

## Inspiration

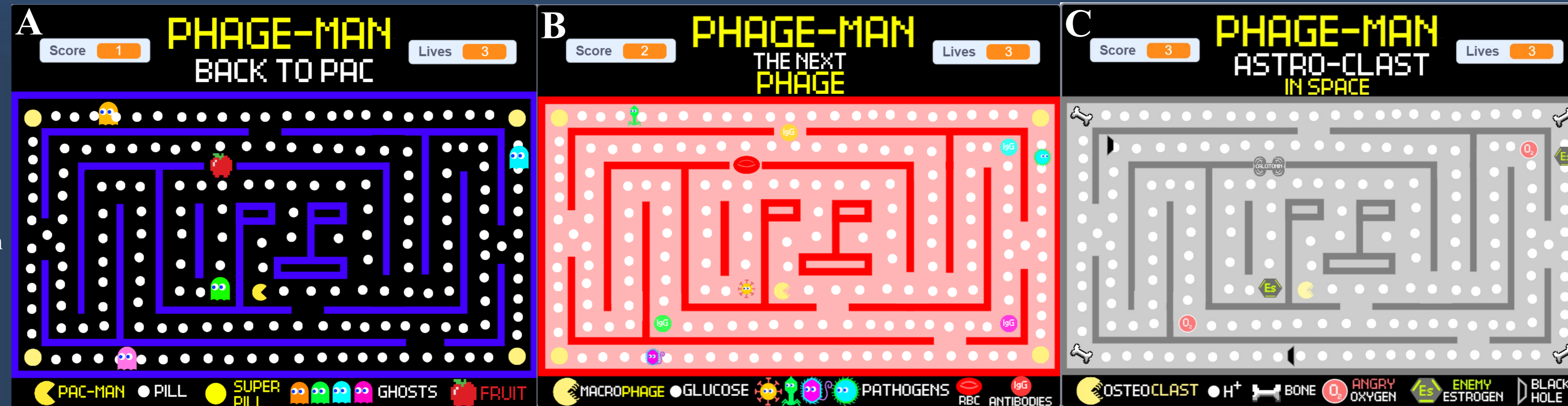
From theories to terminologies, studying the complex fields of immunology and cellular biology can be laborious. While these fields are central to understanding the function and significance of immune cells, many undergraduate students may underestimate the importance of immune cells when coordinating an effective immune response against an infection. Among these cells, macrophages are known to play key roles in the phagocytosis of pathogens, T-cell activation and the initiation of the innate immune response.<sup>1</sup> But despite these important functions, students may find studying of their cellular and molecular dynamics to be daunting.

