

Introduction: Themes in the Study of Life

Lecture 1

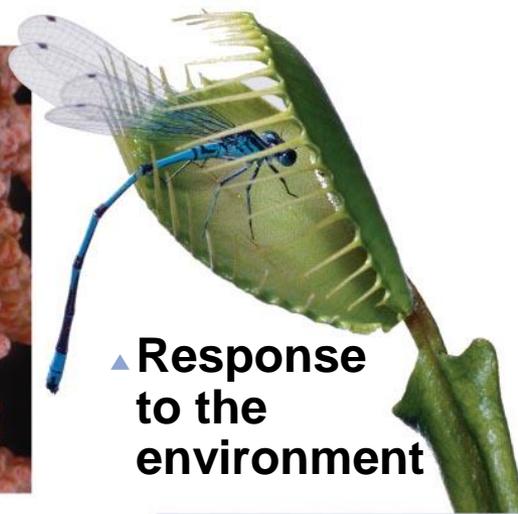
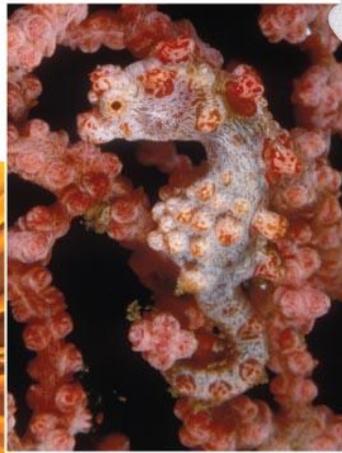
Presented by:
Dr. Samer Y. Alqaraleh

Overview: Inquiring About the **World of Life**

- **Evolution** is the process of change that has transformed life on Earth.
 - **Biology** is the scientific study of life. **Bio**: life, **logy**: Science
 - Biologists ask questions such as:
 - How a single cell develops into an organism?
 - How the human mind works ?
 - How living things interact in communities?
-

Some properties of life

▼ Order



▲ Response to the environment

▲ Evolutionary adaptation



▲ Regulation



▲ Energy processing



▲ Growth and development



▲ Reproduction

-
- **Evolution** makes sense of everything we know about living organisms.
 - It's the central theory of biology.
 - Evolution provides a unifying framework that explains the **diversity**, **complexity**, and **adaptation** of life on Earth.
 - Organisms living on Earth are modified descendants of common ancestors
-

Theme: New properties emerge at each level in the biological hierarchy

- Life can be studied at different levels from molecules to the entire living planet
 - The study of life can be divided into different levels of biological organization
-

Biological hierarchy



Emergent Properties

- **Emergent properties** result from the arrangement and interaction of parts within a system
 - Emergent properties characterize nonbiological entities as well
 - For example, a functioning bicycle emerges only when all of the necessary parts connect in the correct way
-

The Power and Limitations of Reductionism

- **Reductionism** is the reduction of complex systems to simpler components that are more manageable to study
 - For example, the molecular structure of DNA
 - An understanding of biology balances between reductionism and the study of emergent properties
 - For example, new understanding comes from studying the interactions of DNA with other molecules
-

