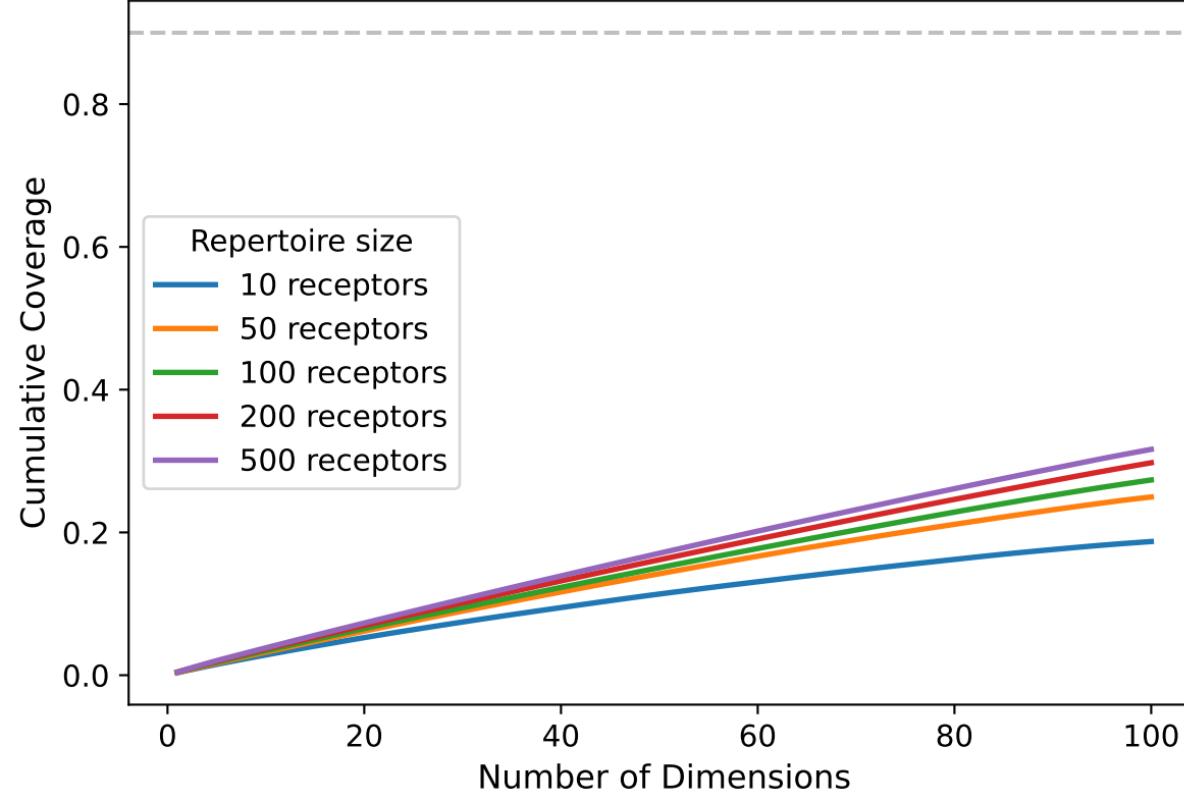


VDJ Diversity Covers State Space



V(D)J Recombination Statistics

Heavy chain:

- ~50 V segments
- ~25 D segments
- ~6 J segments
- Combinatorial: ~7,500

Light chain:

- ~40 V segments
- ~5 J segments
- Combinatorial: ~200

Total naive diversity:
 $\sim 1.5 \times 10^6$ combinations

With junctional diversity:
 $\sim 10^{11}$ unique receptors

Key insight:
This astronomical diversity is not noise—it is systematic exploration of a high-dimensional space.

Random ≠ Purposeless