2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.

A. Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.

-Operons in gene regulation

-Temperature regulation in animals

-Plant responses to water limitations

B. Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set-point. Amplification occurs when the stimulus is further activated which, in turn, initiates an additional response that produces system change.

-Lactation in mammals

-Onset of labor in childbirth

-Ripening of fruit

C. Alteration in the mechanisms of feedback often results in deleterious consequences.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

-Diabetes mellitus in response to decreased insulin

-Dehydration in response to decreased antidiuretic hormone (ADH)

-Graves' disease (hyperthyroidism)

-Blood clotting

2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

A. Disruptions at the molecular and cellular levels affect the health of the organism.

-Dehydration

2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.

C. In fungi, protists and bacteria, internal and external signals regulate a variety of physiological responses that synchronize with environmental cycles and cues.
-Fruiting body formation in fungi, slime molds and certain types of bacteria
-Quorum sensing in bacteria

3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene.

A. Signal transmission within and between cells mediates gene expression.

- Cytokines regulate gene expression to allow for cell replication and division.
-Mating pheromones in yeast trigger mating gene expression.
-Levels of cAMP regulate metabolic gene expression in bacteria.
-Expression of the SRY gene triggers the male sexual development pathway in animals.
-Ethylene levels cause changes in the production of different enzymes, allowing fruits to ripen.
-Seed germination and gibberellin.

B. Signal transmission within and between cells mediates cell function.

- *Mating pheromones in yeast trigger mating genes expression and sexual reproduction.*
- *Morphogens stimulate cell differentiation and development.*
- *Changes in p53 activity can result in cancer.*
- *HOX genes and their role in development.*

3.D.1: Cell communication processes share common features that reflect a shared evolutionary history.Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment. [See also 1.B.1]

A. Communication involves transduction of stimulatory or inhibitory signals from other cells, organisms or the environment. [See also 1.B.1]

B. Correct and appropriate signal transduction processes are generally under strong selective pressure.

C. In single-celled organisms, signal transduction pathways influence how the cell responds to its environment.

-Use of chemical messengers by microbes to communicate with other

nearby cells and to regulate specific pathways in response to population density (quorum sensing).

-Use of pheromones to trigger reproduction and developmental pathways

-Response to external signals by bacteria that influences cell movement.

D. In multicellular organisms, signal transduction pathways coordinate the activities within individual cells that support the function of the organism as a whole.

-Epinephrine stimulation of glycogen breakdown in mammals

-Temperature determination of sex in some vertebrate organisms

-DNA repair mechanisms

3.D.2: Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.

A. Cells communicate by cell-to-cell contact.

-Immune cells interact by cell-cell contact, antigen-presenting cells , helper T-cells and killer T-cells. [See also 2.D.4]

-Plasmodesmata between plant cells that allow material to be transported from cell to cell.

B. Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell.

-Neurotransmitters

-Plant immune response

-Quorum sensing in bacteria

-Morphogens in embryonic development

C. Signals released by one cell type can travel long distances to target cells of another cell type.

1. *Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body.*

-Insulin

-Human growth hormone

-Thyroid hormones

-Testosterone

-Estrogen

3.D.3: Signal transduction pathways link signal reception with cellular response.

A. Signaling begins with the recognition of a chemical messenger, a ligand, by a receptor protein.

1. Different receptors recognize different chemical messengers, which can be peptides, small chemicals or proteins, in a specific one-to-one relationship.
2. A receptor protein recognizes signal molecules, causing the receptor protein's shape to change, which initiates transduction of the signal.

- *G-protein linked receptors*
- *Ligand-gated ion channels*
- *Receptor tyrosine kinases*

B. Signal transduction is the process by which a signal is converted to a cellular response.

1. *Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, with the result of appropriate responses by the cell.*
2. *Second messengers are often essential to the function of the cascade.*
   Ligand-gated ion channels
   Second messengers, such as cyclic GMP, cyclic AMP
   calcium ions(Ca^{2+}),and inositol triphosphate (IP_3)
3. *Many signal transduction pathways include:*
   i. Protein modifications (an illustrative example could be how methylation changes the signaling process)
   ii. Phosphorylation cascades in which a series of protein kinases add a phosphate group to the next protein in the cascade sequence

3.D.4: Changes in signal transduction pathways can alter cellular response.

A. Conditions where signal transduction is blocked or defective can be deleterious, preventative or prophylactic.

- *Diabetes, heart disease, neurological disease, autoimmune disease, cancer, cholera.*

- *Effects of neurotoxins, poisons, pesticides*
- *Drugs (Hypertensives, Anesthetics, Antihistamines and Birth Control Drugs)*

3.E.2: Animals have nervous systems that detect external and internal signals, transmit and integrate information, and produce responses.

A. The neuron is the basic structure of the nervous system that reflects function.

1. *A typical neuron has a cell body, axon and dendrites. Many axons have a myelin sheath that acts as an electrical insulator.*
2. *The structure of the neuron allows for the detection, generation, transmission and integration of signal information.*
3. *Schwann cells, which form the myelin sheath, are separated by gaps of unsheathed axon over which the impulse travels as the signal propagates along the neuron.*

B. Action potentials propagate impulses along neurons.

1. *Membranes of neurons are polarized by the establishment of electrical potentials across the membranes.*
2. *In response to a stimulus, Na^+ and K^+ gated channels sequentially open and cause the membrane to become locally depolarized.*
3. *Na^+/K^+ pumps, powered by ATP, work to maintain membrane potential.*

C. Transmission of information between neurons occurs across synapses.

1. *In most animals, transmission across synapses involves chemical messengers called neurotransmitters.*

- *Acetylcholine*
- *Epinephrine*
- *Norepinephrine*
- *Dopamine*

- *Serotonin*
- *GABA*

2. *Transmission of information along neurons and synapses results in a response.*
3. *The response can be stimulatory or inhibitory.*

D. Different regions of the vertebrate brain have different functions.

- *Vision*
- *Hearing*
- *Muscle movement*
- *Abstract thought and emotions*
- *Neuro-hormone productio*
- *Forebrain (cerebrum), midbrain (brainstem) and hindbrain (cerebellum)*
- *Right and left cerebral hemispheres in humans*

4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.

B. Interactions and coordination between systems provide essential biological activities.

- *Nervous and muscular*