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Hands-on experiments with planaria

Discussion questions answer sheet

Activity 1

Explain the use of a new planarian for each stimulus tested.

The use of a new planarian for each stimulus tested ensures that the observations and reactions are not influenced by previous stimuli. It helps to eliminate any potential bias or cumulative effects that could occur if the same planarian were used for multiple stimuli. By using a new planarian for each stimulus, the students can ensure that the responses observed are specific to the particular stimulus being tested.

Compare predictions with experimental data.

When comparing predictions with experimental data, it is important to analyze whether the observed reactions align with the expected outcomes. If the predictions match the experimental data, it suggests that the hypothesis was accurate. However, if there are discrepancies between the predictions and the experimental data, it may indicate the need for further investigation or a revision of the initial hypothesis.

Explain the reactions of the planarian to different stimuli.

By observing and recording the planarian's reactions to different stimuli, students can analyze and discuss behavioural responses. When the planarian is touched with a toothpick, it may exhibit a retracting or curling motion response, or it may change its direction of movement (mechanotaxis). Touch might signal a predator is nearby. When a torch is used as a light stimulus, the planarian may exhibit phototaxis: moving away from the light source. Planaria are mostly nocturnal animals (photophobic) and, when exposed to light, they seek cover. When a chemical stimulus like calf liver is placed in the dish, the planarian may display food-finding behaviour (chemotaxis) by moving towards and consuming the liver.

Discuss the role of the nervous system in planarian reactions.

The reactions of planaria to different stimuli provide insights into the role of their nervous systems. Planaria have a complex central nervous system that coordinates their sensory responses and motor behaviour. Planaria have cephalic ganglia (the brain), two ventral nerve cords, and many sensory neurons. These sensory neurons enable them to detect various stimuli, such as touch, light, and chemicals. The sensory neurons transmit signals to the brain, which then coordinate the appropriate motor responses. Discussing the role of the nervous system in planarian reactions allows students to explore the connection between sensory perception, neural processing, and behavioural outputs.

Design your own planarian stimulus experiment.

Students are encouraged to design their own experiments to investigate the responses of planaria to a specific stimulus. They can choose a stimulus of interest (e.g., temperature, different concentrations of a chemical stimulus, magnetic field, or sound) and propose a procedure to test the planarian's reactions. Students should consider factors such as the control group, sample size, duration of observation, and data collection. This exercise promotes critical thinking and experimental design skills.

Explain why scientists use planaria in research on the nervous system.

Planaria have a simpler nervous system than humans, making them accessible models for studying neural function and behaviour. Planaria exhibit remarkable regenerative abilities, including the regeneration of their nervous system, which allows researchers to investigate the processes involved in neural regrowth and functional recovery. Additionally, the genetic similarity between planaria and higher organisms, including humans, makes them useful for studying the basic principles of nervous-system function that may be conserved across different species. By studying planaria, scientists can gain insights into fundamental principles of neuroscience and apply the knowledge to more complex organisms, including humans.

Activity 2

Why is feeding of the planarian stopped 48 h before the experiment?

Stopping the feeding of planaria 48 h before the experiment is done to ensure that their digestive systems are empty. This helps to minimize bacterial presence in the water and allows for a clearer observation of the regenerative process without interference from recently consumed food. It also allows for standardized conditions among the planaria, as their feeding history can influence their physiological state and responses.

Explain the importance of keeping the planarian at 4°C.

Keeping the planaria at 4°C (refrigerator temperature) slows down their metabolism and reduces their activity levels. Cooling planaria helps to minimize movement during the slicing process and allows for more precise cuts. It also helps to reduce stress during the experiment.

What can we learn from the regenerative abilities of planaria?

The regenerative abilities of planaria provide valuable insights into the mechanisms and processes involved in tissue regeneration, cellular differentiation, and the role of stem cells. By studying planarian regeneration, we can gain insights into the cellular mechanisms involved in tissue regrowth, wound healing, organ formation, and potential applications in fields such as regenerative medicine and tissue engineering. Planaria serve as a model system to understand the fundamental principles of regeneration and uncover strategies for promoting and enhancing regenerative capabilities in other organisms.

Can we help planaria regrow faster? Design your own planaria regeneration experiment.

Divide a group of planaria into several subgroups.

- Control group: keep the planaria under standard conditions (see "How to culture planaria") and observe their normal regeneration rate.
- Experimental groups: alter one factor in each subgroup and compare the regeneration rate with the control group. Factors to consider may include temperature, exposure to growth factors or hormones, or variations in the composition of the water medium.

What are the similarities and differences between planarian and human stem cells, and what can we learn by studying them?

Both planaria and humans have stem cells that possess the remarkable ability to divide and differentiate into various types of cells, playing a crucial role in tissue renewal and repair. Planaria have a unique ability to regenerate entire organisms from small fragments due to the presence of abundant pluripotent stem cells, known as neoblasts. In contrast, human stem cells are more restricted in their differentiation potential.

Studying planarian stem cells can provide insights into the basic mechanisms of stem-cell biology, such as self-renewal, differentiation, and regeneration. By comparing planarian and human stem cells, we can gain a better understanding of the fundamental principles that govern stem-cell behaviour, which can be applied to various aspects of human biology, including regenerative medicine, tissue engineering, and disease modelling.

Extension activity

Explain the use of three planaria.

Using three planaria in the experiment allows a more representative and reliable data set to be obtained. By having multiple planaria, any variations or individual differences in their responses to starvation and subsequent degrowth can be observed. This increases the statistical significance of the results, which can enable more robust conclusions.

What factors may influence the rate of planaria degrowth during starvation?

- Initial size and health of the planaria: planaria that are larger and healthier at the start of the experiment may have more energy reserves, and therefore, undergo slower degrowth.
- Species variation: different species of planaria may exhibit different rates of degrowth during starvation.
- Environmental conditions: factors such as temperature (higher temperatures may accelerate metabolic processes, leading to faster degrowth), water quality, and lighting conditions can affect the metabolic rate and degrowth rate of planaria during starvation.

How could the experiment be modified to investigate the effects of other environmental factors, such as temperature or pH, on planaria degrowth?

1. Create separate experimental groups, each exposed to a specific environmental factor (e.g., temperature, pH).
2. Create a separate control group.
3. Maintain consistent conditions within each group, except for the manipulated environmental factor.
4. Follow the same procedure as before, recording the length and width of planaria every third day and calculating the percentage decrease in length.
5. Compare the degrowth rates among the different experimental groups to determine the influence of the specific environmental factor being studied.

What are the potential applications of studying planaria degrowth?

Understanding the factors and mechanisms that influence the degrowth process can provide insights into the biology of regeneration, metabolism, and adaptation to environmental changes. Additionally, this knowledge can contribute to research in areas such as tissue degeneration and metabolic disorders. Moreover, studying planaria degrowth may help identify potential targets for therapeutic interventions and inspire new approaches to promote healthy aging and tissue regeneration in humans.

How can we ensure that our scientific experiments are conducted in a responsible and ethical manner, while still advancing our understanding of biology?

Take measures to minimize any potential harm or discomfort to the planaria, such as providing appropriate housing conditions, handling them with care, and adhering to recommended protocols.

Ensure compliance with local laws and regulations concerning the use of animals in scientific experiments. Document all procedures, observations, and data accurately, ensuring that others can replicate or verify the experimental results.