

## SI Guide

### Supplementary Table 1

SupplementaryTable1.xls: 568 KB, Microsoft Excel

This table contains the adjusted  $R^2$  values between the top PEER factors estimated for each tissue and the sample covariates available for that tissue. Data for each tissue are presented in separate sheets named according to the tissue ID. Example adjusted  $R^2$  data for sample covariates for skeletal muscle (tissue ID: Muscle\_Skeletal) are presented in Extended Data Fig. 1a (left).

### Supplementary Table 2

SupplementaryTable1.xls: 1.5 MB, Microsoft Excel

This table contains the adjusted  $R^2$  values between the top PEER factors estimated for each tissue and the subject covariates available for that tissue. Data for each tissue are presented in separate sheets named according to the tissue ID. Example adjusted  $R^2$  data for subject covariates for skeletal muscle (tissue ID: Muscle\_Skeletal) are presented in Extended Data Fig. 1a (right).

### Supplementary Table 3

SupplementaryTable1.xls: 32 KB, Microsoft Excel

This table contains descriptions of the variant features for the enrichment analyses and training of RIVER. Sheet 'A-Selected features' describes the disjoint variant classes whose enrichments among outliers are presented in Fig. 3 and Extended Data Fig. 5c. Sheet 'B-RIVER features' describes the gene-level features used for training RIVER. The enrichments of these features among outliers are presented in Extended Data Fig. 7.