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July 15, 2025

1 CellSexID: Single-Cell Sex Identification Tool

This notebook demonstrates a comprehensive pipeline for sex prediction in single-cell RNA-seq data using machine learning approaches. The analysis covers data preprocessing, quality control, feature selection, and model training with multiple algorithms to achieve robust sex classification.

1.1 Overview

This analysis pipeline begins with setting up the computational environment for single-cell RNA-seq data analysis. We utilize Scanpy, a leading single-cell analysis toolkit, alongside scikit-learn and XGBoost for machine learning applications. The workflow is designed to handle both mouse and human single-cell datasets for sex prediction tasks.

1.2 Dataset Preparation Strategy

1.2.1 Step 1: Individual Dataset Loading

The pipeline handles separate male and female single-cell RNA-seq datasets through a systematic approach:

1. **Matrix Loading**: Count matrices are loaded from MTX format files and properly oriented (cells × genes)
2. **Gene Annotation**: Gene metadata is imported from TSV files containing gene identifiers and symbols
3. **Gene Assignment**: Gene names are mapped to expression matrices using annotation files
4. **Uniqueness Enforcement**: Duplicate gene names are resolved to prevent downstream conflicts

This approach ensures data integrity and consistency across experimental conditions.

1.2.2 Step 2: Gene Space Harmonization

To enable meaningful comparison between male and female datasets, we perform gene space alignment:

1. **Common Gene Identification**: Calculate the intersection of gene features between datasets
2. **Feature Space Harmonization**: Subset both datasets to retain only shared genes
3. **Consistency Verification**: Ensure identical gene ordering across datasets

This step is critical for downstream analysis as it ensures that all samples are measured across the same feature space.

1.2.3 Step 3: Dataset Integration and Labeling

The final preprocessing step involves combining individual datasets into a unified analysis object:

1. **Cell Identification**: Assign unique identifiers to distinguish cells across datasets
2. **Metadata Assignment**: Add sex labels and batch information for downstream analysis
3. **Dataset Concatenation**: Merge datasets while preserving individual cell and gene identities
4. **Quality Assurance**: Verify proper integration and resolve any naming conflicts

This creates a single AnnData object containing all cells with appropriate metadata for classification tasks.

1.3 Dataset Integration

Combining male and female datasets into a single AnnData object with appropriate cell identifiers and metadata labels. The concatenation preserves individual cell identities while enabling joint analysis across conditions.

[39]:
```
!pip install scanpy
import numpy as np
import pandas as pd
import scanpy as sc
sc.settings.verbosity = 3             # verbosity: errors (0), warnings (1),␣
 ↪info (2), hints (3)
sc.logging.print_header()
sc.settings.set_figure_params(dpi=80, facecolor='white')
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: scanpy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (1.10.2)
Requirement already satisfied: anndata>=0.8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.10.8)
Requirement already satisfied: get-annotations in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.1.2)
Requirement already satisfied: h5py>=3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.11.0)
Requirement already satisfied: joblib in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.4.2)
Requirement already satisfied: legacy-api-wrap>=1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.4)
Requirement already satisfied: matplotlib>=3.6 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.9.1)
Requirement already satisfied: natsort in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (8.4.0)
Requirement already satisfied: networkx>=2.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.2.1)
Requirement already satisfied: numba>=0.56 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.60.0)
Requirement already satisfied: numpy<2,>=1.23 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.26.4)
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Requirement already satisfied: packaging>=21.3 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (24.1)
Requirement already satisfied: pandas>=1.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (2.2.2)
Requirement already satisfied: patsy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.6)
Requirement already satisfied: pynndescent>=0.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.13)
Requirement already satisfied: scikit-learn>=0.24 in
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Requirement already satisfied: scipy>=1.8 in
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Requirement already satisfied: seaborn>=0.13 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.13.2)
Requirement already satisfied: session-info in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.0.0)
Requirement already satisfied: statsmodels>=0.13 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.14.2)
Requirement already satisfied: tqdm in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (4.66.4)
Requirement already satisfied: umap-learn!=0.5.0,>=0.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.6)
Requirement already satisfied: array-api-compat!=1.5,>1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
anndata>=0.8->scanpy) (1.7.1)
Requirement already satisfied: exceptiongroup in
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anndata>=0.8->scanpy) (1.2.1)
Requirement already satisfied: contourpy>=1.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (1.2.1)
Requirement already satisfied: cycler>=0.10 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (0.12.1)
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matplotlib>=3.6->scanpy) (4.53.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (1.4.5)
Requirement already satisfied: pillow>=8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (3.1.2)
Requirement already satisfied: python-dateutil>=2.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
```

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matplotlib>=3.6->scanpy) (2.9.0.post0)
Requirement already satisfied: importlib-resources>=3.2.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (6.4.0)
Requirement already satisfied: llvmlite<0.44,>=0.43.0dev0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
numba>=0.56->scanpy) (0.43.0)
Requirement already satisfied: pytz>=2020.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas>=1.5->scanpy) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas>=1.5->scanpy) (2024.1)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scikit-
learn>=0.24->scanpy) (3.5.0)
Requirement already satisfied: six in /Applications/Xcode.app/Contents/Developer
/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-packages
(from patsy->scanpy) (1.15.0)
Requirement already satisfied: stdlib-list in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from session-
info->scanpy) (0.10.0)
Requirement already satisfied: zipp>=3.1.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from importlib-
resources>=3.2.0->matplotlib>=3.6->scanpy) (3.19.2)

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip
install --upgrade pip
scanpy==1.10.2 anndata==0.10.8 umap==0.5.6 numpy==1.26.4 scipy==1.13.1
pandas==2.2.2 scikit-learn==1.5.1 statsmodels==0.14.2 pynndescent==0.5.13
```

[40]:
```
maledataRR = sc.read_mtx('male.mtx')
femaledataRR = sc.read_mtx('female.mtx')
fff=pd.read_csv('female.tsv',sep='\t',header=None)
mmm=pd.read_csv('male.tsv',sep='\t',header=None)
fff
frames = [fff, mmm]
name=pd.concat(frames,axis=0)
femaledata=femaledataRR.T
maledata=maledataRR.T
femaledata.var.index = fff[1]
maledata.var.index = mmm[1]
femaledata.var
femaledata.obs_names = [f"Cell_{2685+i:d}" for i in range(femaledata.n_obs)]
```

```
maledata.obs_names = [f"Cell_{i:d}" for i in range(maledata.n_obs)]
```

[ ]:
```
!pip install matplotlib==3.1.3
import anndata
fw=femaledata.X.todense()
maledata
fr=maledata.X.todense()
!pip install AnnData
import anndata
x_combined = np.concatenate([fr,fw],axis=0)#male
adata_combined = anndata.AnnData(x_combined)  # np array  anndata
adata_combined.var.index = fff[1]
adata_combined.obs_names = [f"Cell_{i:d}" for i in range(adata_combined.n_obs)]
c11 = np.ones(maledata.n_obs)
c22= np.zeros(femaledata.n_obs)
joined_list = [*c11, *c22]
adata_combined.obs["gender"] = pd.Categorical(joined_list)  # Categoricals are␣
 ↪preferred for efficiency
adata_combined.obs
adata=adata_combined
adata.var.index=fff[1]
adata.X=np.asarray(adata.X)
adata.var.index.name ="n"
sc.pp.filter_genes(adata, min_cells=3)
adata.var['mt'] = adata.var_names.str.startswith('mt-')  # annotate the group␣
 ↪of mitochondrial genes as 'mt'
sc.pp.calculate_qc_metrics(adata, qc_vars=['mt'], percent_top=None,␣
 ↪log1p=False, inplace=True)
adata.var_names_make_unique()
```

```
Defaulting to user installation because normal site-packages is not writeable
Collecting matplotlib==3.1.3
  Using cached matplotlib-3.1.3.tar.gz (40.9 MB)
  Preparing metadata (setup.py) … done
Requirement already satisfied: cycler>=0.10 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (0.12.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (1.4.5)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (3.1.2)
Requirement already satisfied: python-dateutil>=2.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (2.9.0.post0)
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Requirement already satisfied: numpy>=1.11 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (1.26.4)
Requirement already satisfied: six>=1.5 in /Applications/Xcode.app/Contents/Deve
loper/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-
packages (from python-dateutil>=2.1->matplotlib==3.1.3) (1.15.0)
Building wheels for collected packages: matplotlib
  Building wheel for matplotlib (setup.py) … error
  error: subprocess-exited-with-error

  × python setup.py bdist_wheel did not run successfully.
   exit code: 1
   > [518 lines of output]

================================================================================
      Edit setup.cfg to change the build options

      BUILDING MATPLOTLIB
        matplotlib: yes [3.1.3]
            python: yes [3.9.6 (default, Mar 12 2025, 20:22:46)  [Clang
17.0.0
                         (clang-1700.0.13.3)]]
          platform: yes [darwin]

      OPTIONAL SUBPACKAGES
       sample_data: yes [installing]
             tests: no  [skipping due to configuration]

      OPTIONAL BACKEND EXTENSIONS
               agg: yes [installing]
             tkagg: yes [installing; run-time loading from Python
Tcl/Tk]
             macosx: yes [installing, darwin]

      OPTIONAL PACKAGE DATA
              dlls: no  [skipping due to configuration]

      running bdist_wheel
      running build
      running build_py
      creating build
      creating build/lib.macosx-10.9-universal2-3.9
      copying lib/pylab.py -> build/lib.macosx-10.9-universal2-3.9
      creating build/lib.macosx-10.9-universal2-3.9/mpl_toolkits
      copying lib/mpl_toolkits/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/hatch.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/transforms.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/legend_handler.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/textpath.py ->
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      copying lib/matplotlib/quiver.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/backend_bases.py ->
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      copying lib/matplotlib/units.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/pylab.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/colorbar.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_version.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_cm.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/backend_managers.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/mathtext.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/font_manager.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/bezier.py ->
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      copying lib/matplotlib/legend.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/figure.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/offsetbox.py ->
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      copying lib/matplotlib/tight_bbox.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/container.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/gridspec.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/lines.py ->
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      copying lib/matplotlib/animation.py ->
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      copying lib/matplotlib/_mathtext_data.py ->
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      copying lib/matplotlib/artist.py ->
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      copying lib/matplotlib/spines.py ->
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      copying lib/matplotlib/_pylab_helpers.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/tight_layout.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_cm_listed.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/dates.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib
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      copying lib/matplotlib/_animation_data.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/pyplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/rcsetup.py ->
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      copying lib/matplotlib/sankey.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
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build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/streamplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/colors.py ->
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      creating
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      copying lib/mpl_toolkits/axes_grid1/inset_locator.py ->
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      copying lib/mpl_toolkits/axes_grid1/axes_grid.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/parasite_axes.py ->
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      copying lib/mpl_toolkits/axes_grid1/colorbar.py ->
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build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
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      copying lib/mpl_toolkits/axes_grid1/axes_rgb.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
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build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      creating
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/inset_locator.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axislines.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
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build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/grid_finder.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/parasite_axes.py ->
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```

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```

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```

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```

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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
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data/fonts/pdfcorefonts
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```

