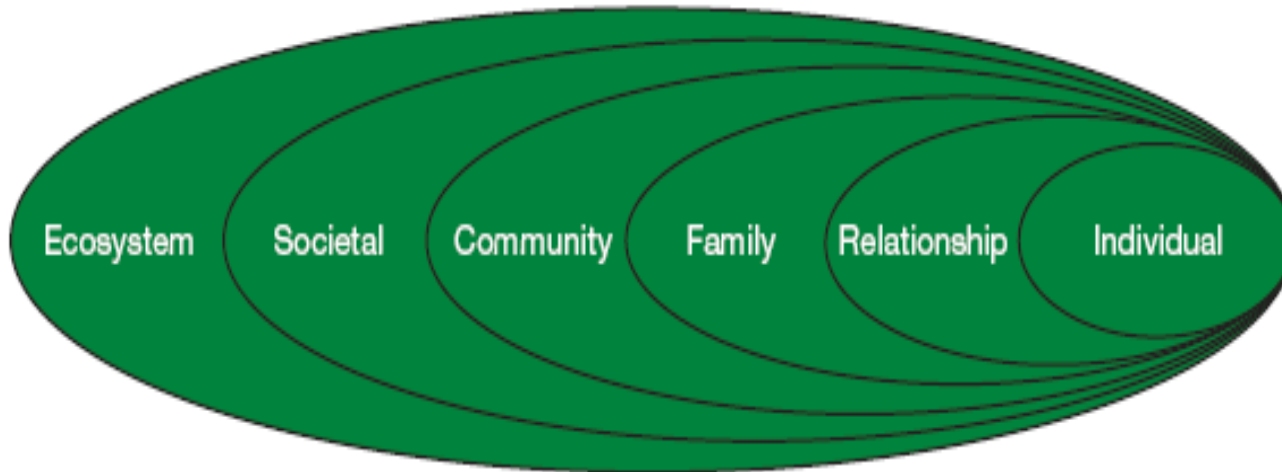 - No single formal model will serve all purposes

