© 2022. Published by The Company of Biologists Ltd | Development (2022) 149, dev200829. doi:10.1242/dev.200829

EDITORIAL

Insights into the role of immune cells in development and regeneration

Florent Ginhoux[1,*] and Paul Martin[2,*]

Inflammatory cells are primarily considered as important for resolving infections; indeed, whenever a tissue is infected, a rapid and robust inflammatory response is triggered to clear the pathogens and repair the damaged site. The inflammatory response has evolved to prevent us dying of septicaemia whenever we are injured, but it has also been co-opted to take on a huge variety of other roles during development, repair and regeneration. Macrophages, in particular, as the first immune cells to colonize developing tissues, are adept at delivering developmental cues. As embryogenesis progresses, they regulate crucial aspects of development, such as angiogenesis and the morphogenesis of various organs, as well as the clearance of apoptotic cells as tissues are sculpted. In recent decades, we have learned a great deal about the developmental origins of various innate and adaptive immune cell lineages, and some differences in these origins across the animal kingdom. There have also been recent discoveries of the cell biology that enables immune cells to home to sites of tissue damage. Moreover, we are uncovering some of the positive and negative contributions of immune cells to repairing and regenerating tissues and organs.

In this Special Issue, we showcase articles that add to this repertoire of immune cell functions during development, repair and regeneration, and provide insights into the developmental pathways leading to the generation and dispersal of these cells. These articles cover tissues as diverse as the placenta (Freyer et al., 2022), mammary gland (Hitchcock et al., 2022) and skin (Reitermaier et al., 2021), as well as repairing bone (Geurtzen et al., 2022) and inner ear epithelium (Janesick et al., 2022), using model organisms from crickets (Bando et al., 2021) through to humans (Toothaker et al., 2022). They include studies on standard inflammatory immune cell lineages, such as circulating B cells (Busse et al., 2021) and macrophages (Bredemeyer et al., 2022), but also lesser studied types – at least in these contexts – such as eosinophils (Theret et al., 2022), tissue-resident lymphocytes (Worthington et al., 2022) and natural killer cells (Melendez et al., 2022).

The issue also contains a set of review-based articles that highlight just some of the most exciting progress in the field. This includes articles that discuss the functions of immune cells in cardiac (Simões and Riley, 2022), neural (Mehl et al., 2022; Becker and Becker, 2022), intestinal (Jowett et al., 2022) and bone (Yahara et al., 2022) development and regeneration. Complementing these articles are short pieces that provide an overview of tissue-resident macrophages (Lee and Ginhoux, 2022), and an evolutionary perspective on non-traditional roles for immune cells in development and regeneration (Arinda et al., 2022).

We hope there is something in here for everyone, and that these papers will remind you all of the close link between immune cells and developmental biology. We also hope that you will consider submitting your next article in this exciting field to Development.

[1]Singapore Immunology Network (SIgN), Agency for Science, Technology and Research (A*STAR), 138648 Singapore. [2]School of Biochemistry, University of Bristol, Bristol BS8 1TD, UK.

*Authors for correspondence (florent_ginhoux@immunol.a-star.edu.sg; paul.martin@bristol.ac.uk)

F.G., 0000-0002-2857-7755; P.M., 0000-0002-2665-5086

References

Arinda, B. N., Innabi, Y. A., Grasis, J. A. and Oviedo, N. J. (2022). Non-traditional roles of immune cells in regeneration: an evolutionary perspective. *Development* **149**, dev199903. doi:10.1242/dev.199903

Bando, T., Okumura, M., Bando, Y., Hagiwara, M., Hamada, Y., Ishimaru, Y., Mito, T., Kawaguchi, E., Inoue, T., Agata, K., Noji, S. and Ohuchi, H. (2021). Toll signalling promotes blastema cell proliferation during cricket leg regeneration via insect macrophages. *Development* **149**, dev199916. doi:10.1242/dev.199916

Becker, T. and Becker, C. G. (2022). Regenerative neurogenesis: the integration of developmental, physiological and immune signals. *Development* **149**, dev199907. doi:10.1242/dev.199907

Bredemeyer, A. L., Amrute, J. M., Koenig, A. L., Idol, R. A., He, L., Luff, S. A., Dege, C., Leid, J. M., Schilling, J. D., Hinson, J. T., Dinauer, M. C., Sturgeon, C. M. and Lavine, K. J. (2022). Derivation of extra-embryonic and intra-embryonic macrophage lineages from human pluripotent stem cells. *Development* **149**, dev200016. doi:10.1242/dev.200016