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ui-1.12.1
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/stylelib/fivethirtyeight.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-
Roman.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
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ui-1.12.1/jquery-ui.structure.min.css ->
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```

```
ui-1.12.1
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ui-1.12.1/jquery-ui.min.css ->
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ui-1.12.1
      copying lib/matplotlib/mpl-data/images/home.gif ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/backends/web_backend/css/fbm.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/mpl-data/fonts/afm/pagdo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pncbi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pcrro8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmss10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/cmex10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/phvr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica-
Bold.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/filesave_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/hand.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pzcmi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pplb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pplbi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery/js
```

```
      copying
lib/matplotlib/backends/web_backend/jquery/js/jquery.min.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery/js
      copying lib/matplotlib/mpl-data/images/home_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/matplotlib_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizFourSymReg.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans-Bold.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.structure.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/move.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvro8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/putri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmtt10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/home.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizFiveSymReg.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/home.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/css/page.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/mpl-data/fonts/afm/cmr10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/css/boilerplate.css
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/mpl-data/fonts/afm/putbi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/None_vs_nearest-
pdf.png -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/phvl8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/help.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/cmex10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-
```

```
data/sample_data/Minduka_Present_Blue_Pack.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/pplri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/cmmi10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/single_figure.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/fonts/afm/psyr.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.theme.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
notebook.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/AUTHORS.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/filesave.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/move.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/backends/web_backend/js/nbagg_mpl.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/mpl-data/sample_data/demodata.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/seaborn-poster.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/stylelib/seaborn-deep.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/sample_data/aapl.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneralBolIta.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/grayscale.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/stylelib/bmh.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/sample_data/eeg.dat ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/sample_data/logo2.png ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/putb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif-Italic.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/subplots.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/ptmri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/forward.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying
lib/matplotlib/backends/web_backend/ipython_inline_figure.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_777620_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/fonts/afm/cmtt10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/forward.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/forward_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/index.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniIta.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/phvbo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/hand.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/cmsy10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizTwoSymBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
```

```
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/filesave.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/stylelib/ggplot.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/help_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery/js/jquery.js
->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery/js
      copying lib/matplotlib/mpl-data/sample_data/s1045.ima.gz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/sample_data/grace_hopper.jpg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/backends/web_backend/nbagg_uat.ipynb ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/fonts/ttf/cmr10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-
BoldItalic.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/afm/pplr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmmi10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/pbkl8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/hand.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/phvbo8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneral.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_444444_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
```

```
      copying lib/matplotlib/mpl-data/images/matplotlib.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-white.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/phvr8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/readme.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/afm/pcrr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/embedding_in_wx3.xrc
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/pbkdi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono-
BoldOblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/zoom_to_rect_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-dark.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUni.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/sample_data/grace_hopper.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier-
Oblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneralBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/js/mpl_tornado.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_ffffff_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/sample_data/data_x_x2_x3.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/pagd8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pncr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-Bold.afm
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/forward.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-talk.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
```

```
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier-
Bold.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/afm/pcrbo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-
Italic.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/ttf/cmb10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/_classic_test.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/home.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-
data/sample_data/percent_bachelors_degrees_women_usa.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.theme.min.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/afm/ptmb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.min.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/matplotlib.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif-Bold.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/LICENSE.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Symbol.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/zoom_to_rect_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/stylelib/dark_background.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/forward_large.png ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/LICENSE_DEJAVU ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/hand.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/Solarize_Light2.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/back_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
whitegrid.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/phvro8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif-
BoldItalic.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizThreeSymReg.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/seaborn-pastel.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/forward.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/sample_data/msft.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/external
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/external/jquery
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/external/jquery/jquery.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/external/jquery
      copying lib/matplotlib/mpl-data/images/subplots.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/sample_data/ct.raw.gz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
```

```
data/sample_data/axes_grid
      copying lib/matplotlib/mpl-
data/sample_data/axes_grid/bivariate_normal.npy ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data/axes_grid
      copying lib/matplotlib/mpl-data/images/subplots_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/filesave.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/membrane.dat ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
colorblind.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/putr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/help_large.ppm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/home_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono-Bold.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans-Oblique.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/matplotlib.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pagk8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/move.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniBolIta.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/move_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
darkgrid.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/pcrb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pbkli8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizTwoSymReg.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/pzdr.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/back.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/matplotlibrc ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data
```

```
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_cc0000_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-
data/images/qt4_editor_options_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/README.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/fast.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/help.ppm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/all_figures.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/fonts/afm/pncb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica-
Oblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/ttf/LICENSE_STIX ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/move.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizOneSymReg.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica-
BoldOblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono-
Oblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizFourSymBol.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/subplots_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-paper.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier-
BoldOblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/stylelib/seaborn-bright.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizOneSymBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/move_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
```

```
ui-1.12.1/images/ui-icons_777777_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/sample_data/topobathy.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansDisplay.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/matplotlib.ppm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-
data/sample_data/jacksboro_fault_dem.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/images/help.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-dark-
palette.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/backends/web_backend/js/mpl.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/mpl-data/images/subplots.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/tableau-
colorblind10.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans-
BoldOblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/classic.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      UPDATING
build/lib.macosx-10.9-universal2-3.9/matplotlib/_version.py
      set build/lib.macosx-10.9-universal2-3.9/matplotlib/_version.py
to '3.1.3'
      running build_ext
      building 'matplotlib.ft2font' extension
      creating build/temp.macosx-10.9-universal2-3.9
      creating build/temp.macosx-10.9-universal2-3.9/src
      clang -Wno-unused-result -Wsign-compare -Wunreachable-code -fno-
common -dynamic -DNDEBUG -g -fwrapv -O3 -Wall
-iwithsysroot/System/Library/Frameworks/System.framework/PrivateHeaders -iwithsy
sroot/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.frame
work/Versions/3.9/Headers -arch arm64 -arch x86_64 -Werror=implicit-function-
declaration -Wno-error=unreachable-code -Wno-error=unused-but-set-variable -Wno-
error=cast-function-type-mismatch -Wno-unknown-warning-option
-DFREETYPE_BUILD_TYPE=system
-DPY_ARRAY_UNIQUE_SYMBOL=MPL_matplotlib_ft2font_ARRAY_API
-DNPY_NO_DEPRECATED_API=NPY_1_7_API_VERSION -D__STDC_FORMAT_MACROS=1
-Iextern/agg24-svn/include -I/Users/haley/Library/Python/3.9/lib/python/site-
```

```
packages/numpy/core/include -I/Applications/Xcode.app/Contents/Developer/Library
/Frameworks/Python3.framework/Versions/3.9/include/python3.9 -c
src/checkdep_freetype2.c -o
build/temp.macosx-10.9-universal2-3.9/src/checkdep_freetype2.o
-I/opt/homebrew/opt/freetype/include/freetype2
-I/opt/homebrew/opt/libpng/include/libpng16
      src/checkdep_freetype2.c:7:9: warning: Compiling with FreeType
version 2.13.3. [-W#pragma-messages]
          7 | #pragma message("Compiling with FreeType version " \
            |         ^
      1 warning generated.
      src/checkdep_freetype2.c:7:9: warning: Compiling with FreeType
version 2.13.3. [-W#pragma-messages]
          7 | #pragma message("Compiling with FreeType version " \
            |         ^
      1 warning generated.
      clang -Wno-unused-result -Wsign-compare -Wunreachable-code -fno-
common -dynamic -DNDEBUG -g -fwrapv -O3 -Wall
-iwithsysroot/System/Library/Frameworks/System.framework/PrivateHeaders -iwithsy
sroot/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.frame
work/Versions/3.9/Headers -arch arm64 -arch x86_64 -Werror=implicit-function-
declaration -Wno-error=unreachable-code -Wno-error=unused-but-set-variable -Wno-
error=cast-function-type-mismatch -Wno-unknown-warning-option
-DFREETYPE_BUILD_TYPE=system
-DPY_ARRAY_UNIQUE_SYMBOL=MPL_matplotlib_ft2font_ARRAY_API
-DNPY_NO_DEPRECATED_API=NPY_1_7_API_VERSION -D__STDC_FORMAT_MACROS=1
-Iextern/agg24-svn/include -I/Users/haley/Library/Python/3.9/lib/python/site-
packages/numpy/core/include -I/Applications/Xcode.app/Contents/Developer/Library
/Frameworks/Python3.framework/Versions/3.9/include/python3.9 -c src/ft2font.cpp
-o build/temp.macosx-10.9-universal2-3.9/src/ft2font.o
-I/opt/homebrew/opt/freetype/include/freetype2
-I/opt/homebrew/opt/libpng/include/libpng16
      src/ft2font.cpp:223:29: error: assigning to 'char *' from
'unsigned char *' converts between pointers to integer types where one is of the
unique plain 'char' type and the other is not
        223 |         tags = outline.tags + first;
            |                ~~~~~~~~~~~~~^~~~~~
      src/ft2font.cpp:339:29: error: assigning to 'char *' from
'unsigned char *' converts between pointers to integer types where one is of the
unique plain 'char' type and the other is not
        339 |         tags = outline.tags + first;
            |                ~~~~~~~~~~~~~^~~~~~
      2 errors generated.
      error: command '/usr/bin/clang' failed with exit code 1
      [end of output]

  note: This error originates from a subprocess, and is likely not a
problem with pip.
```

```
  ERROR: Failed building wheel for matplotlib
  Running setup.py clean for matplotlib
Failed to build matplotlib

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip
install --upgrade pip
ERROR: Failed to build installable wheels for some pyproject.toml based
projects (matplotlib)
Defaulting to user installation because normal site-packages is not
writeable
Requirement already satisfied: AnnData in
/Users/haley/Library/Python/3.9/lib/python/site-packages (0.10.8)
Requirement already satisfied: array-api-compat!=1.5,>1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.7.1)
Requirement already satisfied: exceptiongroup in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.2.1)
Requirement already satisfied: h5py>=3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (3.11.0)
Requirement already satisfied: natsort in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (8.4.0)
Requirement already satisfied: numpy>=1.23 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.26.4)
Requirement already satisfied: packaging>=20.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (24.1)
Requirement already satisfied: pandas!=2.1.0rc0,!=2.1.2,>=1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (2.2.2)
Requirement already satisfied: scipy>1.8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.13.1)
Requirement already satisfied: python-dateutil>=2.8.2 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2024.1)
Requirement already satisfied: six>=1.5 in /Applications/Xcode.app/Contents/Deve
loper/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-
packages (from python-dateutil>=2.8.2->pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData)
(1.15.0)
```

```
[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip
install --upgrade pip
filtered out 15132 genes that are detected in less than 3 cells
/Users/haley/Library/Python/3.9/lib/python/site-
packages/anndata/_core/anndata.py:1820: UserWarning: Variable names are not
unique. To make them unique, call `.var_names_make_unique`.
  utils.warn_names_duplicates("var")
```

1.3.1 Step 4: Quality Control Assessment

Quality control is essential for identifying and filtering low-quality cells that could bias downstream analysis:

1. **Mitochondrial Gene Detection**: Identify genes encoded by mitochondrial DNA as indicators of cell stress
2. **Cellular Quality Metrics**: Calculate key parameters including total transcript counts, gene detection rates, and mitochondrial gene percentages
3. **Data Visualization**: Generate comprehensive plots to assess data quality distributions and identify potential outliers

These metrics help distinguish healthy cells from dying or damaged cells that exhibit high mitochondrial gene expression.

[41]:
```
maledata
ct = np.random.choice(["1"], size=(maledata.n_obs,))
maledata.obs["gender"] = pd.Categorical(ct)  # Categoricals are preferred for␣
 ↪efficiency
maledata.obs
femaledata
ct = np.random.choice(["0"], size=(femaledata.n_obs,))
femaledata.obs["gender"] = pd.Categorical(ct)  # Categoricals are preferred for␣
 ↪efficiency
femaledata.obs

sc.settings.set_figure_params(dpi=80, facecolor='white')
```

[42]:
```
!pip install matplotlib==3.1.3
import anndata
fw=femaledata.X.todense()
maledata
fr=maledata.X.todense()
!pip install AnnData
import anndata
x_combined = np.concatenate([fr,fw],axis=0)#male
adata_combined = anndata.AnnData(x_combined)  # np array  anndata
```

```
adata_combined.var.index = fff[1]
adata_combined.obs_names = [f"Cell_{i:d}" for i in range(adata_combined.n_obs)]
c11 = np.ones(maledata.n_obs)
c22= np.zeros(femaledata.n_obs)
joined_list = [*c11, *c22]
adata_combined.obs["gender"] = pd.Categorical(joined_list)  # Categoricals are␣
 ↪preferred for efficiency
adata_combined.obs
adata=adata_combined
adata.var.index=fff[1]
adata.X=np.asarray(adata.X)
adata.var.index.name ="n"
sc.pp.filter_genes(adata, min_cells=3)
adata.var['mt'] = adata.var_names.str.startswith('mt-')  # annotate the group␣
 ↪of mitochondrial genes as 'mt'
sc.pp.calculate_qc_metrics(adata, qc_vars=['mt'], percent_top=None,␣
 ↪log1p=False, inplace=True)
adata.var_names_make_unique()
```

```
Defaulting to user installation because normal site-packages is not writeable
Collecting matplotlib==3.1.3
  Using cached matplotlib-3.1.3.tar.gz (40.9 MB)
  Preparing metadata (setup.py) … done
Requirement already satisfied: cycler>=0.10 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (0.12.1)
Requirement already satisfied: kiwisolver>=1.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (1.4.5)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (3.1.2)
Requirement already satisfied: python-dateutil>=2.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (2.9.0.post0)
Requirement already satisfied: numpy>=1.11 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib==3.1.3) (1.26.4)
Requirement already satisfied: six>=1.5 in /Applications/Xcode.app/Contents/Deve
loper/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-
packages (from python-dateutil>=2.1->matplotlib==3.1.3) (1.15.0)
Building wheels for collected packages: matplotlib
  Building wheel for matplotlib (setup.py) … error
  error: subprocess-exited-with-error

  × python setup.py bdist_wheel did not run successfully.
```

```
    exit code: 1
   > [518 lines of output]

================================================================================
      Edit setup.cfg to change the build options

      BUILDING MATPLOTLIB
        matplotlib: yes [3.1.3]
            python: yes [3.9.6 (default, Mar 12 2025, 20:22:46)  [Clang
17.0.0
                         (clang-1700.0.13.3)]]
          platform: yes [darwin]

      OPTIONAL SUBPACKAGES
       sample_data: yes [installing]
             tests: no  [skipping due to configuration]

      OPTIONAL BACKEND EXTENSIONS
               agg: yes [installing]
             tkagg: yes [installing; run-time loading from Python
Tcl/Tk]
             macosx: yes [installing, darwin]

      OPTIONAL PACKAGE DATA
              dlls: no  [skipping due to configuration]

      running bdist_wheel
      running build
      running build_py
      creating build
      creating build/lib.macosx-10.9-universal2-3.9
      copying lib/pylab.py -> build/lib.macosx-10.9-universal2-3.9
      creating build/lib.macosx-10.9-universal2-3.9/mpl_toolkits
      copying lib/mpl_toolkits/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/hatch.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/transforms.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/legend_handler.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/axis.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/textpath.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/quiver.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
```

```
      copying lib/matplotlib/backend_bases.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/units.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/pylab.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/colorbar.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_version.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_cm.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/backend_managers.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/mathtext.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/font_manager.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/bezier.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/cm.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/legend.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/figure.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/offsetbox.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/tight_bbox.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/container.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/gridspec.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/lines.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/widgets.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/blocking_input.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/dviread.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/animation.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/type1font.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
```

```
      copying lib/matplotlib/_mathtext_data.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/artist.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/backend_tools.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/docstring.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_color_data.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/texmanager.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/afm.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/patches.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/stackplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/collections.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/spines.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/text.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/markers.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/mlab.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/fontconfig_pattern.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_pylab_helpers.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/tight_layout.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_cm_listed.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/dates.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/table.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_animation_data.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/pyplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/rcsetup.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/ticker.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
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      copying lib/matplotlib/path.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/contour.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_layoutbox.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/image.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/scale.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/category.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/_constrained_layout.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/sankey.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/patheffects.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/streamplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      copying lib/matplotlib/colors.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib
      creating
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/inset_locator.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/axes_grid.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/parasite_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/colorbar.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/anchored_artists.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/axes_size.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/mpl_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/axes_rgb.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      copying lib/mpl_toolkits/axes_grid1/axes_divider.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid1
      creating
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/inset_locator.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
```

```
      copying lib/mpl_toolkits/axes_grid/axislines.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axes_grid.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/grid_finder.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/parasite_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/colorbar.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/anchored_artists.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axis_artist.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axisline_style.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axes_size.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/angle_helper.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/grid_helper_curvelinear.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/clip_path.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/floating_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axes_rgb.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      copying lib/mpl_toolkits/axes_grid/axes_divider.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axes_grid
      creating
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      copying lib/mpl_toolkits/mplot3d/proj3d.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      copying lib/mpl_toolkits/mplot3d/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      copying lib/mpl_toolkits/mplot3d/axes3d.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      copying lib/mpl_toolkits/mplot3d/axis3d.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      copying lib/mpl_toolkits/mplot3d/art3d.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/mplot3d
      creating
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/axislines.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
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```
      copying lib/mpl_toolkits/axisartist/axes_grid.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/grid_finder.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/parasite_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/axis_artist.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/axisline_style.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/angle_helper.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/grid_helper_curvelinear.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/clip_path.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/floating_axes.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/axes_rgb.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      copying lib/mpl_toolkits/axisartist/axes_divider.py ->
build/lib.macosx-10.9-universal2-3.9/mpl_toolkits/axisartist
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/compat
      copying lib/matplotlib/compat/subprocess.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/compat
      copying lib/matplotlib/compat/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/compat
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/trirefine.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/tripcolor.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/trifinder.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/triplot.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/tritools.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/tricontour.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/triangulation.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
      copying lib/matplotlib/tri/triinterpolate.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/tri
```

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      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      copying lib/matplotlib/axes/_axes.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      copying lib/matplotlib/axes/_base.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      copying lib/matplotlib/axes/_subplots.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      copying lib/matplotlib/axes/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      copying lib/matplotlib/axes/_secondary_axes.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/axes
      creating
build/lib.macosx-10.9-universal2-3.9/matplotlib/sphinxext
      copying lib/matplotlib/sphinxext/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/sphinxext
      copying lib/matplotlib/sphinxext/mathmpl.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/sphinxext
      copying lib/matplotlib/sphinxext/plot_directive.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/sphinxext
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/cbook
      copying lib/matplotlib/cbook/deprecation.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/cbook
      copying lib/matplotlib/cbook/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/cbook
      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_template.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_qt4agg.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_gtk3cairo.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_tkagg.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/wx_compat.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_qt5agg.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_qt5.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_gtk3agg.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_cairo.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_pdf.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_wxagg.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_pgf.py ->
```

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build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/backend_mixed.py ->
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      copying lib/matplotlib/backends/_backend_pdf_ps.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/backends
      copying lib/matplotlib/backends/tkagg.py ->
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      copying lib/matplotlib/backends/backend_ps.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/style
```

```
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      copying lib/matplotlib/projections/__init__.py ->
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      copying lib/matplotlib/testing/exceptions.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/qt_editor
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      copying lib/matplotlib/backends/qt_editor/formlayout.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/testing/jpl_units
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      copying lib/matplotlib/testing/jpl_units/UnitDbl.py ->
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build/lib.macosx-10.9-universal2-3.9/matplotlib/testing/jpl_units
      copying lib/matplotlib/testing/jpl_units/__init__.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/testing/jpl_units
      copying lib/matplotlib/testing/jpl_units/UnitDblConverter.py ->
```

```
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      copying lib/matplotlib/testing/jpl_units/StrConverter.py ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/testing/jpl_units
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      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/images
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data/stylelib
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      creating build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/afm
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
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      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.theme.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/help.ppm ->
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data/sample_data
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
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```