Examples

- 1) qualitative; high-level; mapping dimensions
- 2) causal loop model: Foresight obesity model
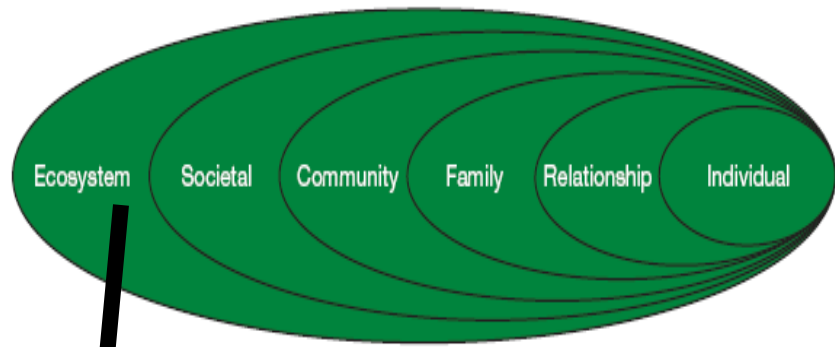
Individual, lifespan perspective
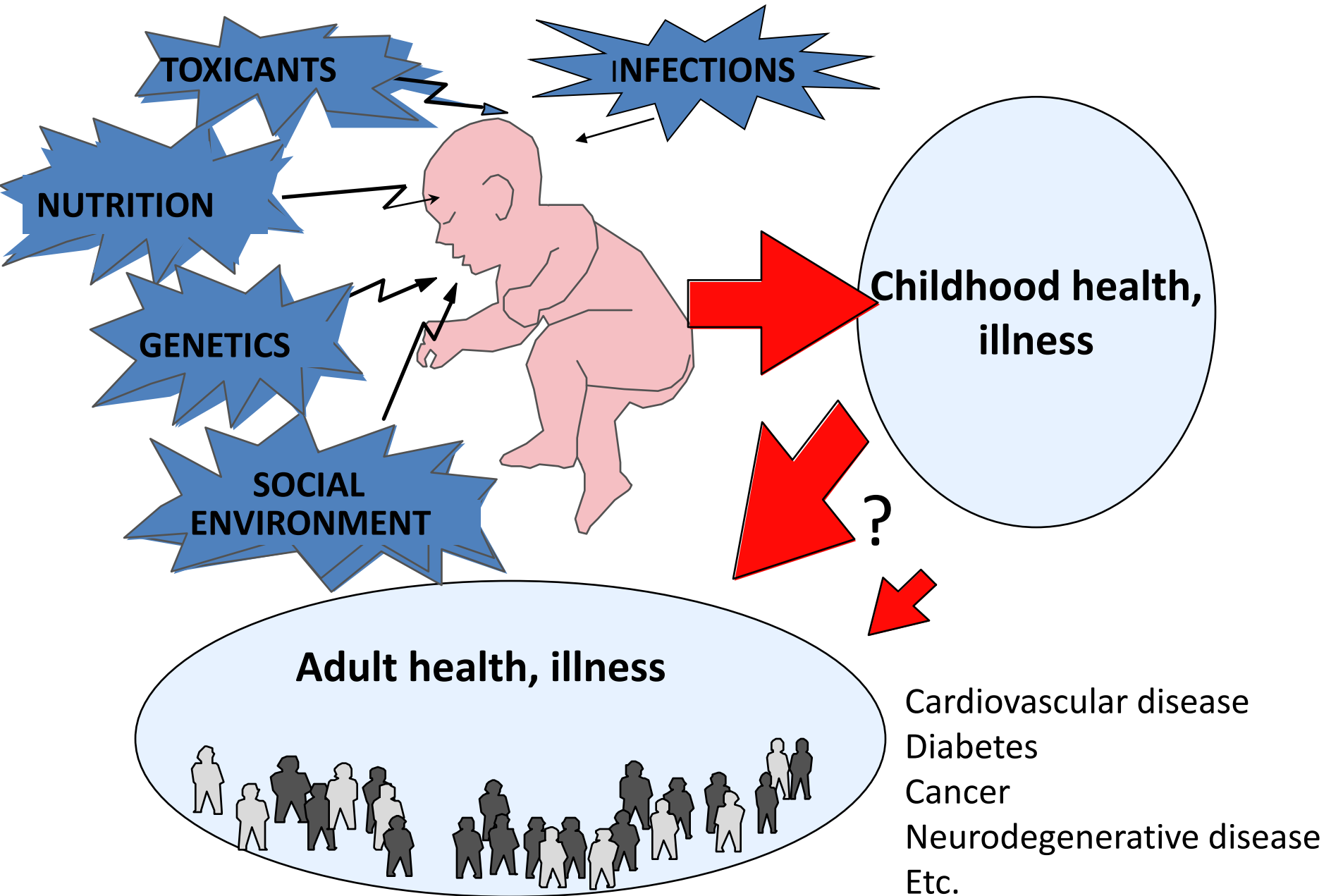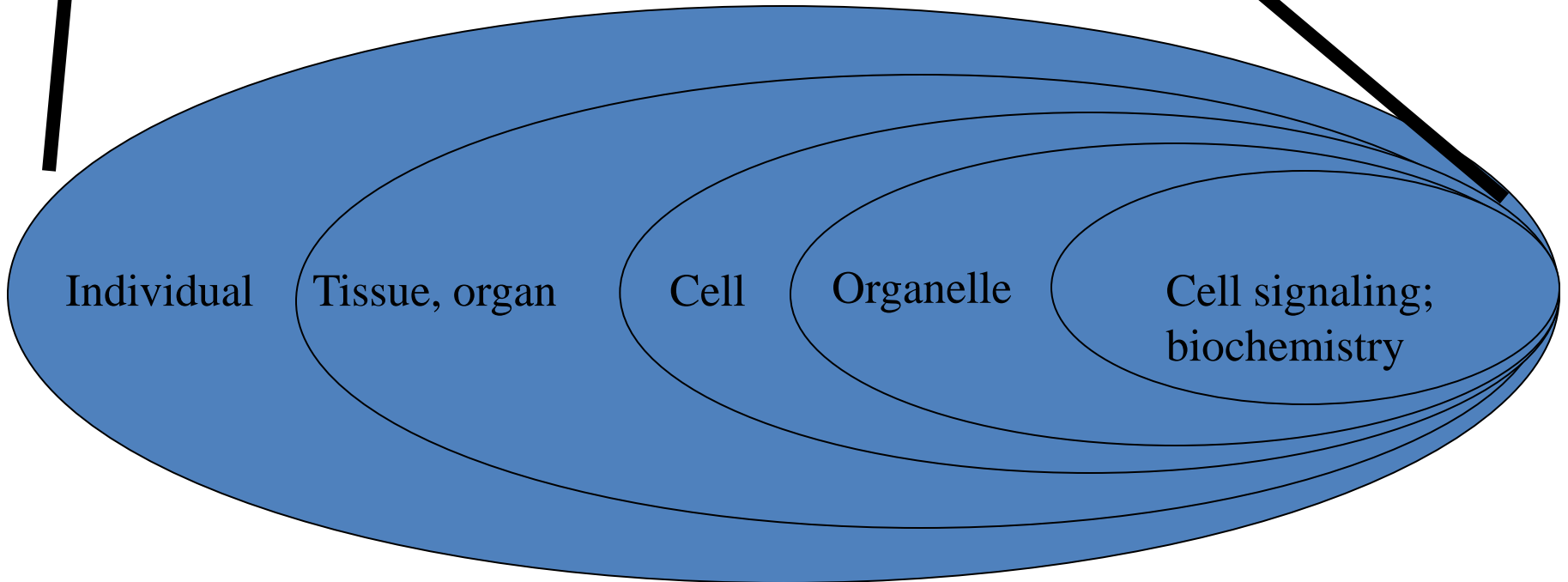
Ecological (eco-social) framework