Busse, M., Langwisch, S., Tedford, K., Fischer, K.-D. and Zenclussen, A. C. (2021). Maternal B cell signaling orchestrates fetal development in mice. *Development* **149**, dev199783. doi:10.1242/dev.199783

Freyer, L., Lallemand, Y., Dardenne, P., Sommer, A., Biton, A. and Gomez Perdiguero, E. (2022). Erythro-myeloid progenitor origin of Hofbauer cells in the early mouse placenta. *Development* **149**, dev200104. doi:10.1242/dev.200104

Geurtzen, K., López-Delgado, A. C., Duseja, A., Kurzyukova, A. and Knopf, F. (2022)). Laser-mediated osteoblast ablation triggers a pro-osteogenic inflammatory response regulated by reactive oxygen species and glucocorticoid signaling in zebrafish. *Development* **149**,, dev199803. doi:10.1242/dev.199803

Hitchcock, J., Hughes, K., Pensa, S., Lloyd-Lewis, B. and Watson, C. J. (2022). The immune environment of the mammary gland fluctuates during post-lactational regression and correlates with tumour growth rate. *Development* **149**, dev200162. doi:10.1242/dev.200162

Janesick, A. S., Scheibinger, M., Benkafadar, N., Kirti, S. and Heller, S. (2022). Avian auditory hair cell regeneration is accompanied by JAK/STAT-dependent expression of immune-related genes in supporting cells. *Development* **149**, dev200113. doi:10.1242/dev.200113

Jowett, G. M., Coales, I. and Neves, J. F. (2022). Organoids as a tool for understanding immune-mediated intestinal regeneration and development. *Development* **149**, dev199904. doi:10.1242/dev.199904

Lee, C. Z. W. and Ginhoux, F. (2022). Biology of resident tissue macrophages. *Development* **149**, dev200270. doi:10.1242/dev.200270

Mehl, L. C., Manjally, A. V., Bouadi, O., Gibson, E. M. and Tay, T. L. (2022). Microglia in brain development and regeneration. *Development* **149**, dev200425. doi:10.1242/dev.200425

Melendez, E., Chondronasiou, D., Mosteiro, L., Martínez de Villarreal, J., Fernández-Alfara, M., Lynch, C. J., Grimm, D., Real, F. X., Alcamí, J., Climent, N., Pietrocola, F. and Serrano, M. (2022). Natural killer cells act as an extrinsic barrier for *in vivo* reprogramming. *Development* **149**, dev200361. doi:10.1242/dev.200361

Reitermaier, R., Ayub, T., Staller, J., Kienzl, P., Fortelny, N., Vieyra-Garcia, P. A., Worda, C., Fiala, C., Staud, C., Eppel, W., Scharrer, A., Krausgruber, T. and Elbe-Bürger, A. (2021). The molecular and phenotypic makeup of fetal human skin T lymphocytes. *Development* **149**, dev199781. doi:10.1242/dev.199781

Simões, F. C. and Riley, P. R. (2022). Immune cells in cardiac repair and regeneration. *Development* **149**, dev199906. doi:10.1242/dev.199906

Theret, M., Rempel, L., Hashimoto, J., Ritso, M., Tung, L. W., Li, F. F., Messing, M., Hughes, M., McNagny, K. and Rossi, F. (2022). Elevated numbers of infiltrating eosinophils accelerate the progression of Duchenne muscular dystrophy pathology in *mdx* mice. *Development* **149**, dev200112. doi:10.1242/dev.200112

Toothaker, J. M., Olaloye, O., McCourt, B. T., McCourt, C. C., Silva, T. N., Case, R. M., Liu, P., Worthington, A. K., Cool, T., Poscablo, D. M., Hussaini, A., Beaudin, A. E. and Forsberg, E. C. (2022). IL7Rα, but not Flk2, is required for hematopoietic stem cell reconstitution of tissue-resident lymphoid cells. *Development* **149**, dev200139. doi:10.1242/dev.200139

Yimlamai, D., Tseng, G. and Konnikova, L. (2022). Immune landscape of human placental villi using single-cell analysis. *Development* **149**, dev200013. doi:10.1242/dev.200013

Yahara, Y., Nguyen, T., Ishikawa, K., Kamei, K. and Alman, B. A. (2022). The origins and roles of osteoclasts in bone development, homeostasis and repair. *Development* **149**, dev199908. doi:10.1242/dev.199908