```
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      copying lib/matplotlib/mpl-data/images/home_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
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data/fonts/ttf
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-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
```

```
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/home_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/subplots.pdf ->
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colorblind10.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
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Bold.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
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Bold.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
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BoldOblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono-
Oblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
```

```
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BoldOblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
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ui-1.12.1/AUTHORS.txt ->
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ui-1.12.1
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-
Italic.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
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ui-1.12.1/images
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ui-1.12.1/images/ui-icons_777777_256x240.png ->
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ui-1.12.1/images
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-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/pzcmi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniBolIta.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
```

```
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build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizOneSymReg.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
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ui-1.12.1/images/ui-icons_cc0000_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica-
BoldOblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
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build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
darkgrid.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/sample_data/goog.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/phvbo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/home.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizThreeSymReg.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-
data/fonts/pdfcorefonts/ZapfDingbats.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/forward.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
whitegrid.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/LICENSE.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/sample_data/eeg.dat ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
```

```
      copying lib/matplotlib/mpl-data/stylelib/seaborn-ticks.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/LICENSE_DEJAVU ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-
data/sample_data/jacksboro_fault_dem.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/ggplot.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/pbkl8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/filesave.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/back_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pcrb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/README.txt ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/seaborn.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/stylelib/fast.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pplb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/phvr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pcrro8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmsy10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/js/mpl_tornado.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/mpl-data/fonts/afm/cmmi10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/subplots_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/cmb10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/index.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/hand_large.gif ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/afm/psyr.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/help_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif-Italic.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/seaborn-dark.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/forward_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/matplotlib.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Symbol.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/zoom_to_rect_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/move.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvro8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/fivethirtyeight.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-
data/sample_data/percent_bachelors_degrees_women_usa.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizFiveSymReg.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica.afm
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/help.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizFourSymBol.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniIta.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/ptmri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/home.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_555555_256x240.png ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/stylelib/seaborn-deep.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/backends/web_backend/js/mpl.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/js
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUni.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/phvb8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/back.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/bmh.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.theme.min.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/stylelib/seaborn-dark-
palette.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/pncb8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/cmtt10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneralItalic.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/grayscale.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_ffffff_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/images/move.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.structure.min.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSerif-
BoldItalic.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/forward.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
```

```
      copying lib/matplotlib/mpl-data/images/back.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/topobathy.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/images/move_large.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/data_x_x2_x3.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/afm/putri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/home.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/package.json ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/images/home.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pagko8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pncri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmex10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.min.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/backends/web_backend/css/fbm.css ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/mpl-
data/sample_data/Minduka_Present_Blue_Pack.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansMono-Bold.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/sample_data/embedding_in_wx3.xrc
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/images/hand.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/cmr10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/putr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/filesave_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/grace_hopper.jpg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/Solarize_Light2.mplstyle
```

```
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/single_figure.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizTwoSymReg.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneralBolIta.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/sample_data/ct.raw.gz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/stylelib/_classic_test.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/filesave.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Helvetica-
Oblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/sample_data/aapl.npz ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-Bold.afm
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/fonts/afm/pagk8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/jquery-ui.min.js ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1
      copying lib/matplotlib/mpl-data/fonts/afm/pbkli8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/pbkd8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/msft.csv ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Times-
Roman.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/zoom_to_rect_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-bright.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/cmsy10.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/None_vs_nearest-
pdf.png -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXGeneralBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/cmr10.ttf ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
notebook.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSans-
BoldOblique.ttf -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/pcrbo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/phvr8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/afm/phvbo8an.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/nbagg_uat.ipynb ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_444444_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/stylelib/dark_background.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/phvlo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/sample_data/ada.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images/ui-icons_777620_256x240.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery-
ui-1.12.1/images
      copying lib/matplotlib/mpl-data/images/forward.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pncr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/cmtt10.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/ttf/LICENSE_STIX ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/zoom_to_rect.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/backends/web_backend/css/boilerplate.css
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/css
      copying lib/matplotlib/mpl-data/fonts/pdfcorefonts/Courier-
Oblique.afm -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/fonts/pdfcorefonts
      copying lib/matplotlib/mpl-data/images/subplots_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/logo2.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
```

```
      copying lib/matplotlib/mpl-data/stylelib/seaborn-
colorblind.mplstyle -> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-
data/stylelib
      copying lib/matplotlib/mpl-data/images/subplots.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/hand.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-talk.mplstyle ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-
data/images/qt4_editor_options_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/hand.svg ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pplri8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/forward.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pncbi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/all_figures.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/images/matplotlib.ppm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/pplr8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/DejaVuSansDisplay.ttf
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/images/matplotlib_large.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/stylelib/seaborn-white.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/images/hand.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvro8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXNonUniBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying
lib/matplotlib/backends/web_backend/ipython_inline_figure.html ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.pdf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/help.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/afm/phvl8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/mpl-data/images/qt4_editor_options.svg ->
```

```
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/images/help_large.ppm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/sample_data/grace_hopper.png ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/sample_data
      copying lib/matplotlib/mpl-data/images/move.gif ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/images
      copying lib/matplotlib/mpl-data/fonts/ttf/STIXSizTwoSymBol.ttf ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/ttf
      copying lib/matplotlib/mpl-data/fonts/afm/pagdo8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      copying lib/matplotlib/backends/web_backend/jquery/js/jquery.js
->
build/lib.macosx-10.9-universal2-3.9/matplotlib/backends/web_backend/jquery/js
      copying lib/matplotlib/mpl-data/stylelib/seaborn-poster.mplstyle
-> build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/stylelib
      copying lib/matplotlib/mpl-data/fonts/afm/pplbi8a.afm ->
build/lib.macosx-10.9-universal2-3.9/matplotlib/mpl-data/fonts/afm
      UPDATING
build/lib.macosx-10.9-universal2-3.9/matplotlib/_version.py
      set build/lib.macosx-10.9-universal2-3.9/matplotlib/_version.py
to '3.1.3'
      running build_ext
      building 'matplotlib.ft2font' extension
      creating build/temp.macosx-10.9-universal2-3.9
      creating build/temp.macosx-10.9-universal2-3.9/src
      clang -Wno-unused-result -Wsign-compare -Wunreachable-code -fno-
common -dynamic -DNDEBUG -g -fwrapv -O3 -Wall
-iwithsysroot/System/Library/Frameworks/System.framework/PrivateHeaders -iwithsy
sroot/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.frame
work/Versions/3.9/Headers -arch arm64 -arch x86_64 -Werror=implicit-function-
declaration -Wno-error=unreachable-code -Wno-error=unused-but-set-variable -Wno-
error=cast-function-type-mismatch -Wno-unknown-warning-option
-DFREETYPE_BUILD_TYPE=system
-DPY_ARRAY_UNIQUE_SYMBOL=MPL_matplotlib_ft2font_ARRAY_API
-DNPY_NO_DEPRECATED_API=NPY_1_7_API_VERSION -D__STDC_FORMAT_MACROS=1
-Iextern/agg24-svn/include -I/Users/haley/Library/Python/3.9/lib/python/site-
packages/numpy/core/include -I/Applications/Xcode.app/Contents/Developer/Library
/Frameworks/Python3.framework/Versions/3.9/include/python3.9 -c
src/checkdep_freetype2.c -o
build/temp.macosx-10.9-universal2-3.9/src/checkdep_freetype2.o
-I/opt/homebrew/opt/freetype/include/freetype2
-I/opt/homebrew/opt/libpng/include/libpng16
      src/checkdep_freetype2.c:7:9: warning: Compiling with FreeType
version 2.13.3. [-W#pragma-messages]
          7 | #pragma message("Compiling with FreeType version " \
            |         ^
      1 warning generated.
```

```
      src/checkdep_freetype2.c:7:9: warning: Compiling with FreeType
version 2.13.3. [-W#pragma-messages]
          7 | #pragma message("Compiling with FreeType version " \
            |         ^
      1 warning generated.
      clang -Wno-unused-result -Wsign-compare -Wunreachable-code -fno-
common -dynamic -DNDEBUG -g -fwrapv -O3 -Wall
-iwithsysroot/System/Library/Frameworks/System.framework/PrivateHeaders -iwithsy
sroot/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.frame
work/Versions/3.9/Headers -arch arm64 -arch x86_64 -Werror=implicit-function-
declaration -Wno-error=unreachable-code -Wno-error=unused-but-set-variable -Wno-
error=cast-function-type-mismatch -Wno-unknown-warning-option
-DFREETYPE_BUILD_TYPE=system
-DPY_ARRAY_UNIQUE_SYMBOL=MPL_matplotlib_ft2font_ARRAY_API
-DNPY_NO_DEPRECATED_API=NPY_1_7_API_VERSION -D__STDC_FORMAT_MACROS=1
-Iextern/agg24-svn/include -I/Users/haley/Library/Python/3.9/lib/python/site-
packages/numpy/core/include -I/Applications/Xcode.app/Contents/Developer/Library
/Frameworks/Python3.framework/Versions/3.9/include/python3.9 -c src/ft2font.cpp
-o build/temp.macosx-10.9-universal2-3.9/src/ft2font.o
-I/opt/homebrew/opt/freetype/include/freetype2
-I/opt/homebrew/opt/libpng/include/libpng16
      src/ft2font.cpp:223:29: error: assigning to 'char *' from
'unsigned char *' converts between pointers to integer types where one is of the
unique plain 'char' type and the other is not
        223 |         tags = outline.tags + first;
            |                ~~~~~~~~~~~~~^~~~~~~
      src/ft2font.cpp:339:29: error: assigning to 'char *' from
'unsigned char *' converts between pointers to integer types where one is of the
unique plain 'char' type and the other is not
        339 |         tags = outline.tags + first;
            |                ~~~~~~~~~~~~~^~~~~~~
      2 errors generated.
      error: command '/usr/bin/clang' failed with exit code 1
      [end of output]

  note: This error originates from a subprocess, and is likely not a
problem with pip.
  ERROR: Failed building wheel for matplotlib

  Running setup.py clean for matplotlib
Failed to build matplotlib

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip

install --upgrade pip
```

```
ERROR: Failed to build installable wheels for some pyproject.toml based
projects (matplotlib)

Defaulting to user installation because normal site-packages is not
writeable
Requirement already satisfied: AnnData in
/Users/haley/Library/Python/3.9/lib/python/site-packages (0.10.8)
Requirement already satisfied: array-api-compat!=1.5,>1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.7.1)
Requirement already satisfied: exceptiongroup in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.2.1)
Requirement already satisfied: h5py>=3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (3.11.0)
Requirement already satisfied: natsort in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (8.4.0)
Requirement already satisfied: numpy>=1.23 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.26.4)
Requirement already satisfied: packaging>=20.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (24.1)
Requirement already satisfied: pandas!=2.1.0rc0,!=2.1.2,>=1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (2.2.2)
Requirement already satisfied: scipy>1.8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from AnnData) (1.13.1)
Requirement already satisfied: python-dateutil>=2.8.2 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData) (2024.1)
Requirement already satisfied: six>=1.5 in /Applications/Xcode.app/Contents/Deve
loper/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-
packages (from python-dateutil>=2.8.2->pandas!=2.1.0rc0,!=2.1.2,>=1.4->AnnData)
(1.15.0)

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip

install --upgrade pip
filtered out 15132 genes that are detected in less than 3 cells

/Users/haley/Library/Python/3.9/lib/python/site-
packages/anndata/_core/anndata.py:1820: UserWarning: Variable names are not
unique. To make them unique, call `.var_names_make_unique`.
```

```
utils.warn_names_duplicates("var")
```

[43]:
```
import scanpy as sc
import matplotlib.pyplot as plt
import seaborn as sns
adata.var_names_make_unique()

# Preprocessing
sc.pp.normalize_total(adata, target_sum=1e4)
sc.pp.log1p(adata)
# sc.pp.highly_variable_genes(adata, min_mean=0.0125, max_mean=3, min_disp=0.5)
# sc.pl.highly_variable_genes(adata, save='5.pdf')

# Dimensionality reduction
sc.tl.pca(adata, svd_solver='arpack')
sc.pl.pca_variance_ratio(adata, log=True, save='6.pdf')

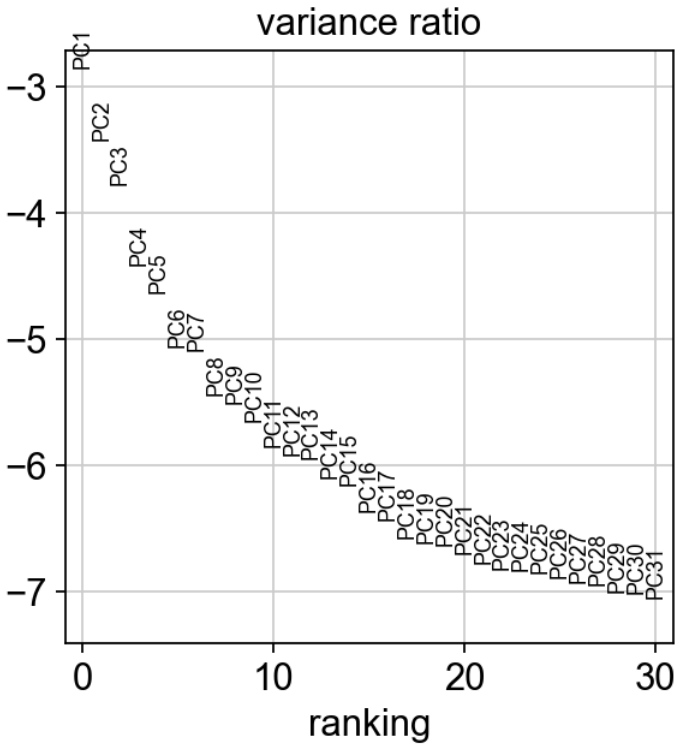
# Compute neighbors and UMAP (only once)
sc.pp.neighbors(adata, n_neighbors=10, n_pcs=40)
sc.tl.umap(adata)


# Create the UMAP plot
sc.pl.umap(adata,
           color='gender',
           palette={1: '#2c7bb6', 0: '#d7191c'},
           size=20,
           alpha=0.5,
           frameon=True,
           legend_loc='right margin',
           title='UMAP Visualization',
           legend_fontsize=12,
           show=False)