Systems Biology

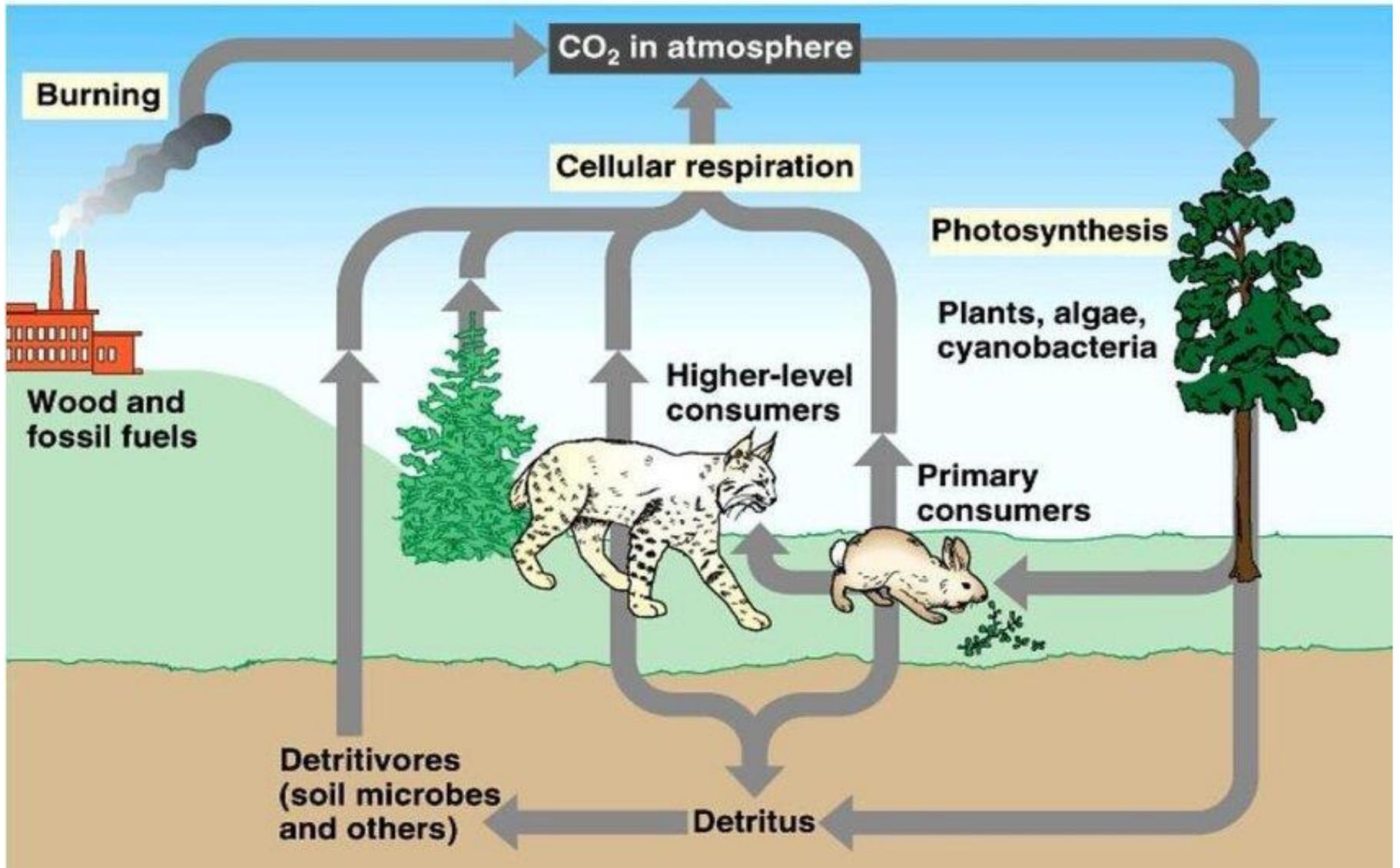
- A **system** is a combination of components that function together
 - **Systems biology** constructs models for the dynamic behavior of whole biological systems
 - The systems approach poses questions such as:
 - How does a drug for blood pressure affect other organs?
 - How does increasing CO₂ alter the biosphere?
-

Theme: Organisms interact with their environments, exchanging matter and energy

- Every organism interacts with its environment, including nonliving factors and other organisms
 - Both organisms and their environments are affected by the interactions between them
 - **For example**, a tree takes up water and minerals from the soil and carbon dioxide from the air; the tree releases oxygen to the air and roots help form soil.
-

Ecosystem Dynamics

- The dynamics of an ecosystem include two major processes:
 - **Cycling of nutrients**, in which materials acquired by plants eventually return to the soil
 - **The flow of energy** from sunlight to producers to consumers
-

