## (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 -CPAscVI -LEMUR PCA-Harmony -Param. Harmony -Rigid LEMUR -Param. Harmony Rigid LEMUR PCA Param. Harmony CPA scVI Rigid LEMUR CPA Harmony Rigid LEMUR CPA Harmony Harmony Param. Harmony LEMUR (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 PCA PCA-Harmony -CPA scVI Rigid LEMUR Rigid LEMUR CPA scVI Rigid LEMUR LEMUR scVI Harmony Param. Harmony Rigid LEMUR Harmony Param. Harmony Harmony Param. Harmony Param. Harmony (C) Ratio of variance explained $\frac{condition}{cell\ type}$ (log-scale) $10^{-1}$ $10^{-3}$