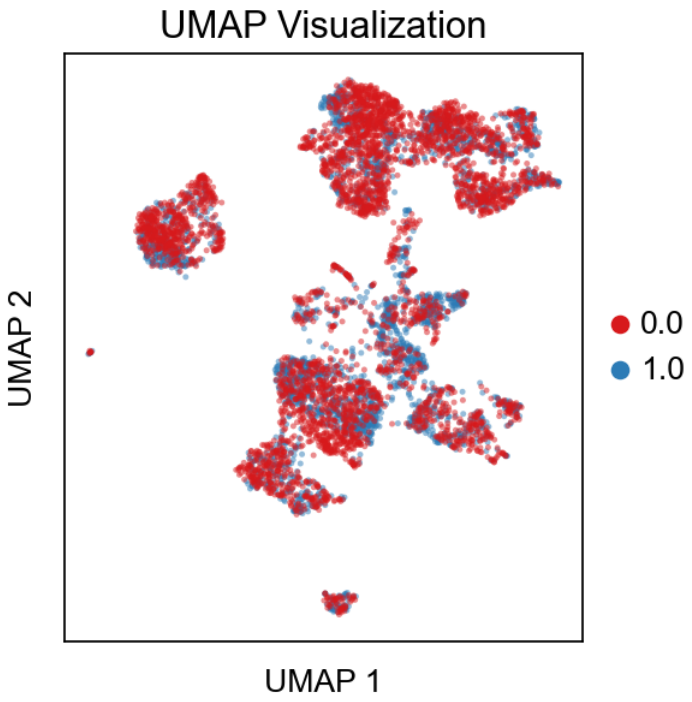
# Customize the plot
ax = plt.gca()
ax.set_title('UMAP Visualization', fontsize=14)
plt.xlabel('UMAP 1', fontsize=12, labelpad=10)
plt.ylabel('UMAP 2', fontsize=12, labelpad=10)
plt.grid(False)
ax.set_facecolor('white')
ax.spines['top'].set_visible(True)
ax.spines['right'].set_visible(True)
ax.spines['bottom'].set_visible(True)
ax.spines['left'].set_visible(True)
plt.tight_layout()
```

```
# Save and display the plot
plt.savefig('umap_sex_difference.pdf',
            dpi=300,
            bbox_inches='tight',
            facecolor='white',
            edgecolor='none')
plt.show()
```

```
normalizing counts per cell
    finished (0:00:00)
computing PCA
    with n_comps=50
    finished (0:00:32)
WARNING: saving figure to file figures/pca_variance_ratio6.pdf
```




```
computing neighbors
    using 'X_pca' with n_pcs = 40
    finished: added to `.uns['neighbors']`
    `.obsp['distances']`, distances for each pair of neighbors
    `.obsp['connectivities']`, weighted adjacency matrix (0:00:00)
computing UMAP
    finished: added
    'X_umap', UMAP coordinates (adata.obsm) (0:00:06)
```



1.4 LOAD test data

[4]:
```
!pip install pyranges
!pip install scanpy
import numpy as np
import pandas as pd
import scanpy as sc
import numpy as np
import pandas as pd
import scanpy as sc
neww=sc.read_h5ad("4_type.h5ad")
```

```
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: pyranges in
/Users/haley/Library/Python/3.9/lib/python/site-packages (0.1.4)
Requirement already satisfied: pandas in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pyranges) (2.2.2)
Requirement already satisfied: ncls>=0.0.63 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pyranges)
(0.0.68)
Requirement already satisfied: tabulate in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pyranges) (0.9.0)
Requirement already satisfied: sorted_nearest>=0.0.33 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pyranges)
```

```
(0.0.39)
Requirement already satisfied: natsort in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pyranges) (8.4.0)
Requirement already satisfied: numpy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
ncls>=0.0.63->pyranges) (1.26.4)
Requirement already satisfied: python-dateutil>=2.8.2 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pandas->pyranges)
(2.9.0.post0)
Requirement already satisfied: pytz>=2020.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pandas->pyranges)
(2024.1)
Requirement already satisfied: tzdata>=2022.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from pandas->pyranges)
(2024.1)
Requirement already satisfied: six>=1.5 in /Applications/Xcode.app/Contents/Deve
loper/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-
packages (from python-dateutil>=2.8.2->pandas->pyranges) (1.15.0)

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip
install --upgrade pip
Defaulting to user installation because normal site-packages is not writeable
Requirement already satisfied: scanpy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (1.10.2)
Requirement already satisfied: anndata>=0.8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.10.8)
Requirement already satisfied: get-annotations in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.1.2)
Requirement already satisfied: h5py>=3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.11.0)
Requirement already satisfied: joblib in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.4.2)
Requirement already satisfied: legacy-api-wrap>=1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.4)
Requirement already satisfied: matplotlib>=3.6 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.9.1)
Requirement already satisfied: natsort in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (8.4.0)
Requirement already satisfied: networkx>=2.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (3.2.1)
Requirement already satisfied: numba>=0.56 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.60.0)
Requirement already satisfied: numpy<2,>=1.23 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.26.4)
```

```
Requirement already satisfied: packaging>=21.3 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (24.1)
Requirement already satisfied: pandas>=1.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (2.2.2)
Requirement already satisfied: patsy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.6)
Requirement already satisfied: pynndescent>=0.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.13)
Requirement already satisfied: scikit-learn>=0.24 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.5.1)
Requirement already satisfied: scipy>=1.8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.13.1)
Requirement already satisfied: seaborn>=0.13 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.13.2)
Requirement already satisfied: session-info in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (1.0.0)
Requirement already satisfied: statsmodels>=0.13 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.14.2)
Requirement already satisfied: tqdm in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (4.66.4)
Requirement already satisfied: umap-learn!=0.5.0,>=0.5 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scanpy) (0.5.6)
Requirement already satisfied: array-api-compat!=1.5,>1.4 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
anndata>=0.8->scanpy) (1.7.1)
Requirement already satisfied: exceptiongroup in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
anndata>=0.8->scanpy) (1.2.1)
Requirement already satisfied: contourpy>=1.0.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (1.2.1)
Requirement already satisfied: cycler>=0.10 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (4.53.1)
Requirement already satisfied: kiwisolver>=1.3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (1.4.5)
Requirement already satisfied: pillow>=8 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (10.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (3.1.2)
Requirement already satisfied: python-dateutil>=2.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
```

```
matplotlib>=3.6->scanpy) (2.9.0.post0)
Requirement already satisfied: importlib-resources>=3.2.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
matplotlib>=3.6->scanpy) (6.4.0)
Requirement already satisfied: llvmlite<0.44,>=0.43.0dev0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
numba>=0.56->scanpy) (0.43.0)
Requirement already satisfied: pytz>=2020.1 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas>=1.5->scanpy) (2024.1)
Requirement already satisfied: tzdata>=2022.7 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from
pandas>=1.5->scanpy) (2024.1)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scikit-
learn>=0.24->scanpy) (3.5.0)
Requirement already satisfied: six in /Applications/Xcode.app/Contents/Developer
/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-packages
(from patsy->scanpy) (1.15.0)
Requirement already satisfied: stdlib-list in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from session-
info->scanpy) (0.10.0)
Requirement already satisfied: zipp>=3.1.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from importlib-
resources>=3.2.0->matplotlib>=3.6->scanpy) (3.19.2)

[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip

install --upgrade pip
```

[5]:
```
import scanpy as sc
import pandas as pd
import matplotlib.pyplot as plt
gene_ids = neww.var['gene_ids']
# # Load the dataset
adata = sc.read("4_type.h5ad")

conditions = adata.obs['conditions'].unique()

# Separating adata based on conditions
# It's a good idea to check the actual condition values and modify as needed
adata1 = adata[adata.obs['conditions'] == conditions[0], :]
adata2 = adata[adata.obs['conditions'] == conditions[1], :]
adata3 = adata[adata.obs['conditions'] == conditions[2], :]
adata4 = adata[adata.obs['conditions'] == conditions[3], :]
```

[6]:
```
adata1
```

[6]:
```
View of AnnData object with n_obs × n_vars = 8268 × 20902
    obs: 'dataset', 'sample', 'n_genes', 'n_genes_by_counts', 'total_counts',
'total_counts_mt', 'pct_counts_mt', 'conditions'
    var: 'gene_ids', 'feature_types', 'n_cells', 'mt', 'n_cells_by_counts',
'mean_counts', 'pct_dropout_by_counts', 'total_counts', 'highly_variable',
'means', 'dispersions', 'dispersions_norm'
    uns: 'hvg', 'log1p'
```

[7]:
```
conditions
```

[7]:
```
['WT_WT', 'mdx_WT', 'WT_mdx', 'mdx_mdx']
Categories (4, object): ['WT_WT', 'mdx_WT', 'WT_mdx', 'mdx_mdx']
```

[8]:
```
import scanpy as sc

# Assuming adata1 is already defined and loaded

# Plot the 20 highest expressed genes
# sc.pl.highest_expr_genes(adata1, n_top=20)

# Filter out genes that are detected in fewer than 3 cells
# sc.pp.filter_genes(adata1, min_cells=3)

# # # Normalize the data (scaling each cell to a total count of 1e4)
# sc.pp.normalize_total(adata1, target_sum=1e4)

# # # Logarithmically scale the data
# sc.pp.log1p(adata1)

# Convert the sparse matrix to a dense matrix and extract gene IDs
matrix = adata1.X.todense()  # Your matrix data
gene_ids = adata1.var.index  # Your gene IDs

# Create a DataFrame
df_adata1= pd.DataFrame(matrix, columns=gene_ids)
```

[9]:
```
df_adata1
```

[9]:

	Xkr4	Gm1992	Rp1	Sox17	Gm37587	Mrpl15	Lypla1	Tcea1	Rgs20	\
0	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	1.067894	0.0	
1	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	1.189107	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	1.751662	0.0	
3	0.0	0.0	0.0	0.0	0.0	0.000000	0.000000	1.616192	0.0	
4	0.0	0.0	0.0	0.0	0.0	0.473922	0.473922	1.036327	0.0	
…	…	…	…	…	…	…	…	…	…	…

```
8263   0.0     0.0  0.0    0.0      0.0  0.000000  0.000000  0.000000    0.0
8264   0.0     0.0  0.0    0.0      0.0  0.000000  0.000000  0.626800    0.0
8265   0.0     0.0  0.0    0.0      0.0  0.499769  0.499769  0.499769    0.0
8266   0.0     0.0  0.0    0.0      0.0  0.000000  0.000000  1.166482    0.0
8267   0.0     0.0  0.0    0.0      0.0  0.000000  0.000000  0.660885    0.0

       Atp6v1h  …  CAAA01118383.1  AC132444.1  AC132444.5  Csprs  \
0     1.067894  …        0.000000         0.0         0.0    0.0
1     1.189107  …        0.000000         0.0         0.0    0.0
2     0.000000  …        0.000000         0.0         0.0    0.0
3     0.000000  …        0.000000         0.0         0.0    0.0
4     0.794151  …        0.000000         0.0         0.0    0.0
…          …  …             …           …          …     …
8263  0.000000  …        0.000000         0.0         0.0    0.0
8264  1.398875  …        0.626800         0.0         0.0    0.0
8265  0.000000  …        0.499769         0.0         0.0    0.0
8266  1.462333  …        0.744476         0.0         0.0    0.0
8267  1.055360  …        0.000000         0.0         0.0    0.0

      AC132444.6     Vamp7  Spry3  Tmlhe  CAAA01147332.1  AC149090.1
0            0.0  0.821026    0.0    0.0        0.000000    0.000000
1            0.0  0.000000    0.0    0.0        0.000000    0.000000
2            0.0  0.000000    0.0    0.0        0.000000    0.000000
3            0.0  0.000000    0.0    0.0        0.000000    2.204726
4            0.0  0.000000    0.0    0.0        0.473922    0.473922
…          …        …    …    …             …          …
8263         0.0  0.000000    0.0    0.0        0.000000    3.339708
8264         0.0  0.000000    0.0    0.0        0.000000    0.361726
8265         0.0  0.000000    0.0    0.0        0.000000    0.831465
8266         0.0  0.000000    0.0    0.0        0.000000    1.166482
8267         0.0  0.000000    0.0    0.0        0.660885    0.000000

[8268 rows x 20902 columns]
```

[11]:
```python
import pandas as pd

# Assuming df is your DataFrame
# And columns_to_extract is your list of column names
columns_to_extract = [ "Xist","Ddx3y","Gm42418","Eif2s3y","Rps27rt",
    "Rpl9-ps6","Kdm5d","Uba52","Rpl35","Rpl36a-ps1",
    "Uty","Wdr89","Lars2","Rps27"]
columns_to_extract = [col for col in columns_to_extract if col in df_adata1.
 ↪columns]
extracted_columns = df_adata1[columns_to_extract]


extracted_columns_1 = df_adata1[columns_to_extract]
```

[12]:
```
extracted_columns_1
```

[12]:

	Xist	Ddx3y	Gm42418	Eif2s3y	Rps27rt	Rpl9-ps6	Kdm5d	\
0	0.0	0.492508	4.253757	0.492508	0.492508	0.000000	0.000000	
1	0.0	0.000000	4.766366	0.000000	0.000000	1.189107	0.000000	
2	0.0	1.751662	4.591736	0.000000	1.751662	0.000000	0.000000	
3	0.0	0.000000	5.250138	0.000000	0.000000	0.000000	0.000000	
4	0.0	0.794151	4.308918	0.000000	0.473922	0.473922	0.000000	
…	…	…	…	…	…	…	…	
8263	0.0	0.000000	5.832282	0.000000	0.000000	0.000000	0.000000	
8264	0.0	0.361726	6.557333	0.626800	0.000000	0.000000	0.626800	
8265	0.0	0.499769	5.148435	0.499769	0.000000	0.000000	0.499769	
8266	0.0	0.744476	5.648857	0.000000	0.000000	0.744476	0.000000	
8267	0.0	0.660885	5.510605	0.660885	0.000000	0.000000	0.000000	

	Uba52	Rpl35	Rpl36a-ps1	Uty	Wdr89	Lars2	Rps27
0	0.821026	2.749676	0.000000	0.492508	0.000000	1.430808	3.000345
1	1.189107	2.519368	0.000000	0.000000	0.000000	1.717089	3.625577
2	1.218493	2.727364	0.000000	0.000000	0.000000	0.000000	3.603629
3	0.000000	0.000000	0.000000	1.616192	0.000000	1.616192	1.616192
4	1.231138	2.037198	0.000000	1.231138	0.000000	1.766484	2.619722
…	…	…	…	…	…	…	…
8263	0.000000	0.000000	0.000000	0.000000	0.000000	3.733287	0.000000
8264	0.626800	2.227895	0.361726	0.836129	0.000000	2.546845	2.476130
8265	1.279088	2.172486	0.000000	0.000000	0.000000	1.587201	3.192131
8266	0.000000	1.875901	0.000000	0.744476	0.744476	2.167609	2.489346
8267	0.000000	1.889949	0.000000	0.660885	0.000000	2.243742	2.882401

[8268 rows x 14 columns]

2 infer data

[85]:
```
inf_data=sc.read_h5ad("IFNR_infer_sexpredect_v2(1).h5ad"  )
# sc.pp.log1p(inf_data)
```

```
/Users/haley/Library/Python/3.9/lib/python/site-
packages/anndata/_core/anndata.py:1818: UserWarning: Observation names are not
unique. To make them unique, call `.obs_names_make_unique`.
  utils.warn_names_duplicates("obs")
```

[86]:
```
import scanpy as sc

# Suppose we have 'group_column' in inf_data.obs
# that can take values "groupA" and "groupB"

inf_IFNRKO = inf_data[inf_data.obs["group"] == "IFNRKO"].copy()
inf_CD45_1 = inf_data[inf_data.obs["group"] == "CD45_1"].copy()
```

