

VU Learning HUB

BIF602 Quiz File

Chapter-wise Solved MCQs

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Chapter 1: From Nature to Natural Computing

1. What are the three main branches of natural computing as classified in the source text?

- A) Molecular computing, cellular automata, and quantum mechanics
- B) Computing inspired by nature, simulation and emulation of nature, and computing with natural materials
- C) Genetic algorithms, artificial neural networks, and swarm intelligence
- D) Theoretical modeling, experimental biology, and hardware design

2. In the dead-body clustering model of ant colonies, what rule governs an ant picking up a dead body?

- A) The likelihood is directly proportional to the density of dead bodies around.
- B) The likelihood is inversely proportional to the number of dead bodies around.
- C) Ants pick up bodies only when commanded by a queen ant.
- D) Ants pick up dead bodies at a constant, fixed time interval.

3. According to the text, what is the defining feature of bird flocking behavior?

- A) Flocks strictly follow a designated single bird leader at all times.
- B) Flocks execute complex central scripts pre-programmed in memory.
- C) There is no 'global rule' or leader; realistic flocking emerges from simple individual behavioral rules.
- D) Flocking is strictly dictated by physical gravity and wind velocity vectors.

4. Why does the physical miniaturization of silicon-based microchips motivate computing with natural materials?

- A) Silicon microchips cannot execute basic logic gates like AND and NOT.
- B) Exponential transistor growth (Moore's Law) reaches atomic physical limits where quantum effects take place.
- C) Natural materials are significantly cheaper to manufacture than silicon.
- D) Silicon microchips are incapable of processing binary signals.

Answer Key

- 1: B — Natural computing is divided into computing inspired by nature, simulation/emulation of nature, and computing with natural materials
- 2: B — An ant's probability of picking up a dead body is inversely proportional to the number of dead bodies in that portion of the arena
- 3: C — Birds in a flock do not follow a leader or global rule; realistic flocking behavior emerges from simple individual rules
- 4: B — Silicon miniaturization approaches atomic scales where standard physical laws fail and quantum effects interfere with conventional operations

Chapter 2: Physiological Systems Modeling, Simulation, and Control

1. What term describes the human mental activity of forming a hypothesis consistent with collected observations, as illustrated by the Saturday theater parable?

- A) Deduction
- B) Abduction
- C) Induction
- D) Reductionism

2. Which ancient physician developed the humoral theory of human physiology based on four humors (blood, phlegm, black bile, yellow bile)?

- A) Thales of Miletus
- B) Empedocles
- C) Hippocrates
- D) Alcmaeon of Croton

3. In linear time-invariant (LTI) systems, what mathematical operation combines the system input with the unit impulse response to yield the system output?

- A) Differentiation
- B) Convolution
- C) Abduction
- D) Logarithmic transformation

4. What is the defining characteristic of a positive feedback mechanism in physiological systems?

- A) It maintains dynamic equilibrium and stability, like a room thermostat.
- B) It is a self-reinforcing process where the response enhances the original stimulus.
- C) It eliminates all non-linearities from input signals.
- D) It decreases system activity in response to an increase in input signal.

Answer Key

1: B — Abduction is the human process of forming a personal opinion or hypothesis consistent with collected data

2: C — Hippocrates developed the humoral theory, modeling human health as an equilibrium among four bodily humors

3: B — The output of an LTI system is mathematically expressed as the convolution integral of the input with the unit impulse response

4: B — Positive feedback is a self-reinforcing process where the system's output response enhances the initial stimulus

Lecture 1: What is Life?

1. In Thomas Mann's 1924 quotes referenced in Lecture 1, what was viewed as the "condition and expression of all life"?

- A) Structureless living matter
- B) Organic differentiation
- C) Mechanical force
- D) Albumen solution

2. Why is vitalism discarded as a viable scientific explanation for life?

- A) Vitalism is fully explained by Newtonian mechanics.
- B) Non-physical agents of design cannot be measured or tested scientifically.
- C) Vitalism asserts that viruses and candle flames are fully living organisms.
- D) Vitalism was disproved experimentally in 1924.

3. How did Manfred Eigen (1992) define life?

- A) "Life is a dynamic state of matter organized by information."
- B) "Life is a mechanical clockwork governed by laws of motion."

- C) "Life is what we can eat."
- D) "Life is an unorganized albumen solution."

