## (A) Integration of conditions $\log$ MMD $\downarrow$ Wasserstein ↓ Var. explained by condition $\downarrow$ 0.10 Holdout 5 0.05 0.00 -5.5 0.10 Training 0.05 PCA 🕂 LEMUR -LEMUR -CPA PCAscVI -LEMUR-PCA-Harmony -Param. Harmony multi-cond. PCA multi-cond. PCA -Param. Harmony PCA Param. Harmony CPA scVI CPA Harmony multi-cond. PCA CPA Harmony Param. Harmony multi-cond. PCA LEMUR Harmony (B) Biological signal retention k-NN Overlap ↑ Var. explained by cell type 20 15 Holdout 10 0.0 0.0 0.0 0 20 15 0.5 10 0.5 5 0.0 scVI-PCA-LEMUR-LEMUR-CPA LEMUR-PCA-CPA scVI-PCA PCA-Harmony -CPA multi-cond. PCA CPA scVI multi-cond. PCA LEMUR scVI Harmony Param. Harmony multi-cond. PCA Harmony Param. Harmony multi-cond. PCA Harmony Param. Harmony Param. Harmony