Ecosystem Societal Community Family Relationship Individual

Multi-level "nesting"

System conditions:
- Relationships and interactions
- Feedback loops
- Complex systems give rise to emergent properties not predictable from knowing about the parts
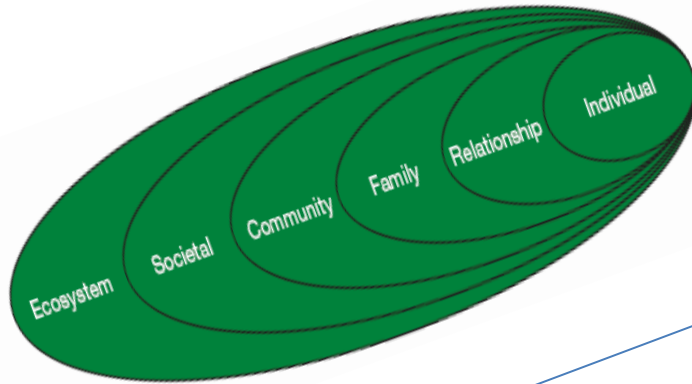
The ecological framework:

"environment getting under the skin"

Ecosystem · Societal · Community · Family · Relationship · Individual

Individual · Tissue, organ · Cell · Organelle · Cell signaling; biochemistry

Ecological Model (Ecosocial)

Multiple variables

Genetic background

Toxic chemicals, pollutants

Radiation

Infections

Physical agents (e.g., heat, noise)

Housing ,

Socioeconomic status

Community safety, assets, services

Access to food, health care

Nutrition

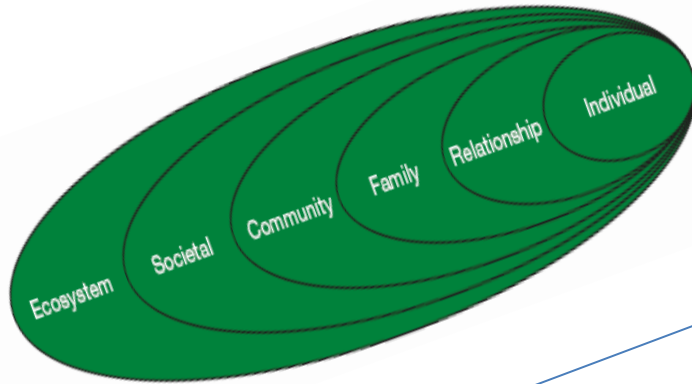**Multiple levels**; nested

Ecological Model (Ecosocial)