```
/Users/haley/Library/Python/3.9/lib/python/site-
packages/anndata/_core/anndata.py:1818: UserWarning: Observation names are not
unique. To make them unique, call `.obs_names_make_unique`.
  utils.warn_names_duplicates("obs")
/Users/haley/Library/Python/3.9/lib/python/site-
packages/anndata/_core/anndata.py:1818: UserWarning: Observation names are not
unique. To make them unique, call `.obs_names_make_unique`.
  utils.warn_names_duplicates("obs")
```

[87]:
```python
def process_inf_data(inf_data):
    import scanpy as sc
    import pandas as pd

    # Apply log1p
    sc.pp.log1p(inf_data)

    # Create the DataFrame
    matrix = inf_data.X
    gene_ids = inf_data.var.index
    df = pd.DataFrame(matrix, columns=gene_ids)

    return df
```

[88]:
```python
inf_IFNRKO_df = process_inf_data(inf_IFNRKO)
inf_CD45_1_df = process_inf_data(inf_CD45_1)
```

[89]:
```python
extracted_columns_IFNRKO = inf_IFNRKO_df[columns_to_extract]
extracted_columns_CD45 = inf_CD45_1_df[columns_to_extract]
```

[90]:
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler
from xgboost import XGBClassifier

def predict_and_plot(
    df,
    model,
    scaler,
    output_prefix="output"
):
    """
    Scales the DataFrame `df` using the provided `scaler`,
    predicts labels using `model`,
    saves the predictions to a CSV file,
    and generates a bar plot of predicted label proportions.
```

```
    Parameters
    ----------
    df : pd.DataFrame
        The test DataFrame to be predicted.
    model : a fitted sklearn-like model (e.g. XGBClassifier)
        The model used for prediction.
    scaler : an already fitted scaler (StandardScaler or similar)
        Used to transform the test data.
    output_prefix : str
        A prefix for naming the output CSV and PNG files.
    """
    # Scale the data
    df_scaled = scaler.transform(df)

    # Predict labels
    predicted_labels = model.predict(df_scaled)

    # Convert predictions to a DataFrame and save
    output_csv = f"{output_prefix}_predicted_labels.csv"
    pd.DataFrame({"Prediction": predicted_labels}).to_csv(output_csv,␣
↪index=False)
    print(f"Predicted labels saved to '{output_csv}'.")

    # Calculate percentages for the bar plot
    label_counts = pd.Series(predicted_labels).value_counts(normalize=True) *␣
↪100  # Convert to percentages

    # Create a bar plot
    ax = label_counts.plot(kind='bar', color=['blue', 'orange'], alpha=0.7)
    plt.xlabel("Prediction")
    plt.ylabel("Percentage")
    plt.title("Proportions of Predicted Labels")
    plt.xticks([0, 1], labels=['0', '1'], rotation=0)
    plt.ylim(0, 100)  # Ensure the y-axis ranges from 0 to 100

    # Add percentage labels on the bars
    for i, v in enumerate(label_counts):
        plt.text(i, v + 1, f"{v:.2f}%", ha='center', va='bottom', fontsize=7)

    # Save and close the plot
    output_png = f"{output_prefix}_prediction_percentage_barplot.png"
    plt.savefig(output_png, dpi=300)
    plt.close()  # Close the figure so we don't keep re-drawing
    print(f"Bar plot of predicted label percentages saved to '{output_png}'.\n")
```

[91]:
```
# For reproducibility
np.random.seed(42)

# Example training data: full_X_train, full_Y_train
# You have your model definition, for example:
model = XGBClassifier(
    use_label_encoder=False,
    eval_metric='logloss',
    n_estimators=300,
    learning_rate=0.01,
    max_depth=6,
    random_state=551
)

# Fit the scaler on training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Fit the model on the training data
model.fit(full_X_train_scaled, full_Y_train)
```

```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [21:14:19] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```

[91]:
```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric='logloss',
              feature_types=None, gamma=None, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=0.01, max_bin=None, max_cat_threshold=None,
              max_cat_to_onehot=None, max_delta_step=None, max_depth=6,
              max_leaves=None, min_child_weight=None, missing=nan,
              monotone_constraints=None, multi_strategy=None, n_estimators=300,
              n_jobs=None, num_parallel_tree=None, random_state=551, …)
```

[92]:
```
# Suppose you have two DataFrames:
#   inf_IFNRKO_df
#   inf_CD45_1_df

# Call the function for the first DataFrame
predict_and_plot(
    df=extracted_columns_IFNRKO ,
    model=model,
```

```
    scaler=scaler,
    output_prefix="inf_IFNRKO"  # This will produce␣
 ↪"inf_IFNRKO_predicted_labels.csv" and␣
 ↪"inf_IFNRKO_prediction_percentage_barplot.png"
)

# Call the function for the second DataFrame
predict_and_plot(
    df=extracted_columns_CD45,
    model=model,
    scaler=scaler,
    output_prefix="inf_CD45_1"
)
```

```
Predicted labels saved to 'inf_IFNRKO_predicted_labels.csv'.
Bar plot of predicted label percentages saved to
'inf_IFNRKO_prediction_percentage_barplot.png'.

Predicted labels saved to 'inf_CD45_1_predicted_labels.csv'.
Bar plot of predicted label percentages saved to
'inf_CD45_1_prediction_percentage_barplot.png'.
```

3 process validation data

[36]:
```
adata
```

[36]:
```
AnnData object with n_obs × n_vars = 6648 × 17153
    obs: 'gender', 'n_genes_by_counts', 'total_counts', 'total_counts_mt',
'pct_counts_mt'
    var: 'n_cells', 'mt', 'n_cells_by_counts', 'mean_counts',
'pct_dropout_by_counts', 'total_counts'
    uns: 'log1p', 'pca', 'neighbors', 'umap', 'gender_colors'
    obsm: 'X_pca', 'X_umap'
    varm: 'PCs'
    obsp: 'distances', 'connectivities'
```

[37]:
```
rc = pd.DataFrame(adata.X, index=adata.obs_names, columns=adata.var_names)
rc["y"] = pd.Categorical(joined_list)
```

[38]:
```
rc
```

[38]:

n	Sox17	Mrpl15	Lypla1	Tcea1	Gm16041	Atp6v1h	Rb1cc1	\
Cell_0	0.0	0.00000	1.354815	0.000000	0.0	0.00000	0.000000	
Cell_1	0.0	0.00000	0.000000	1.223296	0.0	0.00000	0.788087	
Cell_2	0.0	0.00000	0.000000	0.000000	0.0	0.00000	0.000000	
Cell_3	0.0	0.00000	0.000000	2.327345	0.0	0.00000	0.000000	

```
Cell_4       0.0  0.94693  0.000000  0.946930      0.0  0.94693  0.946930
…          …      …        …        …       …       …        …
Cell_6643    0.0  0.00000  0.000000  0.000000      0.0  0.00000  0.000000
Cell_6644    0.0  0.00000  0.000000  0.000000      0.0  0.00000  0.000000
Cell_6645    0.0  0.00000  0.000000  0.000000      0.0  0.00000  0.000000
Cell_6646    0.0  0.00000  0.000000  0.000000      0.0  0.00000  1.482703
Cell_6647    0.0  0.00000  0.000000  0.000000      0.0  0.00000  0.000000

n          4732440D04Rik  St18    Pcmtd1  …  AC168977.1  CAAA01118383.1  \
Cell_0               0.0   0.0  0.000000  …         0.0        0.000000
Cell_1               0.0   0.0  0.000000  …         0.0        0.000000
Cell_2               0.0   0.0  0.000000  …         0.0        0.000000
Cell_3               0.0   0.0  2.327345  …         0.0        0.000000
Cell_4               0.0   0.0  0.000000  …         0.0        0.946930
…                  …   …       …  …         …             …
Cell_6643            0.0   0.0  1.474856  …         0.0        0.000000
Cell_6644            0.0   0.0  0.000000  …         0.0        0.000000
Cell_6645            0.0   0.0  1.235361  …         0.0        0.000000
Cell_6646            0.0   0.0  1.482703  …         0.0        1.482703
Cell_6647            0.0   0.0  0.000000  …         0.0        0.000000

n          AC132444.1  AC132444.5  Csprs     Vamp7  Tmlhe  CAAA01147332.1  \
Cell_0            0.0         0.0    0.0  0.000000    0.0             0.0
Cell_1            0.0         0.0    0.0  0.000000    0.0             0.0
Cell_2            0.0         0.0    0.0  0.000000    0.0             0.0
Cell_3            0.0         0.0    0.0  0.000000    0.0             0.0
Cell_4            0.0         0.0    0.0  0.000000    0.0             0.0
…               …           …    …       …    …             …
Cell_6643         0.0         0.0    0.0  0.000000    0.0             0.0
Cell_6644         0.0         0.0    0.0  0.000000    0.0             0.0
Cell_6645         0.0         0.0    0.0  1.235361    0.0             0.0
Cell_6646         0.0         0.0    0.0  0.000000    0.0             0.0
Cell_6647         0.0         0.0    0.0  0.000000    0.0             0.0

n          AC149090.1    y
Cell_0       1.909851  1.0
Cell_1       0.788087  1.0
Cell_2       0.000000  1.0
Cell_3       2.327345  1.0
Cell_4       0.946930  1.0
…              …  …
Cell_6643    0.000000  0.0
Cell_6644    0.000000  0.0
Cell_6645    0.000000  0.0
Cell_6646    0.000000  0.0
Cell_6647    1.885036  0.0
```

```
[6648 rows x 17154 columns]
```

4 test data

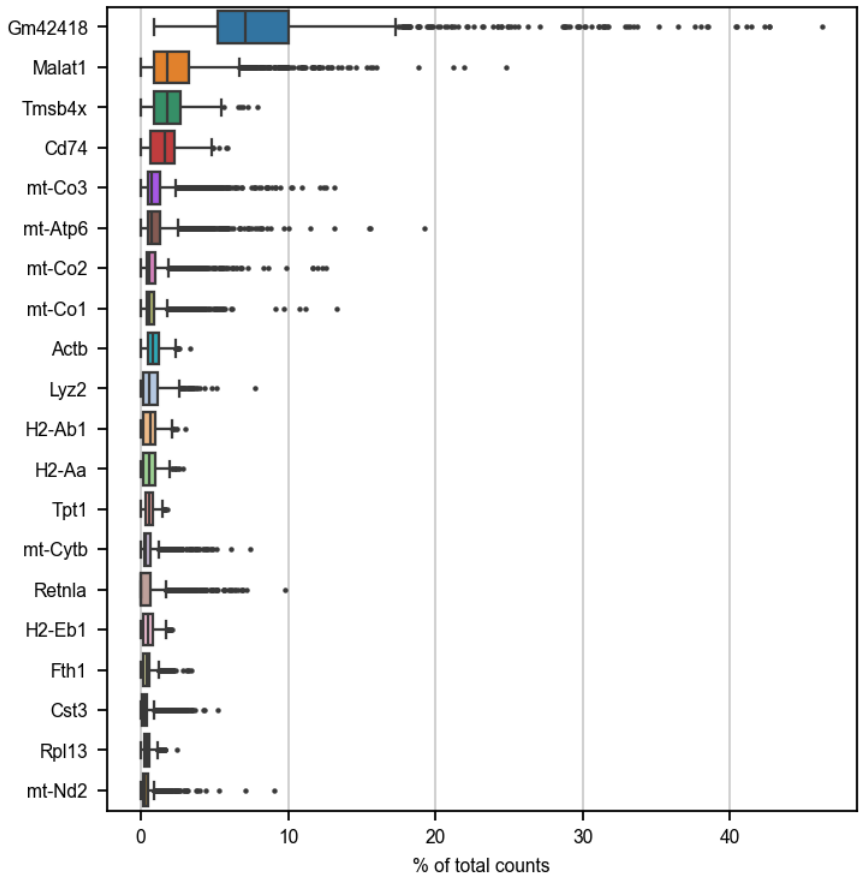
[18]:
```
from sklearn.linear_model import LogisticRegression
from xgboost import XGBRegressor
from sklearn.svm import SVC
from sklearn.pipeline import make_pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.ensemble import RandomForestClassifier
import numpy as np
import pandas as pd
import os
import random
import matplotlib
import matplotlib.pyplot as plt
from sklearn.datasets import load_svmlight_file
from sklearn.preprocessing import StandardScaler
from numpy.core.fromnumeric import transpose
from sklearn.model_selection import train_test_split
from sklearn.metrics import roc_curve, roc_auc_score
```

[21]:
```
realmat = sc.read_mtx('matrix.mtx')
realfeature=pd.read_csv('features.tsv',sep='\t',header=None)
realmat=realmat[0:32285]
realtag=pd.read_csv('tag.csv')
actt=realfeature.loc[realfeature[2] == 'Gene Expression']
celltag=pd.read_csv('barcodes.tsv',sep='\t',header=None)
adata = anndata.AnnData(X=realmat.X.T)
lol = list(celltag[0])  # or pd.Series(actt[1])
adata.obs['cell'] = lol
lmao = list(actt[1])  # or pd.Series(actt[1])
adata.var['gene_ids'] = lmao
sc.settings.verbosity = 3             # verbosity: errors (0), warnings (1),␣
 ↪info (2), hints (3)
sc.logging.print_header()
sc.settings.set_figure_params(dpi=80, facecolor='white', fontsize=7
                              )
sc.pp.filter_cells(adata, min_genes=100)
sc.pp.filter_genes(adata, min_cells=3)

adata
adata.var['mt'] =  adata.var_names.str.startswith('mt-')  # annotate the group␣
 ↪of mitochondrial genes as 'mt'
sc.pp.calculate_qc_metrics(adata, qc_vars=['mt'], percent_top=None,␣
 ↪log1p=False, inplace=True)
```

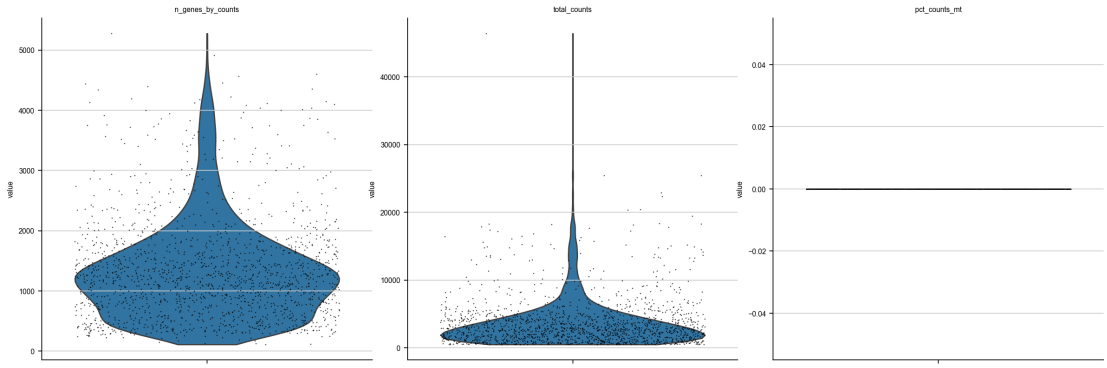
```
adata.var
# Remove headers and set the index to 'gene_ids'
adata.var.index = adata.var['gene_ids'].values
adata.var.index.name = None  # This removes the header (name) of the index
adata.obs

