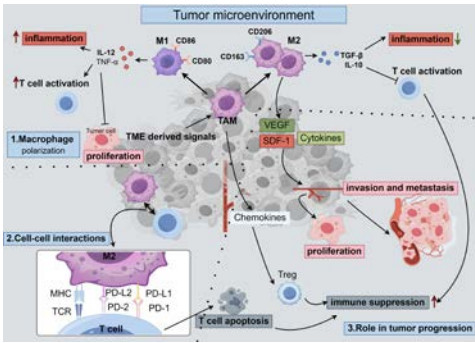


Roles of macrophages in tumor immunotherapy: metabolism, immune checkpoints, and combination strategies

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Research Summary



- - Tumor-associated macrophages (TAMs) are abundant and influential in the tumor microenvironment (TME).
- - TAMs undergo metabolic reprogramming (glucose, lipid, amino acid, purine) that drives immunosuppressive phenotypes.
- - TAMs regulate immune checkpoints (PD-1/PD-L1, CTLA-4) and influence therapy resistance.
- - TAMs play crucial roles in combination strategies: ICIs, chemotherapy/radiotherapy, CAR-T.
- - Emerging technologies (scRNA-seq, spatial transcriptomics, nanomedicine) enable precise TAM profiling and targeting.

Innovation Points

- - First systematic integration of TAM metabolism, immune checkpoints, and combination therapies.
- - Highlighted metabolic reprogramming as a key driver of immune evasion and therapy resistance.
- - Proposed TAMs as central therapeutic targets bridging metabolism and immunotherapy.
- - Introduced multi-omics and spatial transcriptomics for TAM heterogeneity and precision targeting.
- - Provided operational guidance for combining TAM-targeted therapies with ICIs.

Mechanism Overview

- Schematic of TAMs in cancer immunotherapy:
 - - Metabolic reprogramming (Glucose → Lactate, FAO, Glutamine, Purine metabolism).
 - - Immune checkpoint regulation (PD-1/PD-L1, CTLA-4).
 - - Combination strategies (ICIs, radiotherapy/chemotherapy, CAR-T).
 - - Advanced technologies enabling TAM targeting.