Tutorial 1

(14th March 2023 for D4 and 16th March 2023 for D3)

Suggested answers / comments

1. *Invention versus discovery*

(a) How is an invention different from discovery?

Discovery: uncovering a phenomenon or physical entity that was unknown.

Invention: harness discoveries in an innovative way to engineer technologies that make a difference.

(b) Is the study of Biology invention or discovery? Give reason(s).

Study of Biology is invention as well as discovery.

Given the complexity of biological systems, it is not uncommon to discover new biological components or functions in a system.

Some biologists use discoveries to engineer novel strategies to tackle biological and social problems

2. *Biology: scale of study*

Biology can be studied at 10 levels starting from the biosphere going all the way up to molecules (slide #31).

At which levels do the following belong:

(a) Consequences of consanguineous marriages (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7703949/)

Consequences of consanguineous marriages may be studied at population as well as molecular levels.

Morphological and other phenotypic characteristics of groups of affected individuals can be studied at a population level.

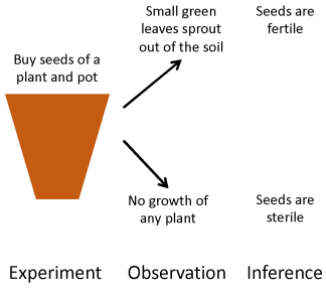
The genetic basis of these characteristics comprises studying these consequences at a molecular level.

(b) Preconception counselling (https://www.ncbi.nlm.nih.gov/books/NBK441880/)

Pre-conception counselling (i.e., seeking counselling before an offspring / baby is conceived) works at organism as well as molecular levels.

Medical and family histories of prospective parents are studied at an organism level. Simultaneously, their genetic makeups are studied at a molecular level to gauge the risk of their offspring developing hereditary disorders.

3. *Controls: potting seeds*



Suggest control experiments to validate the inferences drawn in the two scenarios.

a) Positive control: Using seeds that we are sure that will germinate. This serves to demonstrate that experimental conditions e.g., soil composition, water content, sun light, aeration, etc., are suitable for germination of a seed.

   This is termed as positive control because we expect seeds to sprout in this pot.

   If there is no germination in the positive control pot, then not finding any germination in the "experimental" pot cannot be attributed to the quality (or fertility) of the seeds that we bought.

b) Negative control: Planting no seed. In this pot, we do NOT expect any germination.

   Suppose we observe germination in the negative control. Then any germination that we observe in the "experimental" pot need not be because of only the seeds that were sown.

   Soil is 'prepared' first and equal amounts are distributed to the negative control pot, positive control pot, and "experimental" pot. Water from the same source is used for watering all the pots. All pots are kept in the same location. This uniformity is mandatory.

4. Reductionistic approach and integrative / holistic approach

Suppose we disassemble a mobile phone to study the various components that make up the phone. Then we put all the components in a bag and shake it well. Will the components collectively work as a mobile phone? (Concept: Emergent Property).

As far as Biology is concerned, the second half of the 20th century was dominated by a reductionistic approach to understand how living systems work. Can one put all the components found in a cell together to study how the cell works as an integrative approach?

A cell would not function by simply putting together cellular components. These components function in an ordered harmony to give rise to their functional characteristics.

5. *Cell-free systems*

[Quote from Life (2021) 11:1367] Cell-free systems can generally be defined as platforms where biochemical reactions occur independently of living cells. Cell-free systems are divided into two types based on the method of preparation: extract-based systems and enzyme-based systems. The extract-based cell-free systems were first introduced over a century ago by Eduard Buchner. Buchner demonstrated that cell extracts prepared from yeast could ferment sugar independent of the living yeast cells themselves, a discovery that earned him the 1907 Nobel Prize in Chemistry. [unquote]

(a) Can the use of a cell-free system be an integrative approach to study how living systems work? Why or why not? Give reason(s).

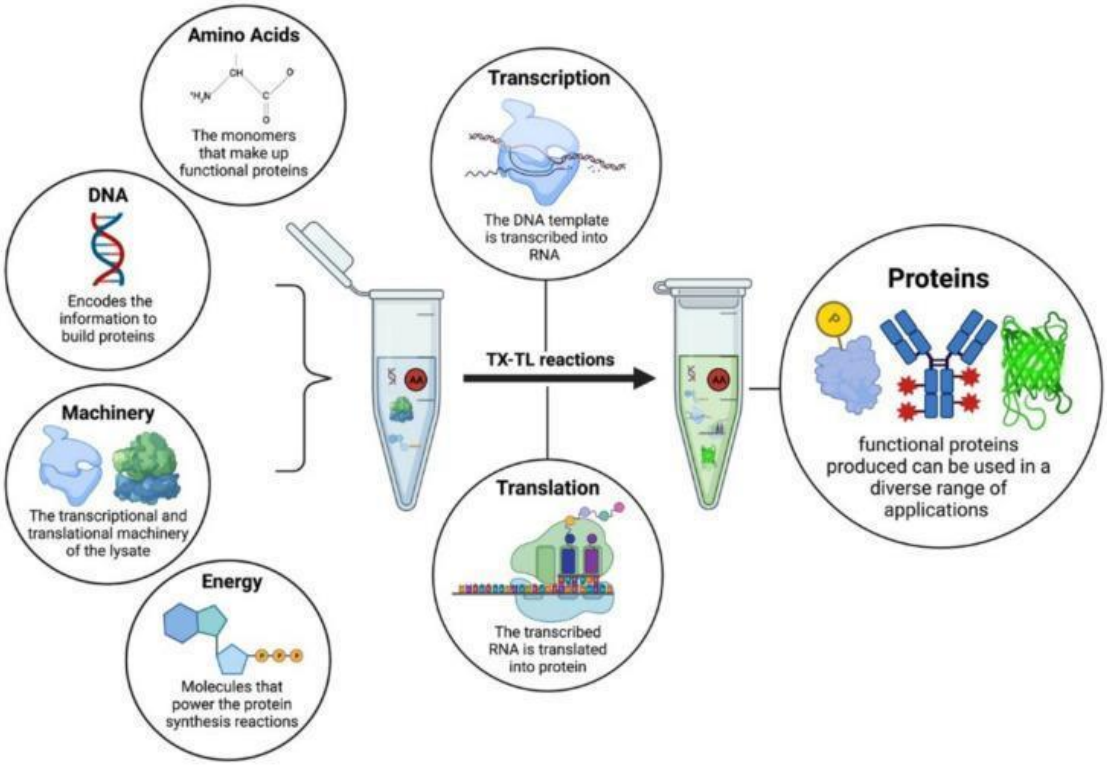
No.

Reason: in an integrative approach, cellular components have to be put together in an ordered arrangement leading to the "emergence" of a property. This is an anti-thesis to a cell-free system.

A cell-free system has its advantages and disadvantages. Depending on the objective of the study, the cellular environment may provide a co-operative effect or may create unnecessary confusion. A cell-free system may be useful when we need to perform reactions that we can control and manipulate. In such cases, if the reaction is carried out in the cell, the cellular machinery would employ additional, undesired control on the reaction.

However, a lot of reactions and functions in a cell require complex, highly timed and ordered control from multiple cellular components.

In such cases, cell-free extracts may not correctly reflect the cellular environment and at times present incorrect outcomes.



Legend to the figure: The components of a cell-free protein synthesis reaction. The reaction is assembled in a test tube, i.e., DNA, amino acids, and energy buffers are mixed along with the molecular machinery present in the cellular lysate to initiate transcription and translation for the synthesis of functional proteins. Taken from Life (2021) 11:1367.

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