There are two general approaches to designing biomaterial implants that have reduced inflammation and fibrosis—engineering inert biomaterials that have no cellular interaction and creating biomaterials that interact with immune cells but modulate them towards the desired outcome. Which general approach do you think is more effective and why? Give an example of a biomaterial design using the approach you chose.

If minimizing the foreign body response (FBR) is the main goal, engineering biomaterial with minimal inflammation appears more suitable. In contrast, if the aim is to modulate the immune response towards a desired outcome, such as tissue integration, then the immunomodulatory biomaterials are more applicable. The second approach represents technical challenges due to the complexity of the immune responses, potentially resulting in unpredictable outcomes. However, it has the advantage of adapting to the biological environment more dynamically. Whereas biomaterial with no cellular interaction, might integrate more predictably, but there's a risk that over time they could be recognized as foreign and trigger a chronic inflammatory response.
There have been a variety of investigations on how biomaterial properties affect macrophage behavior and mediate tissue repair. These investigations range from examining the impact of biomaterial properties on macrophage behavior to directly incorporating macrophage-modulating agents, such as cytokines and drugs, into the biomaterials. These strategies aim either to promote M2 polarization, or to attract monocytes to the injury site [1].
Shields et al. [2], recently proposed an innovative approach for cancer therapy by engineering macrophages to sustain an M1 phenotype. They developed discoidal particles or "backpacks" that adhere to macrophage surfaces and release cytokines to control their phenotypes.
In a mouse breast cancer model, this strategy demonstrated a significant therapeutic potential, as macrophages equipped with IFNγ-releasing backpacks were effective in decelerating tumor progression and diminishing metastasis.

[1] R. Whitaker, B. Hernaez-Estrada, R. M. Hernandez, E. Santos-Vizcaino, and K. L. Spiller, "Immunomodulatory Biomaterials for Tissue Repair," *Chem. Rev.*, vol. 121, no. 18, pp. 11305–11335, 2021, doi: 10.1021/acs.chemrev.0c00895

[2] C. W. ShieldsIV *et al.*, "Cellular backpacks for macrophage immunotherapy," *Sci. Adv.*, vol. 6, no. 18, p. eaaz6579, 2020, doi: 10.1126/sciadv.aaz6579