#adata.var.index = actt[1].astype('string')
sc.pl.highest_expr_genes(adata, n_top=20, )
adata.var_names_make_unique()  # this is unnecessary if us
sc.pl.violin(adata, ['n_genes_by_counts', 'total_counts', 'pct_counts_mt'],
             jitter=0.4, multi_panel=True,save='8.pdf')
sc.pl.scatter(adata, x='total_counts', y='pct_counts_mt',save='9.pdf')
sc.pl.scatter(adata, x='total_counts', y='n_genes_by_counts',save='10.pdf')
sc.pp.normalize_total(adata, target_sum=1e4)
sc.pp.log1p(adata)
METT=adata.X
dense_matrix = METT.toarray()

#METT = METT[~METT['cell'].isin(realtag['cell_barcode'])]
# Convert the dense NumPy array to a Pandas DataFrame
METT = pd.DataFrame(dense_matrix,columns=adata.var_names, index=adata.
 ↪obs['cell'].values)
METT['cell']=adata.obs['cell'].values
realtag.index=realtag['cell_barcode'].values
result = METT.join(realtag[['feature_call']], how='left')
print(METT.index.isin(realtag.index).sum())
result
# Remove rows where 'gender' is NaN
result = result.dropna(subset=['feature_call'])

print(result)
# Initialize the 'gender' column with NaN or some default value
result['gender'] = None

# Update 'gender' based on 'feature_call'
result.loc[result['feature_call'] == 'CMO305', 'gender'] = 1
result.loc[result['feature_call'] == 'CMO306', 'gender'] = 0
print(result)


columns_to_extract = ["Xist", "Ddx3y", "Gm42418", "Eif2s3y", "Rps27rt",
    "Rpl9-ps6", "Kdm5d", "Uba52", "Rpl35", "Rpl36a-ps1",
    "Uty", "Wdr89", "Lars2", "Rps27"]


extracted_df = result[columns_to_extract]
print(extracted_df)
```

```
extracted_df['gender']=result['gender']
realtest=extracted_df.drop('gender',axis=1)
realtest_y=result['gender']
realtest_y = realtest_y.astype('float')
realtest_y
```

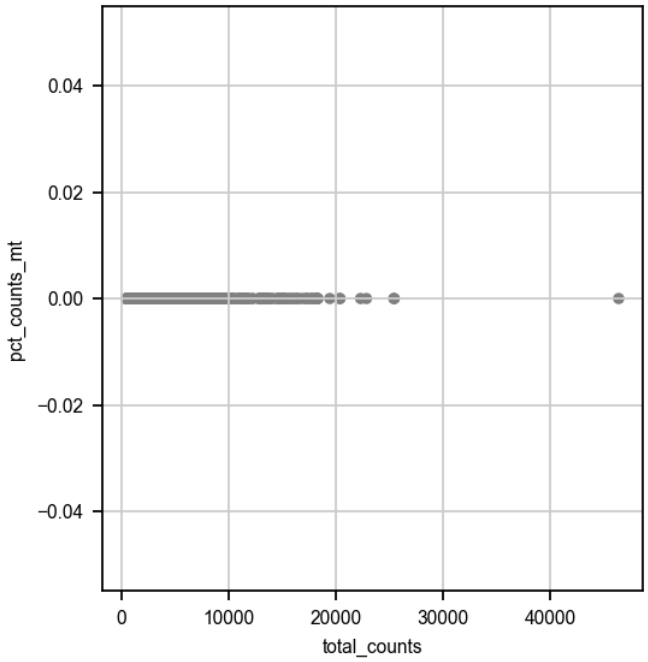
```
scanpy==1.10.2 anndata==0.10.8 umap==0.5.6 numpy==1.26.4 scipy==1.13.1
pandas==2.2.2 scikit-learn==1.5.1 statsmodels==0.14.2 pynndescent==0.5.13
filtered out 3 cells that have less than 100 genes expressed
filtered out 19261 genes that are detected in less than 3 cells
normalizing counts per cell
    finished (0:00:00)
```



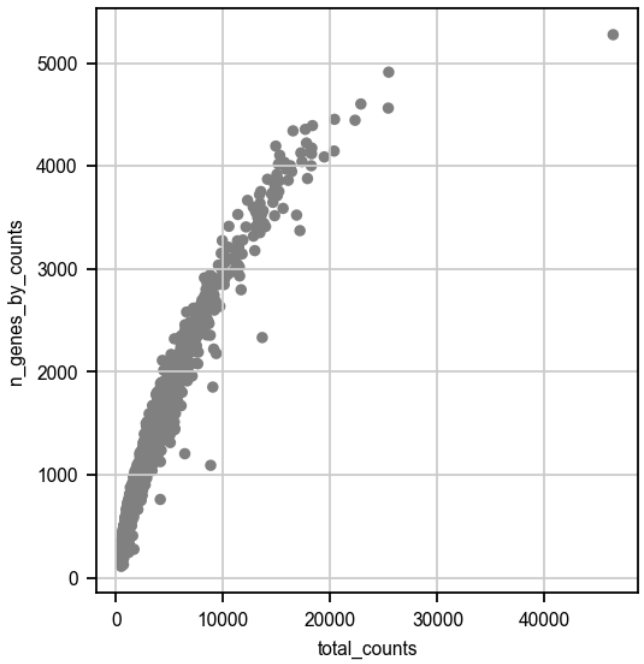

```
WARNING: saving figure to file figures/violin8.pdf
```




```
WARNING: saving figure to file figures/scatter9.pdf
```




```
WARNING: saving figure to file figures/scatter10.pdf
```




```
normalizing counts per cell
    finished (0:00:00)
1649
                    Mrpl15  Lypla1     Tcea1  Atp6v1h    Rb1cc1  \
AAACCCAAGACAGCTG-1     0.0     0.0  0.000000      0.0  0.000000
AAACCCACAAAGACGC-1     0.0     0.0  0.000000      0.0  1.921457
AAACGAAAGCACTCGC-1     0.0     0.0  0.000000      0.0  0.000000
AAACGAACAAATGGTA-1     0.0     0.0  0.000000      0.0  0.000000
AAAGGATGTGTGTTTG-1     0.0     0.0  0.000000      0.0  2.565319
…                      …       …         …       …         …
TTTGGTTCAGTGGCTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTGTAACGTTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTTCAGCGTCG-1     0.0     0.0  1.767994      0.0  0.000000
TTTGTTGGTACGTTCA-1     0.0     0.0  0.000000      0.0  0.000000
TTTGTTGGTCCACTCT-1     0.0     0.0  1.086885      0.0  0.000000

                    4732440D04Rik    Pcmtd1  Gm26901      Rrs1  2610203C22Rik  \
AAACCCAAGACAGCTG-1            0.0  0.744418      0.0  0.000000            0.0
AAACCCACAAAGACGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAAAGCACTCGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAACAAATGGTA-1            0.0  0.000000      0.0  0.000000            0.0
AAAGGATGTGTGTTTG-1            0.0  0.000000      0.0  0.000000            0.0
…                             …         …       …         …            …
TTTGGTTCAGTGGCTC-1            0.0  1.859427      0.0  0.000000            0.0
TTTGGTTGTAACGTTC-1            0.0  0.000000      0.0  0.000000            0.0
```

```
TTTGGTTTCAGCGTCG-1            0.0  1.767994      0.0  0.000000            0.0
TTTGTTGGTACGTTCA-1            0.0  0.000000      0.0  2.698028            0.0
TTTGTTGGTCCACTCT-1            0.0  0.000000      0.0  0.000000            0.0

                     …   mt-Cytb  AC125149.3  AC168977.1  CAAA01118383.1  \
AAACCCAAGACAGCTG-1   …  3.274121         0.0         0.0        0.744418
AAACCCACAAAGACGC-1   …  4.262269         0.0         0.0        0.000000
AAACGAAAGCACTCGC-1   …  5.364882         0.0         0.0        0.000000
AAACGAACAAATGGTA-1   …  4.365047         0.0         0.0        0.000000
AAAGGATGTGTGTTTG-1   …  5.380296         0.0         0.0        0.000000
…                    …       …           …           …              …
TTTGGTTCAGTGGCTC-1   …  4.695021         0.0         0.0        0.000000
TTTGGTTGTAACGTTC-1   …  4.216785         0.0         0.0        0.000000
TTTGGTTTCAGCGTCG-1   …  3.800684         0.0         0.0        0.000000
TTTGTTGGTACGTTCA-1   …  4.032499         0.0         0.0        0.000000
TTTGTTGGTCCACTCT-1   …  3.416918         0.0         0.0        1.086885

                     Csprs  Vamp7  CAAA01147332.1  AC149090.1  \
AAACCCAAGACAGCTG-1     0.0    0.0             0.0    0.000000
AAACCCACAAAGACGC-1     0.0    0.0             0.0    1.921457
AAACGAAAGCACTCGC-1     0.0    0.0             0.0    0.000000
AAACGAACAAATGGTA-1     0.0    0.0             0.0    0.000000
AAAGGATGTGTGTTTG-1     0.0    0.0             0.0    0.000000
…                      …      …               …          …
TTTGGTTCAGTGGCTC-1     0.0    0.0             0.0    1.859427
TTTGGTTGTAACGTTC-1     0.0    0.0             0.0    2.763031
TTTGGTTTCAGCGTCG-1     0.0    0.0             0.0    0.000000
TTTGTTGGTACGTTCA-1     0.0    0.0             0.0    0.000000
TTTGTTGGTCCACTCT-1     0.0    0.0             0.0    1.086885

                                    cell  feature_call
AAACCCAAGACAGCTG-1  AAACCCAAGACAGCTG-1        CMO305
AAACCCACAAAGACGC-1  AAACCCACAAAGACGC-1        CMO305
AAACGAAAGCACTCGC-1  AAACGAAAGCACTCGC-1        CMO305
AAACGAACAAATGGTA-1  AAACGAACAAATGGTA-1        CMO305
AAAGGATGTGTGTTTG-1  AAAGGATGTGTGTTTG-1        CMO305
…                                 …           …
TTTGGTTCAGTGGCTC-1  TTTGGTTCAGTGGCTC-1        CMO306
TTTGGTTGTAACGTTC-1  TTTGGTTGTAACGTTC-1        CMO306
TTTGGTTTCAGCGTCG-1  TTTGGTTTCAGCGTCG-1        CMO305
TTTGTTGGTACGTTCA-1  TTTGTTGGTACGTTCA-1        CMO305
TTTGTTGGTCCACTCT-1  TTTGTTGGTCCACTCT-1        CMO305

[1649 rows x 13026 columns]
                     Mrpl15  Lypla1     Tcea1  Atp6v1h    Rb1cc1  \
AAACCCAAGACAGCTG-1      0.0     0.0  0.000000      0.0  0.000000
AAACCCACAAAGACGC-1      0.0     0.0  0.000000      0.0  1.921457
AAACGAAAGCACTCGC-1      0.0     0.0  0.000000      0.0  0.000000
```

```
AAACGAACAAATGGTA-1     0.0     0.0  0.000000      0.0  0.000000
AAAGGATGTGTGTTTG-1     0.0     0.0  0.000000      0.0  2.565319
…                    …     …       …      …       …
TTTGGTTCAGTGGCTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTGTAACGTTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTTCAGCGTCG-1     0.0     0.0  1.767994      0.0  0.000000
TTTGTTGGTACGTTCA-1     0.0     0.0  0.000000      0.0  0.000000
TTTGTTGGTCCACTCT-1     0.0     0.0  1.086885      0.0  0.000000

                    4732440D04Rik    Pcmtd1  Gm26901      Rrs1  2610203C22Rik  \
AAACCCAAGACAGCTG-1            0.0  0.744418      0.0  0.000000            0.0
AAACCCACAAAGACGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAAAGCACTCGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAACAAATGGTA-1            0.0  0.000000      0.0  0.000000            0.0
AAAGGATGTGTGTTTG-1            0.0  0.000000      0.0  0.000000            0.0
…                           …       …      …       …           …
TTTGGTTCAGTGGCTC-1            0.0  1.859427      0.0  0.000000            0.0
TTTGGTTGTAACGTTC-1            0.0  0.000000      0.0  0.000000            0.0
TTTGGTTTCAGCGTCG-1            0.0  1.767994      0.0  0.000000            0.0
TTTGTTGGTACGTTCA-1            0.0  0.000000      0.0  2.698028            0.0
TTTGTTGGTCCACTCT-1            0.0  0.000000      0.0  0.000000            0.0

                    …  AC125149.3  AC168977.1  CAAA01118383.1  Csprs  Vamp7  \
AAACCCAAGACAGCTG-1  …         0.0         0.0        0.744418    0.0    0.0
AAACCCACAAAGACGC-1  …         0.0         0.0        0.000000    0.0    0.0
AAACGAAAGCACTCGC-1  …         0.0         0.0        0.000000    0.0    0.0
AAACGAACAAATGGTA-1  …         0.0         0.0        0.000000    0.0    0.0
AAAGGATGTGTGTTTG-1  …         0.0         0.0        0.000000    0.0    0.0
…                 …         …         …            …    …    …
TTTGGTTCAGTGGCTC-1  …         0.0         0.0        0.000000    0.0    0.0
TTTGGTTGTAACGTTC-1  …         0.0         0.0        0.000000    0.0    0.0
TTTGGTTTCAGCGTCG-1  …         0.0         0.0        0.000000    0.0    0.0
TTTGTTGGTACGTTCA-1  …         0.0         0.0        0.000000    0.0    0.0
TTTGTTGGTCCACTCT-1  …         0.0         0.0        1.086885    0.0    0.0

                    CAAA01147332.1  AC149090.1                cell  \
AAACCCAAGACAGCTG-1             0.0    0.000000  AAACCCAAGACAGCTG-1
AAACCCACAAAGACGC-1             0.0    1.921457  AAACCCACAAAGACGC-1
AAACGAAAGCACTCGC-1             0.0    0.000000  AAACGAAAGCACTCGC-1
AAACGAACAAATGGTA-1             0.0    0.000000  AAACGAACAAATGGTA-1
AAAGGATGTGTGTTTG-1             0.0    0.000000  AAAGGATGTGTGTTTG-1
…                            …         …                 …
TTTGGTTCAGTGGCTC-1             0.0    1.859427  TTTGGTTCAGTGGCTC-1
TTTGGTTGTAACGTTC-1             0.0    2.763031  TTTGGTTGTAACGTTC-1
TTTGGTTTCAGCGTCG-1             0.0    0.000000  TTTGGTTTCAGCGTCG-1
TTTGTTGGTACGTTCA-1             0.0    0.000000  TTTGTTGGTACGTTCA-1
TTTGTTGGTCCACTCT-1             0.0    1.086885  TTTGTTGGTCCACTCT-1
```

```
                    feature_call  gender
AAACCCAAGACAGCTG-1        CMO305       1
AAACCCACAAAGACGC-1        CMO305       1
AAACGAAAGCACTCGC-1        CMO305       1
AAACGAACAAATGGTA-1        CMO305       1
AAAGGATGTGTGTTTG-1        CMO305       1
…                           …      …
TTTGGTTCAGTGGCTC-1        CMO306       0
TTTGGTTGTAACGTTC-1        CMO306       0
TTTGGTTTCAGCGTCG-1        CMO305       1
TTTGTTGGTACGTTCA-1        CMO305       1
TTTGTTGGTCCACTCT-1        CMO305       1