## Research Objective

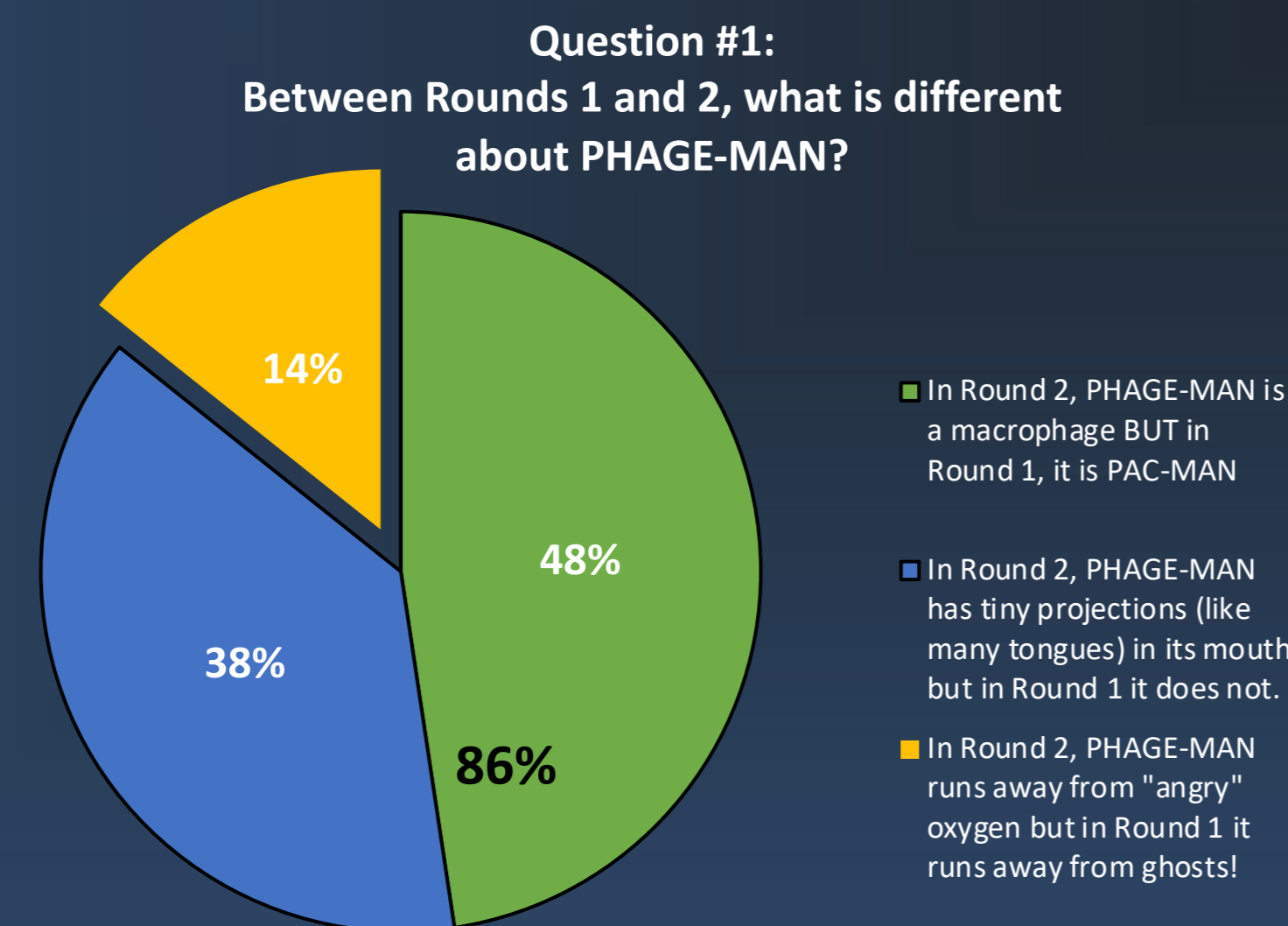
To translate and evaluate the understanding of the molecular and cellular events of macrophages during phagocytosis by designing PHAGE-MAN: a creative, scientific ‘edu-tainment’ game that disassembles these biological changes while engaging the player.

## Methods

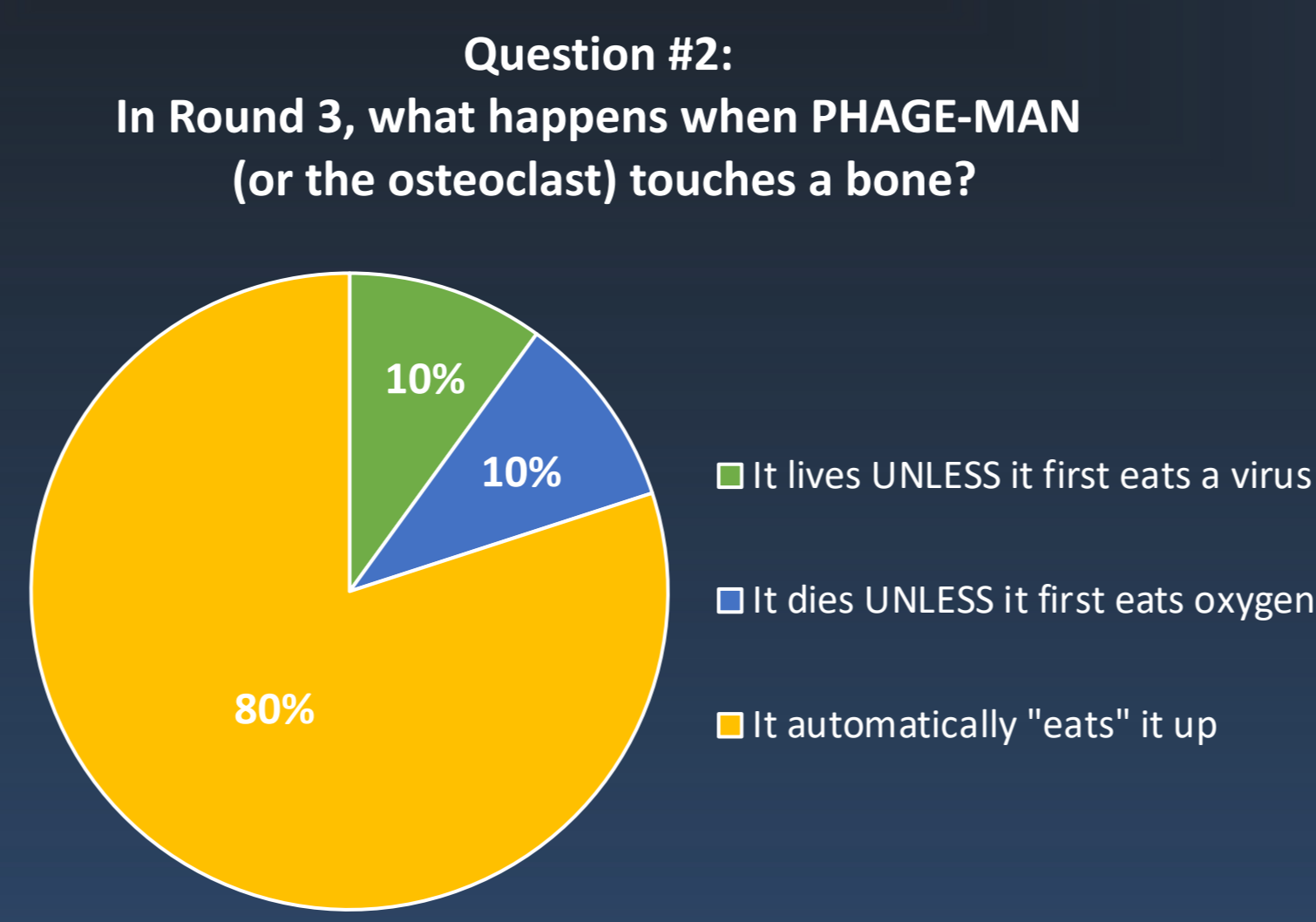
Lecture material from Special Topics of Cell Biology (BIOD20) and Immunology (BIOC39) courses with research were used and two topics were chosen: phagocytosis (following antibody recognition) and osteoclastogenesis (generation of osteoclasts or bone-degrading cells by macrophage fusion).<sup>1,2,3,4</sup> Following a 13-part tutorial, I designed 3 rounds of PHAGE-MAN using Scratch (Version 3.0; see Figure 1). Before playing, participants’ academic background and knowledge of cell biology and immunology were recorded via Google Forms. After game completion, game engagement, participant knowledge of osteoclastogenesis and phagocytosis were evaluated.