4. What attribute elevates a living organization beyond simple mechanistic physical interactions?

- A) Thermal equilibrium
- B) The ability to recognize and act on relevant information functional to its own survival (self-reference)
- C) Absolute physical inertia
- D) Total absence of genomic control

Answer Key

- 1: B — Thomas Mann noted that organic differentiation remained at once the condition and expression of all life
- 2: B — Concepts relying on unobservable physical agents lie beyond science because they cannot be measured or tested
- 3: A — Manfred Eigen defined life specifically as a dynamic state of matter organized by information
- 4: B — Living systems use relevant information for self-referential functions that support their own survival

Lecture 2: The Logical Mechanisms of Life

1. According to Christopher Langton (1989), Artificial Life (AL) is primarily concerned with which basis of life?

- A) The material carbon-chain basis of life
- B) The formal basis of life (life-as-it-could-be)
- C) The chemical synthesis of albumen solutions
- D) The vitalistic essence of living cells

2. What is identified as the 'key' concept in Artificial Life by Langton?

- A) Emergent behavior
- B) Vitalistic energy
- C) Universal consciousness
- D) Static reductionism

3. Why are simulated flocking Boids considered genuine instances of flocking alongside biological birds?

- A) Boids possess physical feathers and wings.
- B) Flocking is an emergent phenomenon validated at the behavioral level.
- C) Boids are directed by central external controllers.
- D) Boids are made of carbon-chain organic molecules.

4. In bottom-up Artificial Life modeling, how is an organism conceptualized?

- A) As a single monolithic mathematical equation
- B) As a large population of simple, rule-governed machines interacting nonlinearly
- C) As an unorganized solution of reactive proteins
- D) As a top-down centralized hierarchy

Answer Key

- 1: B — Biology focuses on the material basis of life, whereas Artificial Life focuses on the formal basis of life-as-it-could-be

2: A — Langton defined emergent behavior as the key concept underlying Artificial Life

3: B — Boids and birds are both genuine instances of flocking because flocking is defined by emergent behavior rather than physical material

4: B — ALife builds synthetic systems bottom-up from large populations of simple, rule-governed, nonlinearly interacting units

Lecture 3: Formalizing and Modeling the World

1. What are the three essential components of the semiotic information relation?

- A) Input, Output, and Process
- B) Sign, Thing (Object), and Agent
- C) Genotype, Phenotype, and Environment
- D) Syntax, Grammar, and Code

2. In Charles Sanders Peirce's typology, how is a 'Symbol' defined?

- A) A direct pictorial representation similar to the object
- B) An indirect representation physically caused by the object, like smoke to fire
- C) An arbitrary representation requiring exclusively a social convention or agreed code
- D) A physical scale model of an object

3. Which branch of semiotics studies the characteristics of signs and symbols devoid of meaning, focusing on operational rules?

- A) Semantics
- B) Syntax
- C) Pragmatics
- D) Vitalism

4. In Heinrich Hertz's modeling relation, what establishes the link between physical reality and formal model rules?

- A) Arbitrary convention without measurement
- B) Measurement (Semantics) and comparison of predicted vs. observed results (Pragmatics)
- C) Vitalistic intuition
- D) Continuous-time differential equations exclusively

Answer Key

1: B — Information in semiotics is a triadic relation where an Agent is informed by a Sign about some Thing

2: C — Symbols are arbitrary representations whose meaning depends entirely on an agreed social convention or code

3: B — Syntax evaluates sign characteristics and rules of manipulation independently of their meaning

4: B — Hertz's modeling relation connects physical reality to formal syntax via measurement (semantics) and experimental verification (pragmatics)

Lecture 4: Self-Organization and Emergent Complex Behavior

1. How is self-organization defined in dynamical systems?

- A) A process where external controllers force components into a fixed state
- B) A process where multi-component systems spontaneously reach structured states with no external interference

- C) A linear scaling of output amplitude relative to input amplitude
- D) The complete absence of state variables

2. In the discrete logistic equation, what dynamic transition occurs as the parameter r approaches $r=4$?

- A) The system converges to a single steady-state point.
- B) The system stabilizes into a two-state limit cycle.
- C) The limit cycle becomes chaotic, displaying extreme sensitivity to initial conditions.
- D) The system halts all numerical iterations.

3. What term denotes a critical point where a dynamical system undergoes a sudden qualitative shift in attractor behavior as parameters change?

- A) Linear convolution
- B) Bifurcation (or phase transition)
- C) Reductionist threshold
- D) Static equilibrium

4. Which discrete computational frameworks are widely used to study self-organization?

- A) Continuous Laplace transforms
- B) Boolean networks and Cellular Automata
- C) Single linear differential equations
- D) Analog voltage dividers

Answer Key

- 1: B — Self-organization is the spontaneous formation of organized structures or behaviors without external interference
- 2: C — For values near $r=4$, the logistic map transitions into chaos, becoming strongly dependent on initial conditions
- 3: B — A bifurcation or phase transition occurs when small parameter adjustments cause a sudden shift in dynamic attractor behavior
- 4: B — Self-organization is computationally studied using discrete dynamical systems like Boolean networks and cellular automata

Lecture 5: Reality is Stranger than Fiction - Advances in Biology

1. When early 20th-century biologists searched for the physical carrier of genetic inheritance, why did they initially suspect proteins instead of DNA?

- A) DNA was completely unknown to organic chemists at the time.
- B) Proteins were chemically reactive and functional, whereas DNA appeared chemically inert.
- C) DNA was found exclusively outside the cell nucleus.
- D) Proteins lacked nitrogen atoms.