Multiple variables
Genetic background
Toxic chemicals, pollutants
Radiation
Infections
Physical agents (e.g., heat, noise)
Housing ,
Socioeconomic status
Community safety, assets, services
Access to food, health care
Nutrition

Multiple levels; nested

Individual
Relationship
Family
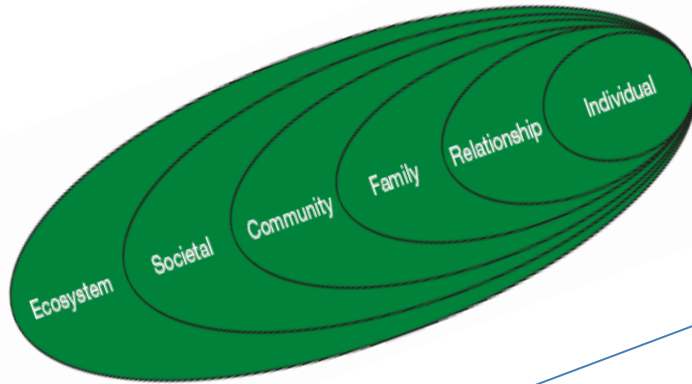Community
Societal
Ecosystem

Scale;
Proportion;
Ratios;
Relationships

-diversity
- the "right mix"; in agriculture, residential/commercial mix in real estate, adequate green space for the number of residents, healthy dietary components, etc.
-Networks, connections

Ecological Model (Ecosocial)

Multiple variables

Genetic background
Toxic chemicals, pollutants
Radiation
Infections
Physical agents (e.g., heat, noise)
Housing ,
Socioeconomic status
Community safety, assets, services
Access to food, health care
Nutrition

Multiple levels; nested

Ecosystem · Societal · Community · Family · Relationship · Individual

Scale;
Proportion;
Ratios;
Relationships

Time
 - timing of exposures or events
 - cyclicity, rhythmicity
 - latency
 - personal lifespan, aging
 - intergenerational time
 - recent historical time (decades, century)
 - evolutionary time

Ecological Model (Ecosocial)

Multiple variables

Multiple levels; nested

Ecosystem
Societal
Community
Family
Relationship
Individual
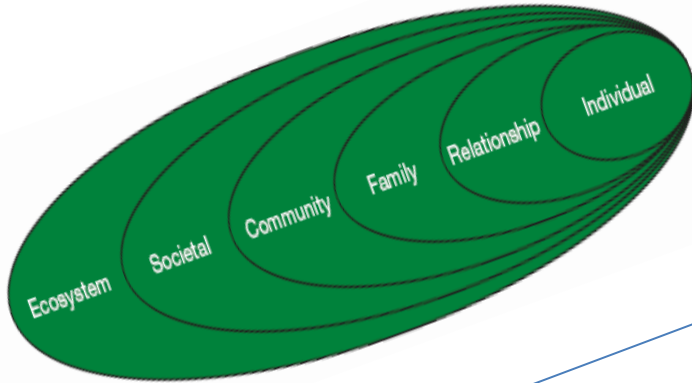
Time

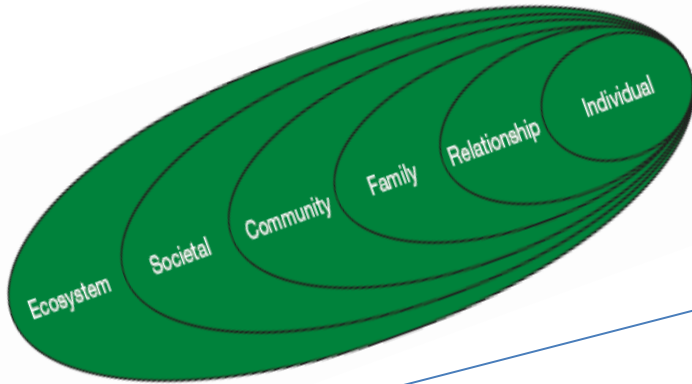**Scale**;
Proportion;
Ratios;
Relationships

