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Editorial

The Application of Transgenesis to Abraham Trembley's Hydra, an Ancient Animal Model for the Study of Regeneration that has now entered the 21st Century

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Abstract

Developmental biology and regenerative biology began with the studies of Abraham Trembley who was a mathematician. Trembley initiated studies with the freshwater hydrozoan, hydra to determine if the organism was a plant or animal. His first studies in 1740 found that bisection of the organism lead to the formation of two complete adult appearing hydra and he then proceeded to perform extensive experiments to evaluate the extent of hydra's "regenerative capabilities". He performed numerous experiments that culminated in the publication of his book in 1744 on the biology and regenerative nature of hydra. His studies established the early foundations of regenerative biology that have been built upon over the years and has led to current studies focusing on cellular and molecular mechanisms. From Trembley's initial studies, regenerative biology has grown to encompass the field of regenerative medicine that applies our understanding of regenerative processes to the human condition.

Early Studies by Trembly with Hydra Established a Foundation for Our Understanding of the Regenerative Process

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Developmental biology and its subcomponent, regenerative biology began with the studies of Abraham Trembley who was a mathematician. Trembley initiated studies with the freshwater hydrozoan, hydra (originally classified as a plant) to determine if the organism was a plant or animal. His first studies in 1740 found that bisection of the organism lead to the formation of two complete adult appearing Hydra [1,2]. From this initial observation, Trembly concluded that hydra was actually an animal and proceeded to perform extensive experiments to evaluate the extent of its "regenerative capabilities". He performed numerous experiments that culminated in the publication of his book in 1744 on the biology and regenerative nature or hydra [1,2]. His studies established the early foundations of regenerative biology that have been built upon over the years and has led to current studies focusing on cellular and molecular mechanisms. From these first studies, regenerative biology has grown to encompass the field of regenerative medicine that applies our understanding of regenerative processes to the human condition [3].

Hydra has had an important role in our understanding of regeneration and has become an important model for the study of regenerative processes and its underlying mechanisms [4]. Briefly, studies by the laboratory of Hans Bode and others see the 2019 review by Vogg, Galliot and Tsiaris for an excellent discussion of past and current hydra studies have shown that bisection of a hydra along its longitudinal axis leads to the upper head half regenerating a new basal disc and the lower basal disc half regenerating a new head; regardless of where the incision is made along the axis [4]. Concomitant grafting experiments established that the polarity of hydra is controlled by a series of morphogenetic gradients that dictate that the head and basal disc only form at specific locations along the longitudinal body axis. Further experiments defined a head activator gradient (highest at the hypostome- tip of head region) and a basal activator gradient (highest at the basal disc that defines the inferior end of hydra). Additionally, it was found that a basal disc activator gradient and a basal disk inhibitor gradient exists.

Inhibitor and activator gradients provide instructions that define the apical and basal ends of the adult polyp. In addition to these gradient systems, hydra also utilizes cell-cell and cell-ECM interactions to further control the regenerative process [5]. Cell-cell interactions, include a broad range of adhesion molecules such as integrins, tight junctional complexes (septate junctions, in hydra) and gap junctions to name a few [5]. These molecules function not only in adhesion and signal transduction, but also serve to facilitate cell trans-differentiation processes that are essential for regeneration to occur [5]. These cell-cell interactions interplay with cell-ECM interactions to provide precise control mechanism in the hydra's regenerative processes. ECM formation is closely coupled with the above-mentioned regenerative processes as previously shown [6-8]. Moreover, these matrix studies have shown that hydra's ECM components mimic that seen in higher vertebrates and man demonstrating the conservation of matrix components among the animal groups [9].

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Application of Transgenic Techniques to the Study of Hydra Regenerative Processes

The first report on transgenic hydra was published in 2006 from the laboratory of Thomas Bosch [10]. These studies injected the hot EGFP expression vector into the two-eight cell Hydra embryo with expression of the vector observed 2-3 days after embryonic hatching [10]. In these injected embryos hatching was observed 14-49 days after fertilization. While expression was transient (8-12 days) in the majority of injected embryos, expression was stably integrated into the genome in some embryos leading to establishment of transgenic hydra lines [10]. The laboratory of R.E. Steele confirmed the reproducibility of the hydra transgenic technique in 2014 with a follow-up publication involving a GFP expression vector construct that resulted in a 10-20% success rate for obtaining stably integrated transgenic hydra [11]. In 2019 the laboratory of Bosch published a detailed description of the hydra technique in nature protocols [11]. The authors pointed out that the major limitations of generating transgenic hydra includes:

1) An inability to apply Cre/loxP or Gal4 technologies into hydra transgenics

2) A limited knowledge of the integration of genomic constructs into hydra that obscures one's ability to determine the number of transgene copies incorporated into the genome or the chromatin context of the integration

3) Genetic manipulations are limited to only the transcriptional level thereby precluding the development of knockout or genome-editing approaches

Conclusion

Beginning from the early studies of Trembly, hydra has provided a useful animal model for analysis of the mechanisms involved in the regenerative process. Data from hydra studies have been translated into other animal systems to include the more complicated vertebrate models such as zebrafish and mouse. With the advent of transgenic approaches in hydra it will be possible to better elucidate the molecular mechanisms underlying hydra regeneration. As an extension of this research, studies are now underway to apply the CRISPR approach to hydra so that more expansive studies can be undertaken to better understand hydra regenerative mechanisms.

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References

1. Breen Q. Abraham Trembley of Geneva, scientist and philosopher, 1710-1784. J Med Library Association. 1956;44(1):84-5.
2. Lenhoff SG, Lenhoff HM, Trembley A. Hydra and the birth of experimental biology, 1744: Abraham Trembley's Mémoires concerning the polyps. Boxwood Pr. 1986.
3. Lanza R. Regenerative medicine: The last 10 years. Regen Med. 2016;11(8):745-6.
4. Vogg MC, Galliot B, Tsiairis CD. Model systems for regeneration: Hydra. Dev. 2019;146(21).
5. Sarras M, Jr. Leontovich, AA Hydra's ECM./Integrin/Matrix Metalloproteinase Network: Comparative analysis of hydra and vertebrate ECM signaling systems based on current genomic and est databases. MOJ Anat Physiol. 2017;3(3):1.
6. Sarras MP. Components structure biogenesis and function of the hydra extracellular matrix in regeneration pattern formation and cell differentiation. Int J Dev Biol. 2012;56(6-8):567-76.
7. Sarras MP, Jr., Zhang X, Huff JK, Accavitti MA, St John PL, Abrahamson DR. Extracellular matrix (mesoglea) of Hydra vulgaris III. Formation and function during morphogenesis of hydra cell aggregates. Dev Biol. 1993;157(2):383-98.
8. Shimizu H, Zhang X, Zhang J, Leontovich A, Fei K, Yan L, et al. Epithelial morphogenesis in hydra requires de novo expression of extracellular matrix components and matrix metalloproteinases. Dev. 2002;129(6):1521-32.
9. Wittlieb J, Khalturin K, Lohmann JU, Anton-Erxleben F, Bosch TC. Transgenic hydra allow *in-vivo* tracking of individual stem cells during morphogenesis. Proc Natl Acad Sci USA. 2006;103(16):6208-11.
10. Juliano CE, Lin H, Steele RE. Generation of transgenic hydra by embryo microinjection. J Vis Exp. 2014(91):51888.
11. Klimovich A, Wittlieb J, Bosch TCG. Transgenesis in hydra to characterize gene function and visualize cell behavior. Nat Protoc. 2019;14(7):2069-90.

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