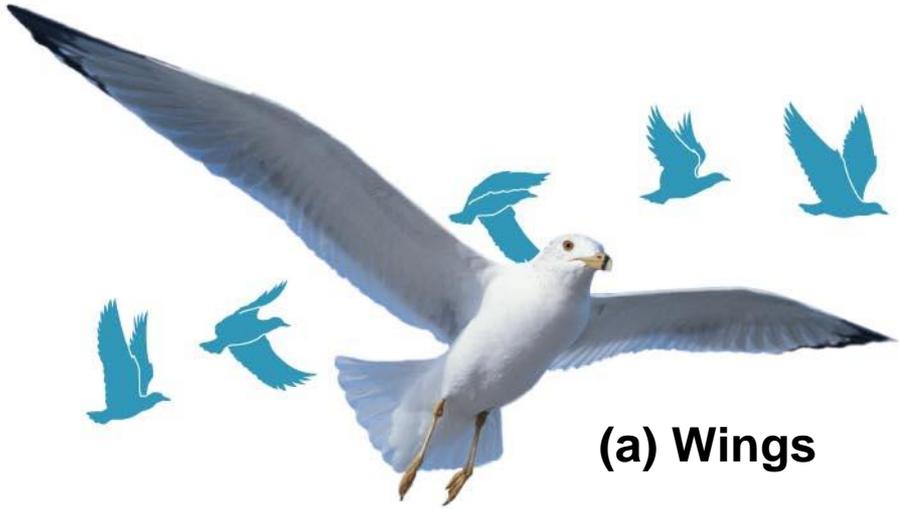


Energy Conversion

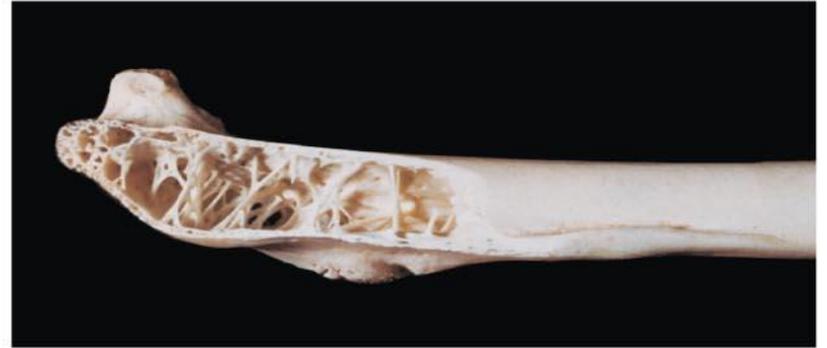
- Work requires a source of energy
 - Energy can be stored in different forms, for example, light, chemical, kinetic, or thermal
 - The energy exchange between an organism and its environment often involves energy transformations
 - Energy flows *through* an ecosystem, usually entering as light and exiting as heat
-

Theme: Structure and function are correlated at all levels of biological organization

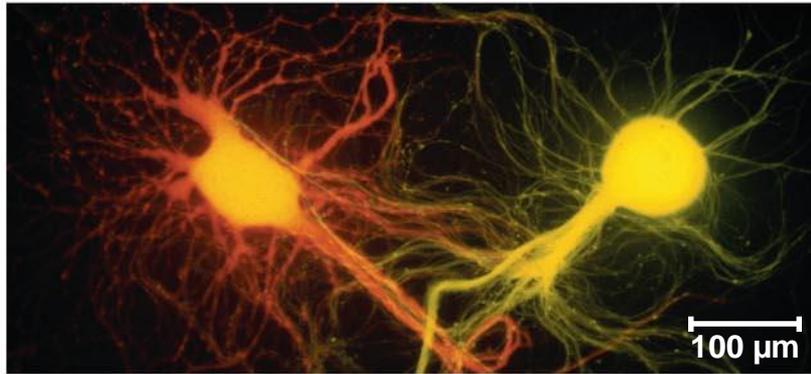
- Structure and function of living organisms are closely related
 - For example, a leaf is thin and flat, maximizing the capture of light by chloroplasts



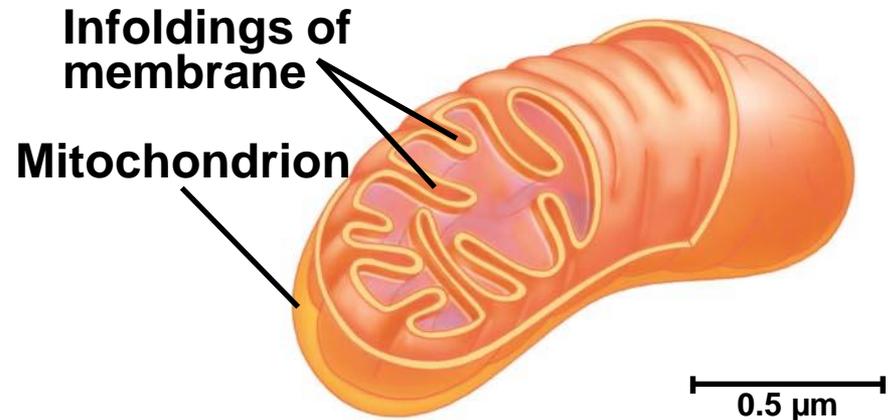
(a) Wings



(b) Bones



(c) Neurons



(d) Mitochondria

Theme: Cells are an organism's basic units of structure and function

- The **cell** is the lowest level of organization that can perform all activities required for life
 - All cells:
 - Are enclosed by a membrane
 - Use DNA as their genetic information
 - The ability of cells to divide is the basis of all reproduction, growth, and repair of multicellular organisms
-