Aesthetic
 - response to pattern, beauty
 - response to nature
 - response to an aesthetically
      barren environment

Ecological Model (Ecosocial)

Multiple variables

Multiple levels; nested

Ecosystem · Societal · Community · Family · Relationship · Individual

Spiritual
- inner path
- immaterial reality
- may be secular or religious
- influences worldviews; how people act in the world

Scale;
**Proportion**;
Ratios;
Relationships

Aesthetic

Time

Causal loop model

- A useful way to represent dynamic interrelationships

- Provide a visual representation with which to communicate that understanding

- Make explicit one's understanding of a system structure - Capture the mental model

-Importance of physical need
-Conscious control of accumulation
-Effort to acquire energy
-Tendency to preserve energy
-What/how much is available
-Strength of lock-in to accumulate
       energy

Positive and negative feedback loops;
e.g. locked in to positive energy balance
through acquiring certain habits vs.
stopping eating when not hungry
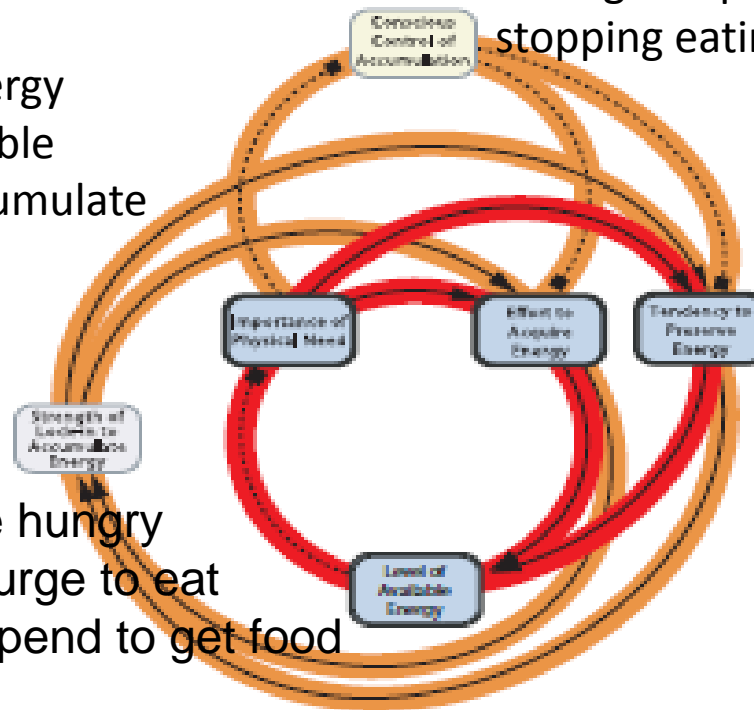
System behavior often
non-linear;