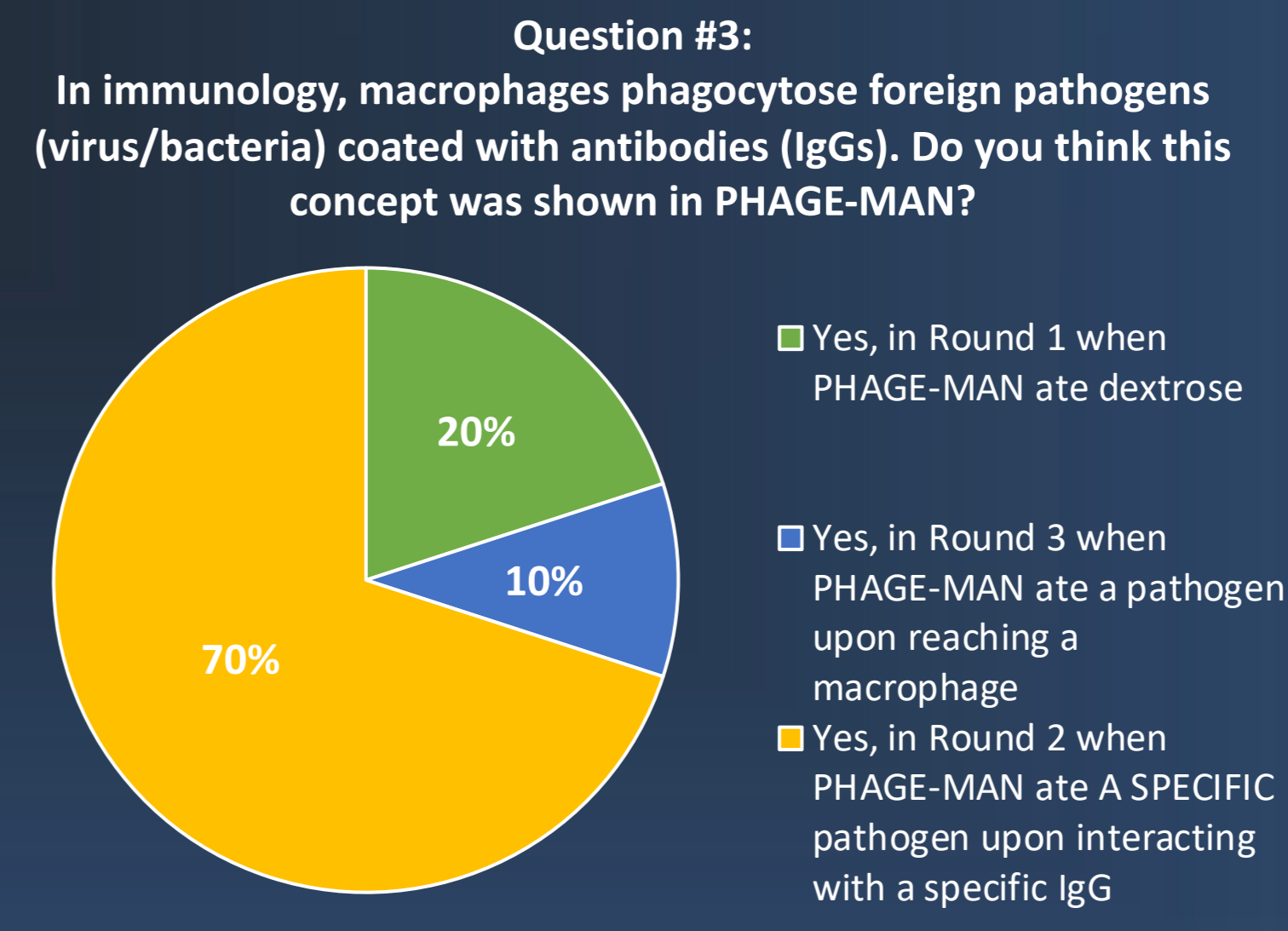
**Figure 1: Overview of PHAGE-MAN** (© Mohammed Said 2021-2022). The scientific edu-tainment tool contains 3 different rounds – “Back to Pac” (Round 1, see Fig. 1A), “The Next Phage” (Round 2, see Fig. 1B) and “Astro-Clast in Space” (Round 3, see Fig. 1C). (A) The first round refreshes players with an iconic maze showing Super Pills, different-coloured ghosts and PAC-MAN. (B) Round 2 changes the maze to a tissue infected with four different pathogens, where players use PHAGE-MAN as a macrophage to interact with IgG pills and macrophages to induce phagocytosis. (C) The last round mimics a micro-gravity simulator, where PHAGE-MAN becomes an osteoclast following the fusion of macrophages and now avoids inhibitors including oxygen and estrogen. Each round includes an audio recording, allowing for players to become ‘edutained’ to learn more about macrophages in real-time.