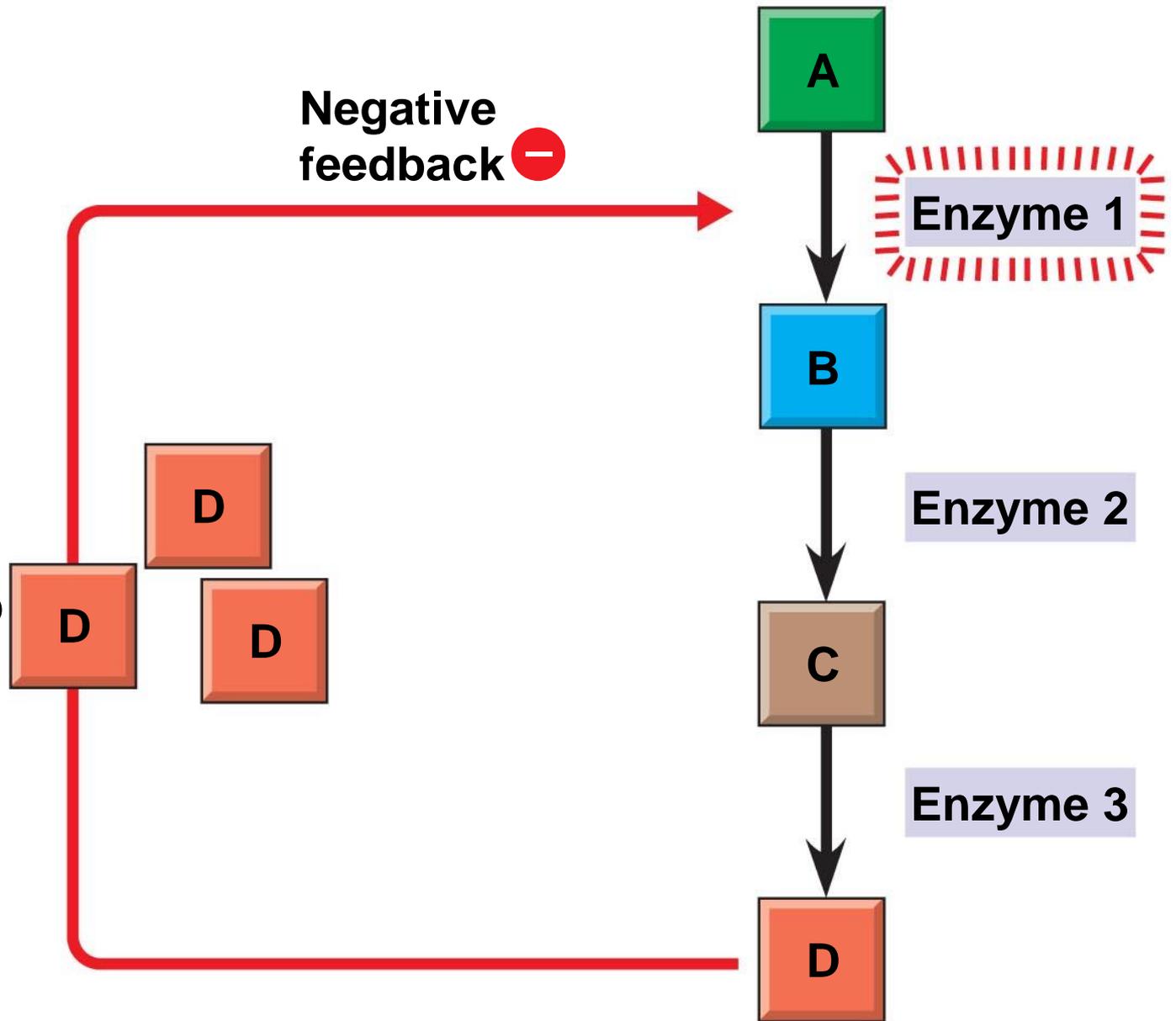
-
- Advances in **systems biology** at the cellular and molecular level depend on:
 - “High-throughput” technology, which yields enormous amounts of data
 - **Bioinformatics**, which is the use of computational tools to process a large volume of data
 - Interdisciplinary research teams
-