Depending on system
conditions and how and
where a system is
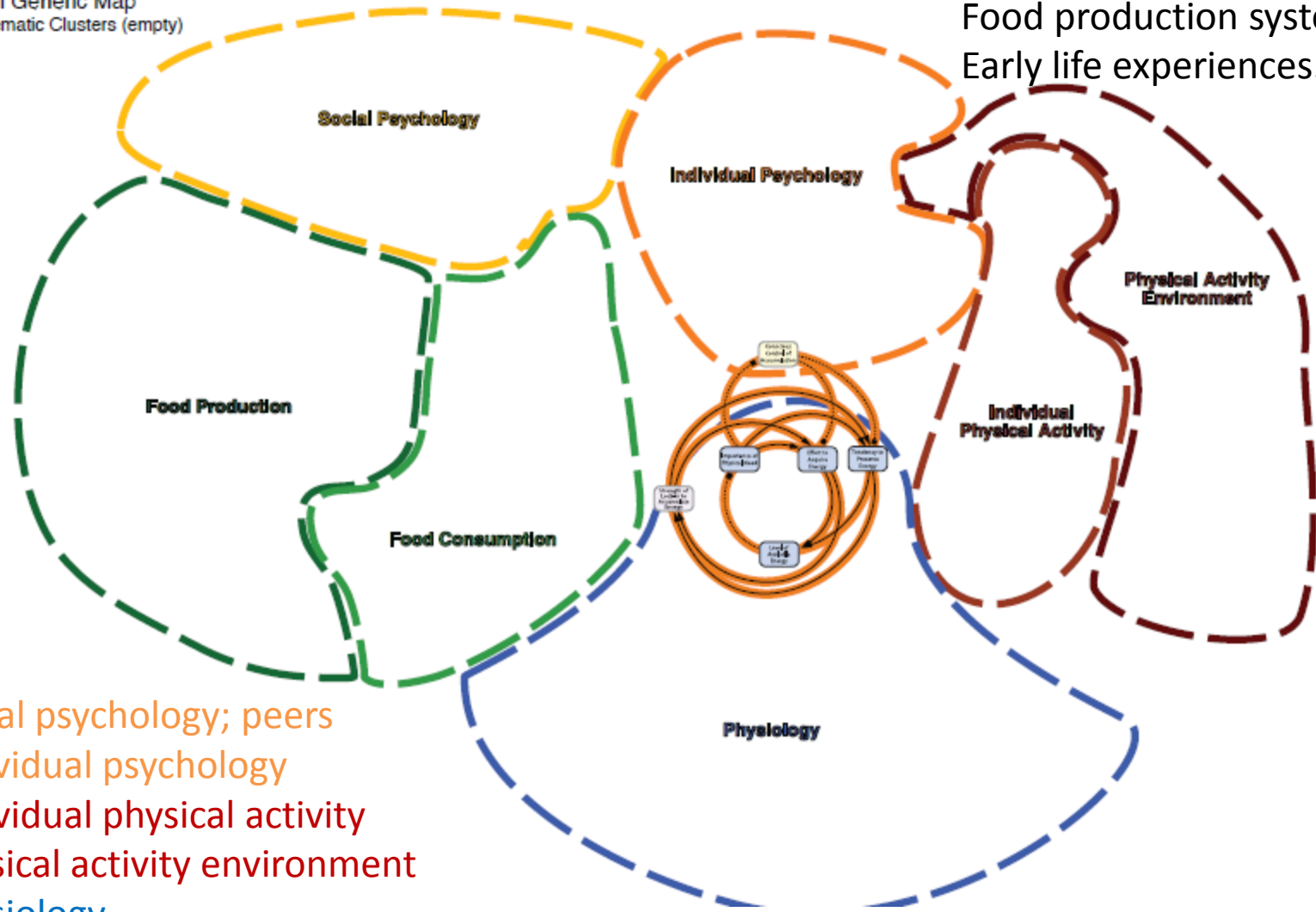perturbed, feedback loops
may change direction

Do you care if you are hungry
Can you control your urge to eat
How much willing to spend to get food
Your own physiology
What's available
My style of eating

Foresight obesity model

http://www.bis.gov.uk/foresight/our-work/projects/published-projects/tackling-obesities

Full Generic Map
Thematic Clusters (empty)