**Figure 2: Pie Chart of Survey Responses differentiating PHAGE-MAN from PAC-MAN.** From 10 responses, 18/21 (86%) correctly compared that PHAGE-MAN appears like a macrophage with tiny finger-like projections in Round 2 but is PAC-MAN in Round 1.



**Figure 3: Pie Chart of Survey Responses assessing understanding on osteoclastogenesis from PHAGE-MAN.** From 10 responses, 8 players (80%) correctly noted PHAGE-MAN degrades bones as an osteoclast.



**Figure 4: Pie Chart assessing understanding on antibody-mediated phagocytosis from PHAGE-MAN.** From 10 responses, 7 players (70%) correctly noted PHAGE-MAN eat a specific pathogen after interaction with a specific antibody (IgG).

## Results

From survey responses on knowledge, 15 participants had (on a scale from 1 to 5) some background about immune cells (average score: 2.0±1.0). After playing PHAGE-MAN, 10 participants showed 88% interest and 100% of respondents would recommend PHAGE-MAN. Participants accurately detected 86% (18/21) visual differences between PAC-MAN and PHAGE-MAN (see Figures 1 and 2). In terms of biological changes, 80% (8/10) of participants correctly noted osteoclastogenesis (see Fig. 3), and 70% (7/10) observing antibody-mediated phagocytosis (see Fig. 4).

## Conclusion

The strong interest and recommendation of PHAGE-MAN as a scientific edutainment tool for players with minimal scientific knowledge was intriguing. Notably, participants were able to appreciate the cellular and molecular dynamics of macrophages during osteoclastogenesis and antibody-mediated phagocytosis as notable features differentiating PHAGE-MAN from PAC-MAN. Overall, the game shows great promise to translate macrophage biology to academic students and avid game players.

## Acknowledgements

I would like to thank Dr. Rene Harrison for teaching the dynamics of phagocytosis and osteoclastogenesis in macrophages. I would also like to acknowledge The Tech Train for their descriptive 13-part video series on making a standard PAC-MAN game.

## References

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