Theme: Feedback mechanisms regulate biological systems

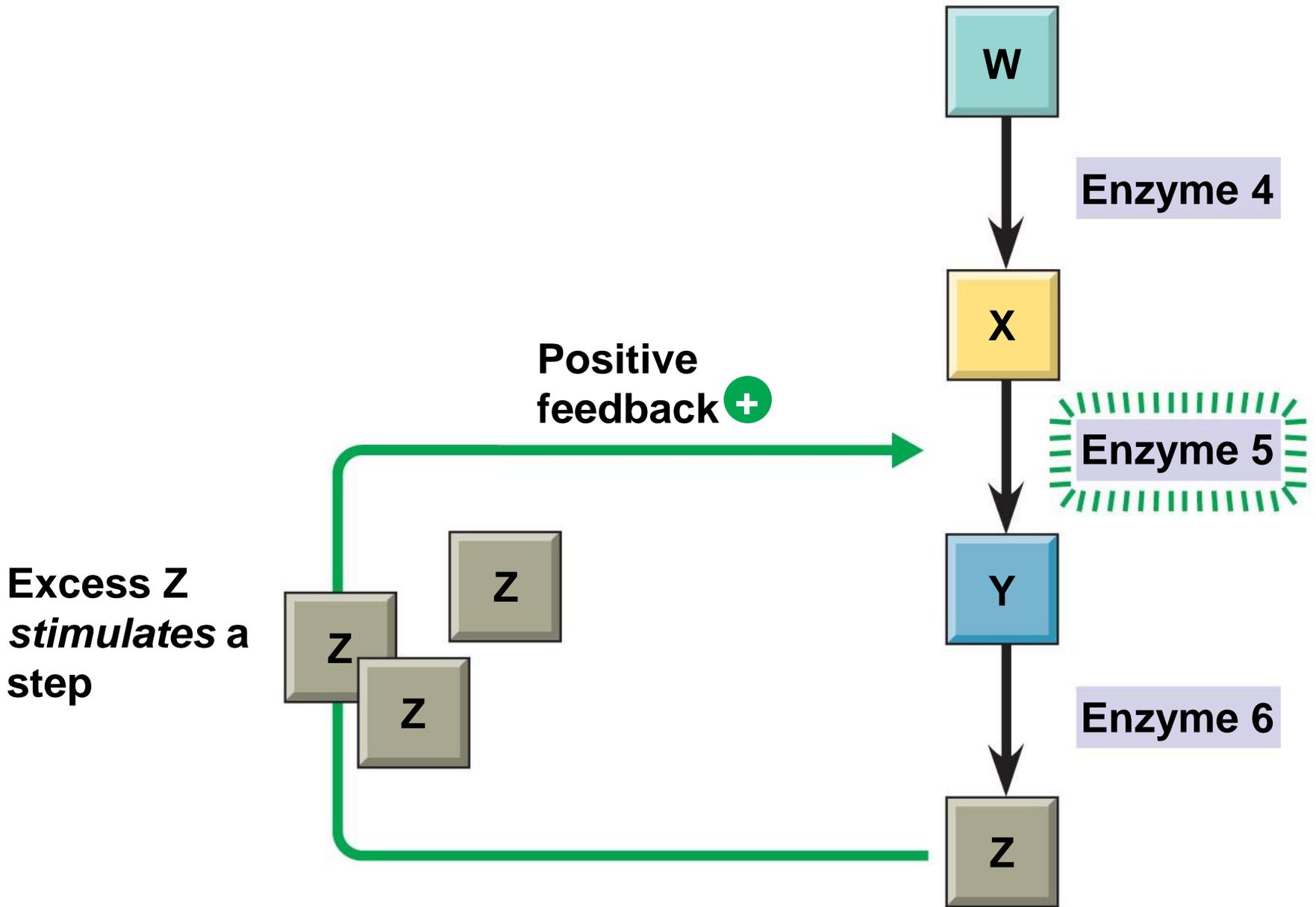
- Feedback mechanisms allow biological processes to self-regulate
 - **Negative feedback** means that as more of a product accumulates, the process that creates it *slows* and *less* of the product is produced
 - **Positive feedback** means that as more of a product accumulates, the process that creates it *speeds up* and *more* of the product is produced
-

Negative feedback 

Excess D
blocks a step



(a) Negative feedback



(b) Positive feedback