Social Psychology

Individual Psychology

Physical Activity Environment

Food Production

Individual Physical Activity

Food Consumption

Physiology

Media
Education
Food production system
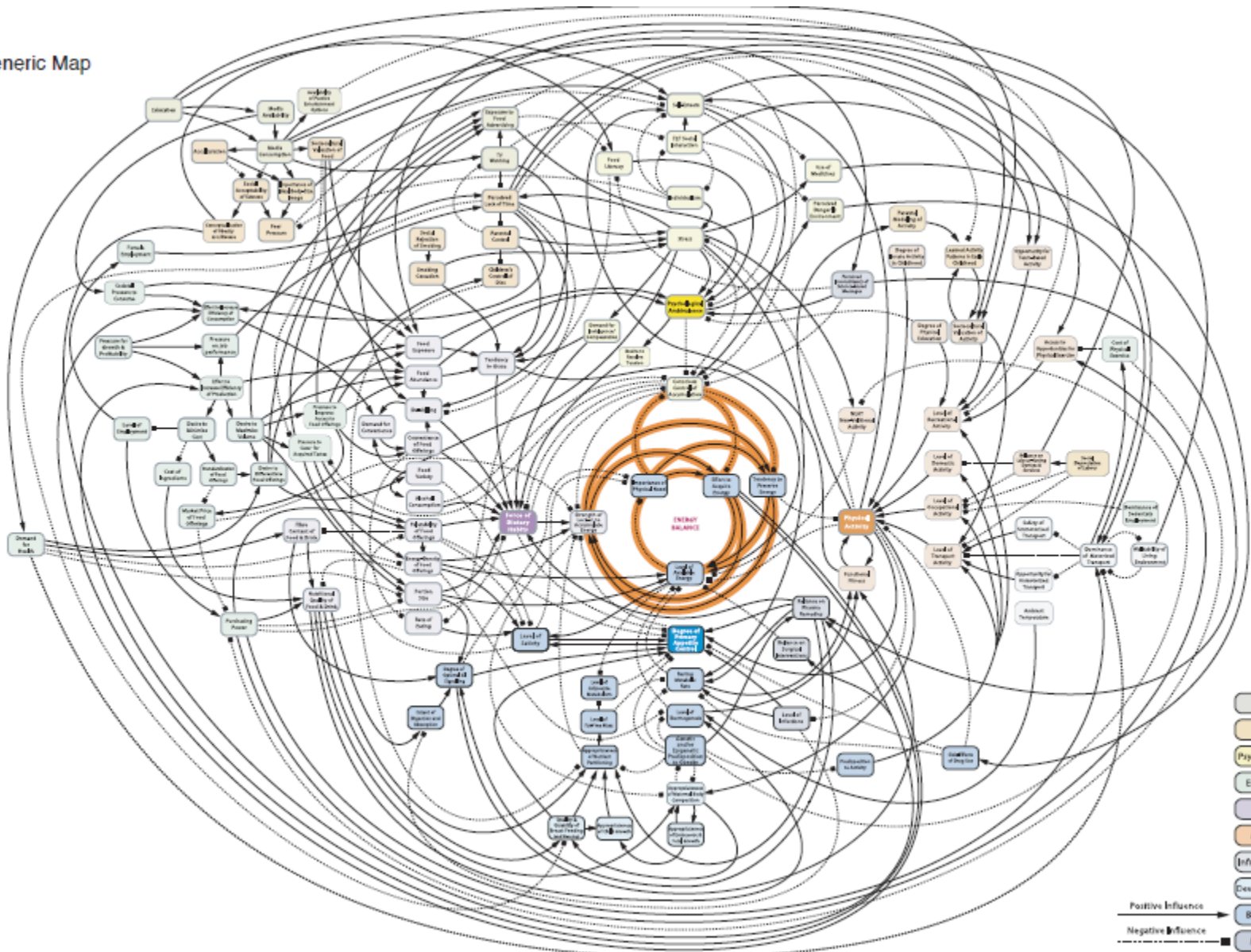Early life experiences. etc

Social psychology; peers
Individual psychology
Individual physical activity
Physical activity environment
Physiology
Food consumption
Food production

Generic Map

Positive Influence →
Negative Influence ■

Why do this?

- **to make sense of complexity**.
  - constructing or studying a causal loop model helps in understanding the system
  - In particular, once the top-level architecture of a model (rather than its fine detail) has been absorbed, it becomes a powerful filter for identifying relevant variables and an aid to thinking about the issue.

- **to communicate complexity.**
  - The anatomy of a system map is a clear confirmation of the inescapably systemic and messy nature of the issue under study. This highlights the need for broad and diversified policies or strategies to change the dynamics of the system.

Why do this?

- **to support the development of a strategy(s) to intervene in a complex system.**
  - Careful study of a causal loop model will reveal features that help in deciding where to intervene most effectively in the system. These features are: leverage points, feedback loops and causal cascades

Effectiveness, difficulty

9. Numbers (subsidies, taxes, standards).
8. Material stocks and flows.
7. Regulating negative feedback loops.
6. Driving positive feedback loops.
5. Information flows.
4. The rules of the system (incentives, punishment, constraints).
3. The power of self-organization.
2. The goals of the system.
1. The mindset or paradigm out of which the goals, rules, feedback structure arise.

D Meadows; Places to Intervene in a System