[1649 rows x 13027 columns]
                         Xist     Ddx3y   Gm42418   Eif2s3y   Rps27rt  \
AAACCCAAGACAGCTG-1  0.000000  0.000000  5.790079  0.000000  0.000000
AAACCCACAAAGACGC-1  0.000000  0.000000  6.888156  0.000000  0.000000
AAACGAAAGCACTCGC-1  0.000000  0.000000  5.788145  0.000000  0.000000
AAACGAACAAATGGTA-1  0.000000  0.000000  5.986185  0.000000  2.264689
AAAGGATGTGTGTTTG-1  0.000000  0.000000  8.123958  0.000000  0.000000
…                      …        …         …         …         …
TTTGGTTCAGTGGCTC-1  3.335779  0.000000  7.200241  0.000000  0.000000
TTTGGTTGTAACGTTC-1  3.969675  0.000000  6.050117  0.000000  0.000000
TTTGGTTTCAGCGTCG-1  0.000000  0.000000  6.049121  0.000000  0.000000
TTTGTTGGTACGTTCA-1  0.000000  0.000000  7.608987  0.000000  0.000000
TTTGTTGGTCCACTCT-1  0.000000  1.086885  7.211483  1.086885  0.000000

                    Rpl9-ps6  Kdm5d     Uba52     Rpl35  Rpl36a-ps1  Uty  \
AAACCCAAGACAGCTG-1       0.0    0.0  0.744418  1.690256         0.0  0.0
AAACCCACAAAGACGC-1       0.0    0.0  2.538590  0.000000         0.0  0.0
AAACGAAAGCACTCGC-1       0.0    0.0  0.000000  0.000000         0.0  0.0
AAACGAACAAATGGTA-1       0.0    0.0  2.264689  0.000000         0.0  0.0
AAAGGATGTGTGTTTG-1       0.0    0.0  0.000000  0.000000         0.0  0.0
…                          …      …         …         …         …  …
TTTGGTTCAGTGGCTC-1       0.0    0.0  1.859427  2.471493         0.0  0.0
TTTGGTTGTAACGTTC-1       0.0    0.0  0.000000  0.000000         0.0  0.0
TTTGGTTTCAGCGTCG-1       0.0    0.0  1.767994  2.745812         0.0  0.0
TTTGTTGGTACGTTCA-1       0.0    0.0  2.070049  3.080791         0.0  0.0
TTTGTTGGTCCACTCT-1       0.0    0.0  1.595348  2.181557         0.0  0.0

                       Wdr89     Lars2     Rps27
AAACCCAAGACAGCTG-1  0.000000  2.167511  2.489244
AAACCCACAAAGACGC-1  1.921457  3.191448  2.538590
AAACGAAAGCACTCGC-1  0.000000  0.000000  0.000000
AAACGAACAAATGGTA-1  0.000000  2.904508  0.000000
AAAGGATGTGTGTTTG-1  0.000000  3.219260  0.000000
…                      …        …         …
TTTGGTTCAGTGGCTC-1  0.000000  2.471493  0.000000
```

```
TTTGGTTGTAACGTTC-1  0.000000  0.000000  2.131073
TTTGGTTTCAGCGTCG-1  0.000000  0.000000  2.745812
TTTGTTGGTACGTTCA-1  0.000000  3.356926  3.573077
TTTGTTGGTCCACTCT-1  1.086885  3.118624  2.181557

[1649 rows x 14 columns]
```

```
/var/folders/yw/8s12n9193cs3klhgvl8yg4p80000gn/T/ipykernel_92685/327623629.py:68
: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  extracted_df['gender']=result['gender']
```

[21]:
```
AAACCCAAGACAGCTG-1    1.0
AAACCCACAAAGACGC-1    1.0
AAACGAAAGCACTCGC-1    1.0
AAACGAACAAATGGTA-1    1.0
AAAGGATGTGTGTTTG-1    1.0
                     …
TTTGGTTCAGTGGCTC-1    0.0
TTTGGTTGTAACGTTC-1    0.0
TTTGGTTTCAGCGTCG-1    1.0
TTTGTTGGTACGTTCA-1    1.0
TTTGTTGGTCCACTCT-1    1.0
Name: gender, Length: 1649, dtype: float64
```

[22]:
```
ffrc=rc.loc[:,columns_to_extract]
ffrc["y"] = pd.Categorical(joined_list)
female_exp = result[result['gender'] == 0]
male_exp = result[result['gender'] == 1]
female_exp_data= female_exp.drop('gender',axis=1)
male_exp_data= male_exp.drop('gender',axis=1)
```

[23]:
```
result
```

[23]:
```
                    Mrpl15  Lypla1     Tcea1  Atp6v1h    Rb1cc1  \
AAACCCAAGACAGCTG-1     0.0     0.0  0.000000      0.0  0.000000
AAACCCACAAAGACGC-1     0.0     0.0  0.000000      0.0  1.921457
AAACGAAAGCACTCGC-1     0.0     0.0  0.000000      0.0  0.000000
AAACGAACAAATGGTA-1     0.0     0.0  0.000000      0.0  0.000000
AAAGGATGTGTGTTTG-1     0.0     0.0  0.000000      0.0  2.565319
…                      …       …        …        …        …
TTTGGTTCAGTGGCTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTGTAACGTTC-1     0.0     0.0  0.000000      0.0  0.000000
TTTGGTTTCAGCGTCG-1     0.0     0.0  1.767994      0.0  0.000000
```

```
TTTGTTGGTACGTTCA-1     0.0     0.0  0.000000      0.0  0.000000
TTTGTTGGTCCACTCT-1     0.0     0.0  1.086885      0.0  0.000000

                   4732440D04Rik    Pcmtd1  Gm26901      Rrs1  2610203C22Rik  \
AAACCCAAGACAGCTG-1           0.0  0.744418      0.0  0.000000            0.0
AAACCCACAAAGACGC-1           0.0  0.000000      0.0  0.000000            0.0
AAACGAAAGCACTCGC-1           0.0  0.000000      0.0  0.000000            0.0
AAACGAACAAATGGTA-1           0.0  0.000000      0.0  0.000000            0.0
AAAGGATGTGTGTTTG-1           0.0  0.000000      0.0  0.000000            0.0
…                              …         …      …         …           …
TTTGGTTCAGTGGCTC-1           0.0  1.859427      0.0  0.000000            0.0
TTTGGTTGTAACGTTC-1           0.0  0.000000      0.0  0.000000            0.0
TTTGGTTTCAGCGTCG-1           0.0  1.767994      0.0  0.000000            0.0
TTTGTTGGTACGTTCA-1           0.0  0.000000      0.0  2.698028            0.0
TTTGTTGGTCCACTCT-1           0.0  0.000000      0.0  0.000000            0.0

                   …  AC125149.3  AC168977.1  CAAA01118383.1  Csprs  Vamp7  \
AAACCCAAGACAGCTG-1 …         0.0         0.0        0.744418    0.0    0.0
AAACCCACAAAGACGC-1 …         0.0         0.0        0.000000    0.0    0.0
AAACGAAAGCACTCGC-1 …         0.0         0.0        0.000000    0.0    0.0
AAACGAACAAATGGTA-1 …         0.0         0.0        0.000000    0.0    0.0
AAAGGATGTGTGTTTG-1 …         0.0         0.0        0.000000    0.0    0.0
…                  …         …           …              …    …    …
TTTGGTTCAGTGGCTC-1 …         0.0         0.0        0.000000    0.0    0.0
TTTGGTTGTAACGTTC-1 …         0.0         0.0        0.000000    0.0    0.0
TTTGGTTTCAGCGTCG-1 …         0.0         0.0        0.000000    0.0    0.0
TTTGTTGGTACGTTCA-1 …         0.0         0.0        0.000000    0.0    0.0
TTTGTTGGTCCACTCT-1 …         0.0         0.0        1.086885    0.0    0.0

                   CAAA01147332.1  AC149090.1                cell  \
AAACCCAAGACAGCTG-1             0.0    0.000000  AAACCCAAGACAGCTG-1
AAACCCACAAAGACGC-1             0.0    1.921457  AAACCCACAAAGACGC-1
AAACGAAAGCACTCGC-1             0.0    0.000000  AAACGAAAGCACTCGC-1
AAACGAACAAATGGTA-1             0.0    0.000000  AAACGAACAAATGGTA-1
AAAGGATGTGTGTTTG-1             0.0    0.000000  AAAGGATGTGTGTTTG-1
…                              …           …                 …
TTTGGTTCAGTGGCTC-1             0.0    1.859427  TTTGGTTCAGTGGCTC-1
TTTGGTTGTAACGTTC-1             0.0    2.763031  TTTGGTTGTAACGTTC-1
TTTGGTTTCAGCGTCG-1             0.0    0.000000  TTTGGTTTCAGCGTCG-1
TTTGTTGGTACGTTCA-1             0.0    0.000000  TTTGTTGGTACGTTCA-1
TTTGTTGGTCCACTCT-1             0.0    1.086885  TTTGTTGGTCCACTCT-1

                   feature_call  gender
AAACCCAAGACAGCTG-1       CMO305       1
AAACCCACAAAGACGC-1       CMO305       1
AAACGAAAGCACTCGC-1       CMO305       1
AAACGAACAAATGGTA-1       CMO305       1
```

```
AAAGGATGTGTGTTTG-1        CMO305       1
…                          …     …
TTTGGTTCAGTGGCTC-1        CMO306       0
TTTGGTTGTAACGTTC-1        CMO306       0
TTTGGTTTCAGCGTCG-1        CMO305       1
TTTGTTGGTACGTTCA-1        CMO305       1
TTTGTTGGTCCACTCT-1        CMO305       1

[1649 rows x 13027 columns]
```

[24]:
```
male_exp_data
```

[24]:
```
                    Mrpl15    Lypla1     Tcea1  Atp6v1h    Rb1cc1  \
AAACCCAAGACAGCTG-1     0.0  0.000000  0.000000      0.0  0.000000
AAACCCACAAAGACGC-1     0.0  0.000000  0.000000      0.0  1.921457
AAACGAAAGCACTCGC-1     0.0  0.000000  0.000000      0.0  0.000000
AAACGAACAAATGGTA-1     0.0  0.000000  0.000000      0.0  0.000000
AAAGGATGTGTGTTTG-1     0.0  0.000000  0.000000      0.0  2.565319
…                      …         …         …       …         …
TTTGATCGTCCGTTTC-1     0.0  0.414969  0.414969      0.0  0.000000
TTTGGAGCAGTGACCC-1     0.0  0.000000  0.000000      0.0  0.000000
TTTGGTTTCAGCGTCG-1     0.0  0.000000  1.767994      0.0  0.000000
TTTGTTGGTACGTTCA-1     0.0  0.000000  0.000000      0.0  0.000000
TTTGTTGGTCCACTCT-1     0.0  0.000000  1.086885      0.0  0.000000

                    4732440D04Rik    Pcmtd1  Gm26901      Rrs1  2610203C22Rik  \
AAACCCAAGACAGCTG-1            0.0  0.744418      0.0  0.000000            0.0
AAACCCACAAAGACGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAAAGCACTCGC-1            0.0  0.000000      0.0  0.000000            0.0
AAACGAACAAATGGTA-1            0.0  0.000000      0.0  0.000000            0.0
AAAGGATGTGTGTTTG-1            0.0  0.000000      0.0  0.000000            0.0
…                             …         …       …         …              …
TTTGATCGTCCGTTTC-1            0.0  0.000000      0.0  0.000000            0.0
TTTGGAGCAGTGACCC-1            0.0  0.000000      0.0  0.000000            0.0
TTTGGTTTCAGCGTCG-1            0.0  1.767994      0.0  0.000000            0.0
TTTGTTGGTACGTTCA-1            0.0  0.000000      0.0  2.698028            0.0
TTTGTTGGTCCACTCT-1            0.0  0.000000      0.0  0.000000            0.0

                    …   mt-Cytb  AC125149.3  AC168977.1  CAAA01118383.1  \
AAACCCAAGACAGCTG-1  …  3.274121         0.0         0.0        0.744418
AAACCCACAAAGACGC-1  …  4.262269         0.0         0.0        0.000000
AAACGAAAGCACTCGC-1  …  5.364882         0.0         0.0        0.000000
AAACGAACAAATGGTA-1  …  4.365047         0.0         0.0        0.000000
AAAGGATGTGTGTTTG-1  …  5.380296         0.0         0.0        0.000000
…                   …         …           …           …              …
TTTGATCGTCCGTTTC-1  …  3.867098         0.0         0.0        0.414969
TTTGGAGCAGTGACCC-1  …  4.696054         0.0         0.0        0.000000
```

```
TTTGGTTTCAGCGTCG-1  …  3.800684         0.0         0.0        0.000000
TTTGTTGGTACGTTCA-1  …  4.032499         0.0         0.0        0.000000
TTTGTTGGTCCACTCT-1  …  3.416918         0.0         0.0        1.086885

                     Csprs  Vamp7  CAAA01147332.1  AC149090.1  \
AAACCCAAGACAGCTG-1     0.0    0.0             0.0    0.000000
AAACCCACAAAGACGC-1     0.0    0.0             0.0    1.921457
AAACGAAAGCACTCGC-1     0.0    0.0             0.0    0.000000
AAACGAACAAATGGTA-1     0.0    0.0             0.0    0.000000
AAAGGATGTGTGTTTG-1     0.0    0.0             0.0    0.000000
…                      …      …               …          …
TTTGATCGTCCGTTTC-1     0.0    0.0             0.0    0.933333
TTTGGAGCAGTGACCC-1     0.0    0.0             0.0    0.000000
TTTGGTTTCAGCGTCG-1     0.0    0.0             0.0    0.000000
TTTGTTGGTACGTTCA-1     0.0    0.0             0.0    0.000000
TTTGTTGGTCCACTCT-1     0.0    0.0             0.0    1.086885

                                    cell  feature_call
AAACCCAAGACAGCTG-1  AAACCCAAGACAGCTG-1        CMO305
AAACCCACAAAGACGC-1  AAACCCACAAAGACGC-1        CMO305
AAACGAAAGCACTCGC-1  AAACGAAAGCACTCGC-1        CMO305
AAACGAACAAATGGTA-1  AAACGAACAAATGGTA-1        CMO305
AAAGGATGTGTGTTTG-1  AAAGGATGTGTGTTTG-1        CMO305
…                                  …            …
TTTGATCGTCCGTTTC-1  TTTGATCGTCCGTTTC-1        CMO305
TTTGGAGCAGTGACCC-1  TTTGGAGCAGTGACCC-1        CMO305
TTTGGTTTCAGCGTCG-1  TTTGGTTTCAGCGTCG-1        CMO305
TTTGTTGGTACGTTCA-1  TTTGTTGGTACGTTCA-1        CMO305
TTTGTTGGTCCACTCT-1  TTTGTTGGTCCACTCT-1        CMO305

[1427 rows x 13026 columns]
```

5 EXPDATA

[25]:
```
realtest
```

[25]:
```
                        Xist     Ddx3y   Gm42418   Eif2s3y   Rps27rt  \
AAACCCAAGACAGCTG-1  0.000000  0.000000  5.790079  0.000000  0.000000
AAACCCACAAAGACGC-1  0.000000  0.000000  6.888156  0.000000  0.000000
AAACGAAAGCACTCGC-1  0.000000  0.000000  5.788145  0.000000  0.000000
AAACGAACAAATGGTA-1  0.000000  0.000000  5.986185  0.000000  2.264689
AAAGGATGTGTGTTTG-1  0.000000  0.000000  8.123958  0.000000  0.000000
…                        …         …         …         …         …
TTTGGTTCAGTGGCTC-1  3.335779  0.000000  7.200241  0.000000  0.000000
TTTGGTTGTAACGTTC-1  3.969675  0.000000  6.050117  0.000000  0.000000
TTTGGTTTCAGCGTCG-1  0.000000  0.000000  6.049121  0.000000  0.000000
```