2. What fundamental functional distinction exists between DNA and proteins in modern molecular biology?

- A) DNA acts as functional machinery, while proteins act as long-term memory.
- B) DNA acts as long-term random-access memory, while proteins act as functional machines.
- C) Both DNA and proteins are short-term symbolic messengers.
- D) Neither DNA nor proteins carry information.

3. Which research team synthesized a "prosthetic genome" copied from one bacterium and transferred it to create a synthetic cell?

- A) Alan Turing's team
- B) Craig Venter's team
- C) John von Neumann's team
- D) Gregor Mendel's team

4. What potential flaw does biological reality pose to Artificial Life when ALife defines itself strictly as "life-as-it-could-be"?

- A) ALife risks constructing theories on what scientists think life is rather than what physical experiments reveal.
- B) Computer simulations become impossible to execute.
- C) Synthetic cells lose the ability to divide.
- D) Boolean networks can no longer model chaotic systems.

Answer Key

1: B — Biologists assumed proteins carried genetic traits due to their reactivity, viewing inert DNA as unfit for information storage

2: B — Life relies on distinct roles: DNA functions as long-term memory, RNA as short-term symbol processing, and proteins as functional machines

3: B — Craig Venter's team synthesized a bacterial prosthetic genome to reprogram and create a synthetic cell

4: A — Focusing exclusively on "life-as-it-could-be" risks creating a science based on subjective expectations rather than experimental reality

Lecture 6: Von Neumann and Natural Selection

1. What error in Erwin Schrodinger's 1944 book What is Life? was highlighted by Sydney Brenner (2012)?

- A) Schrodinger correctly identified DNA as a universal constructor.
- B) Schrodinger confused the program and the constructor by calling chromosomes "architect's plan and builder's craft in one."
- C) Schrodinger proved that chromosomes contain no code script.
- D) Schrodinger invented the stored-program computer.

2. In John von Neumann's self-reproduction scheme, what is the specific role of Automaton B?

- A) Universal constructor that interprets descriptions to build new automata
- B) Copier automaton that copies any description without interpreting it
- C) Central controller or operating system
- D) Environmental selection filter

3. Why must a description in von Neumann's self-reproducing scheme be handled in both an uninterpreted and an interpreted role?

- A) To increase the electrical voltage of the constructor
- B) To avoid a logical paradox of self-reference where a description cannot describe itself
- C) Because universal constructors cannot process binary numbers
- D) To prevent mutations during replication

4. According to von Neumann, what capability enables non-trivial open-ended evolution rather than naive replication (like crystal growth)?

- A) The ability of symbolic descriptions to undergo inheritable mutations
- B) Strict adherence to static differential equations
- C) The complete removal of constructor automata
- D) External human intervention during every generation cycle

Answer Key

- 1: B — Brenner noted Schrodinger erred by conflating the program (description) with the constructor (executive craft)
- 2: B — Automaton B is the dedicated copier that duplicates uninterpreted genetic descriptions
- 3: B — Dual roles (translated for construction, copied for offspring) prevent the logical paradox of self-reference
- 4: A — Non-trivial self-reproduction requires memory descriptions capable of inheriting functional mutations

Lecture 7: Modeling Evolution: Evolutionary Computation

1. Unlike purely self-organizing dynamical systems, how is order established in Evolutionary Computation (Genetic Algorithms)?

- A) Order emerges purely from internal material dynamics without external influence.
- B) Order is dictated by external selective pressures (fitness functions) acting on encoded symbolic descriptions.
- C) Order is manually pre-programmed for every individual generation.
- D) Order is generated randomly without selection.

2. In standard Genetic Algorithms (GAs), which reproduction operator creates offspring by exchanging sub-sequences between two parent strings?

- A) Bit-flipping mutation
- B) Bit-string crossover
- C) Inversion
- D) Translocation

3. In Mendelian genetics, the genetic makeup of an organism is termed the _____, whereas its physical manifestation is the _____.

- A) Phenotype; Genotype
- B) Genotype; Phenotype
- C) Chromosome; Allele
- D) Gamete; Zygote

4. What is the main advantage of incorporating an artificial developmental/morphogenetic stage (e.g., L-systems) between genotype and phenotype in GAs?

- A) It eliminates the need for an external fitness function.
- B) It allows encoding much larger, complex structures while dramatically reducing search space size.
- C) It converts real-valued vectors into binary strings automatically.
- D) It prevents mutation operators from modifying genetic descriptions.

Answer Key

- 1: B — Evolutionary algorithms do not self-organize via internal dynamics alone; order is driven by external selection criteria
- 2: B — Bit-string crossover forms offspring by swapping sub-sequences between two parent strings

- 3: B — Genotype refers to the underlying genetic makeup, while phenotype refers to expressed physical traits
- 4: B — Morphogenetic development solves scalability issues by generating large phenotypic structures from compact rule encodings

End of Quiz

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