```
TTTGTTGGTACGTTCA-1  0.000000  0.000000  7.608987  0.000000  0.000000
TTTGTTGGTCCACTCT-1  0.000000  1.086885  7.211483  1.086885  0.000000

                    Rpl9-ps6  Kdm5d     Uba52     Rpl35  Rpl36a-ps1  Uty  \
AAACCCAAGACAGCTG-1       0.0    0.0  0.744418  1.690256         0.0  0.0
AAACCCACAAAGACGC-1       0.0    0.0  2.538590  0.000000         0.0  0.0
AAACGAAAGCACTCGC-1       0.0    0.0  0.000000  0.000000         0.0  0.0
AAACGAACAAATGGTA-1       0.0    0.0  2.264689  0.000000         0.0  0.0
AAAGGATGTGTGTTTG-1       0.0    0.0  0.000000  0.000000         0.0  0.0
…                        …      …         …         …          …    …
TTTGGTTCAGTGGCTC-1       0.0    0.0  1.859427  2.471493         0.0  0.0
TTTGGTTGTAACGTTC-1       0.0    0.0  0.000000  0.000000         0.0  0.0
TTTGGTTTCAGCGTCG-1       0.0    0.0  1.767994  2.745812         0.0  0.0
TTTGTTGGTACGTTCA-1       0.0    0.0  2.070049  3.080791         0.0  0.0
TTTGTTGGTCCACTCT-1       0.0    0.0  1.595348  2.181557         0.0  0.0

                       Wdr89     Lars2     Rps27
AAACCCAAGACAGCTG-1  0.000000  2.167511  2.489244
AAACCCACAAAGACGC-1  1.921457  3.191448  2.538590
AAACGAAAGCACTCGC-1  0.000000  0.000000  0.000000
AAACGAACAAATGGTA-1  0.000000  2.904508  0.000000
AAAGGATGTGTGTTTG-1  0.000000  3.219260  0.000000
…                      …         …         …
TTTGGTTCAGTGGCTC-1  0.000000  2.471493  0.000000
TTTGGTTGTAACGTTC-1  0.000000  0.000000  2.131073
TTTGGTTTCAGCGTCG-1  0.000000  0.000000  2.745812
TTTGTTGGTACGTTCA-1  0.000000  3.356926  3.573077
TTTGTTGGTCCACTCT-1  1.086885  3.118624  2.181557

[1649 rows x 14 columns]
```

[26]:
```
realtest_y
```

[26]:
```
AAACCCAAGACAGCTG-1    1.0
AAACCCACAAAGACGC-1    1.0
AAACGAAAGCACTCGC-1    1.0
AAACGAACAAATGGTA-1    1.0
AAAGGATGTGTGTTTG-1    1.0
                     …
TTTGGTTCAGTGGCTC-1    0.0
TTTGGTTGTAACGTTC-1    0.0
TTTGGTTTCAGCGTCG-1    1.0
TTTGTTGGTACGTTCA-1    1.0
TTTGTTGGTCCACTCT-1    1.0
Name: gender, Length: 1649, dtype: float64
```

[27]:
```
full_train = rc.sample(frac=1, random_state=25)
full_Y_train=full_train["y"]
full_X_train=full_train.drop(["y"],axis=1)
full_X_train = full_X_train[columns_to_extract]
```

[28]:
```
full_X_train
```

[28]:
```
n           Xist  Ddx3y  Gm42418  Eif2s3y  Rps27rt  Rpl9-ps6  Kdm5d  Uba52  \
Cell_1678    0.0    0.0     13.0      0.0      1.0       0.0    0.0    2.0
Cell_3705    5.0    0.0      7.0      0.0      0.0       0.0    0.0    0.0
Cell_5187   10.0    0.0     28.0      0.0      3.0       2.0    0.0    1.0
Cell_1921    0.0    1.0     19.0      0.0      1.0       2.0    0.0    2.0
Cell_1575    0.0    0.0     32.0      0.0     17.0       6.0    0.0    5.0
…           …      …       …        …        …         …      …      …
Cell_2934    7.0    0.0     14.0      0.0      6.0       1.0    0.0    0.0
Cell_2191    0.0    0.0     27.0      0.0      1.0       0.0    0.0    1.0
Cell_6618    7.0    0.0     16.0      0.0      2.0       1.0    0.0    0.0
Cell_318     0.0    0.0      8.0      0.0      6.0       0.0    0.0    0.0
Cell_5252    1.0    0.0      1.0      0.0      0.0       0.0    0.0    0.0

n           Rpl35  Rpl36a-ps1  Uty  Wdr89  Lars2  Rps27
Cell_1678     2.0         0.0  0.0    0.0    1.0    0.0
Cell_3705     0.0         0.0  0.0    0.0    0.0    0.0
Cell_5187     6.0         0.0  0.0    0.0    0.0    1.0
Cell_1921     6.0         1.0  0.0    1.0    1.0    2.0
Cell_1575    13.0         3.0  0.0    1.0    2.0    2.0
…           …          …    …      …      …      …
Cell_2934     8.0         2.0  0.0    0.0    1.0    5.0
Cell_2191     3.0         1.0  0.0    0.0    3.0    1.0
Cell_6618     5.0         0.0  0.0    0.0    1.0    1.0
Cell_318      4.0         0.0  0.0    0.0    0.0    0.0
Cell_5252     0.0         1.0  0.0    0.0    0.0    0.0

[6648 rows x 14 columns]
```

skip the following sev block straight to wtwt experimental

6 Performance with Scanorama

[30]:
```
#!/usr/bin/env python3
"""
Train models on original training data, test on Scanorama-corrected data,
save ROC/PRC plots, and export all curve data points for later use.
"""
import numpy as np
import pandas as pd
import scanorama
```

```
import pickle
import json

# First, let's check what's in your data
print("Checking original data...")
print(f"Type: {type(result)}")
print(f"Shape: {result.shape}")

# Check if data is already numeric
if isinstance(result, pd.DataFrame):
    print(f"Data types of first few columns: {result.dtypes[:5]}")
    print(f"Any non-numeric columns? {not all(result.dtypes.apply(lambda x: np.
 ↪issubdtype(x, np.number)))}")

    # Check for actual NaN values
    print(f"NaN count per column (first 5): {result.isnull().sum()[:5].
 ↪tolist()}")
    print(f"Total NaN values: {result.isnull().sum().sum()}")

# Scanorama batch correction function
def scanorama_correction(result):
    """
    Batch correction using Scanorama instead of ComBat.
    """

    # Convert to numeric if needed
    if isinstance(result, pd.DataFrame):
        if all(result.dtypes.apply(lambda x: np.issubdtype(x, np.number))):
            print("Data is already numeric!")
            data_array = result.values
            gene_names = result.columns[:-1].tolist()  # Get gene names
        else:
            print("Converting to numeric efficiently...")
            result_numeric = result.apply(pd.to_numeric, errors='coerce')
            data_array = result_numeric.values
            gene_names = result.columns[:-1].tolist()
    else:
        data_array = result.astype(float)
        gene_names = [f"Gene_{i}" for i in range(data_array.shape[1] - 1)]

    # Extract expression and gender
    expression_data = data_array[:, :-1]
    gender = data_array[:, -1]

    print(f"\nExpression shape: {expression_data.shape}")
    print(f"Gender values: {np.unique(gender[~np.isnan(gender)])}")
```

```
    # Handle NaN values
    expr_nan_count = np.isnan(expression_data).sum()
    gender_nan_count = np.isnan(gender).sum()

    print(f"NaN in expression data: {expr_nan_count} out of {expression_data.
↪size} values")
    print(f"NaN in gender: {gender_nan_count} out of {len(gender)} values")

    # Remove columns that are all NaN
    cols_all_nan = np.isnan(expression_data).all(axis=0)
    if cols_all_nan.any():
        print(f"Found {cols_all_nan.sum()} columns that are all NaN. Removing␣
↪them...")
        expression_data = expression_data[:, ~cols_all_nan]
        gene_names = [gene for gene, is_nan in zip(gene_names, cols_all_nan) if␣
↪not is_nan]

    # Replace remaining NaN with 0 (Scanorama doesn't handle NaN well)
    if np.isnan(expression_data).any():
        print("Replacing remaining NaN values with 0...")
        expression_data = np.nan_to_num(expression_data, nan=0)

    # Ensure gender is valid
    gender = np.nan_to_num(gender, nan=0).astype(int)

    print(f"\nFinal shapes - Expression: {expression_data.shape}, Gender:␣
↪{len(gender)}")
    print(f"Gender distribution: {np.bincount(gender)}")

    # Split data by gender for Scanorama
    male_mask = gender == 0
    female_mask = gender == 1

    male_data = expression_data[male_mask]
    female_data = expression_data[female_mask]

    print(f"\nMale samples: {male_data.shape[0]}, Female samples: {female_data.
↪shape[0]}")

    # Prepare data for Scanorama
    # Scanorama expects a list of datasets
    datasets = [male_data, female_data]
    genes_list = [gene_names, gene_names]  # Same genes for both

    try:
        # Apply Scanorama correction
        print("\nApplying Scanorama batch correction...")
```

```
        corrected_datasets, _ = scanorama.correct(datasets, genes_list,␣
 ↪return_dimred=False)

        # Combine corrected datasets back together
        male_corrected = corrected_datasets[0]
        female_corrected = corrected_datasets[1]

        # Reconstruct full dataset in original order
        corrected_data = np.zeros_like(expression_data)
        corrected_data[male_mask] = male_corrected
        corrected_data[female_mask] = female_corrected

        print(f"Scanorama correction complete! Shape: {corrected_data.shape}")
        return corrected_data

    except Exception as e:
        print(f"Scanorama failed: {e}")
        print("Falling back to simple batch correction...")
        return simple_batch_correction(expression_data, gender)

def simple_batch_correction(expression_data, gender):
    """
    Simple batch correction as fallback.
    """
    corrected = expression_data.copy()

    for col in range(expression_data.shape[1]):
        feature = expression_data[:, col]
        for g in np.unique(gender):
            mask = gender == g
            if mask.sum() > 0:
                corrected[mask, col] = feature[mask] - np.
 ↪nanmean(feature[mask]) + np.nanmean(feature)

    return corrected

# Apply Scanorama correction
realtest_scanorama = scanorama_correction(result)

if realtest_scanorama is not None:
    print(f"\nSuccess! Final shape: {realtest_scanorama.shape}")

# Now continue with the ML pipeline
from pathlib import Path
import matplotlib.pyplot as plt
from matplotlib import rcParams
```

```
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    roc_curve,
    auc,
    precision_recall_curve,
    average_precision_score,
)
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier

#   global config
rcParams.update({"font.family": "Arial", "font.size": 7})
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/scanorama")
OUTDIR.mkdir(exist_ok=True)

colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]

models = [
    LogisticRegression(max_iter=1000, random_state=551),
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=551,
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   define columns to extract
columns_to_extract = [
    "Xist", "Ddx3y", "Gm42418", "Eif2s3y", "Rps27rt",
    "Rpl9-ps6", "Kdm5d", "Uba52", "Rpl35", "Rpl36a-ps1",
    "Uty", "Wdr89", "Lars2", "Rps27"
]

#   align features between train and test
print(f"\nOriginal shapes:")
print(f"  Training: {full_X_train.shape}")
print(f"  Test: {realtest_scanorama.shape}")

# Convert realtest_scanorama to DataFrame if it's an array
if isinstance(realtest_scanorama, np.ndarray):
```

```
    # Need to get column names from somewhere - assuming they match the␣
 ↪original data
    if 'result' in globals() and isinstance(result, pd.DataFrame):
        # Use column names from the original result DataFrame (minus the last␣
 ↪gender column)
        test_columns = result.columns[:-1]
        # Account for any removed all-NaN columns
        if realtest_scanorama.shape[1] < len(test_columns):
            # Some columns were removed, need to figure out which ones
            test_columns = test_columns[:realtest_scanorama.shape[1]]
        realtest_scanorama_df = pd.DataFrame(realtest_scanorama,␣
 ↪columns=test_columns)
    else:
        print("ERROR: Cannot determine column names for test data")
        raise ValueError("Need column names to extract specific features")
else:
    realtest_scanorama_df = realtest_scanorama

# Extract only the columns that exist in the test data
available_columns = [col for col in columns_to_extract if col in␣
 ↪realtest_scanorama_df.columns]
missing_columns = [col for col in columns_to_extract if col not in␣
 ↪realtest_scanorama_df.columns]

if missing_columns:
    print(f"WARNING: Missing columns in test data: {missing_columns}")

print(f"Extracting {len(available_columns)} columns from test data")
realtest_scanorama_aligned = realtest_scanorama_df[available_columns]

print(f"\nAligned shapes:")
print(f"  Training: {full_X_train.shape}")
print(f"  Test: {realtest_scanorama_aligned.shape}")

# Verify they match
if realtest_scanorama_aligned.shape[1] != full_X_train.shape[1]:
    print(f"ERROR: Feature count mismatch! Train has {full_X_train.shape[1]},␣
 ↪test has {realtest_scanorama_aligned.shape[1]}")
    print("Please check that the training data used the same columns")

#   scale data
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s = scaler.transform(realtest_scanorama_aligned)

#   Initialize data storage for curves
```

```
curve_data = {
    'roc_curves': {},
    'prc_curves': {},
    'summary_metrics': {},
    'metadata': {
        'test_samples': len(realtest_y),
        'features_used': available_columns,
        'class_distribution': np.bincount(realtest_y).tolist(),
        'correction_method': 'scanorama'
    }
}

#   create plots
plt.figure(figsize=(12, 5))
roc_ax = plt.subplot(1, 2, 1)
pr_ax = plt.subplot(1, 2, 2)

#   fit, predict, plot
for model, color in zip(models, colors):
    name = model.__class__.__name__
    print(f"\nTraining {name}...")

    model.fit(X_train_s, full_Y_train)
    y_prob = model.predict_proba(X_test_s)[:, 1]

    # ROC
    fpr, tpr, roc_thresholds = roc_curve(realtest_y, y_prob)
    roc_auc = auc(fpr, tpr)
    roc_ax.plot(fpr, tpr, label=f'{name} (AUC={roc_auc:.3f})', color=color,␣
 ↪lw=2)

    # PR
    prec, rec, prc_thresholds = precision_recall_curve(realtest_y, y_prob)
    pr_auc = average_precision_score(realtest_y, y_prob)
    pr_ax.plot(rec, prec, label=f'{name} (AP={pr_auc:.3f})', color=color, lw=2)

    print(f"  → AUROC: {roc_auc:.3f}, AUPRC: {pr_auc:.3f}")

    #   Store curve data
    # ROC curve data
    curve_data['roc_curves'][name] = {
        'fpr': fpr.tolist(),
        'tpr': tpr.tolist(),
        'thresholds': roc_thresholds.tolist(),
        'auc': float(roc_auc)
    }
```

```
    # PRC curve data
    curve_data['prc_curves'][name] = {
        'precision': prec.tolist(),
        'recall': rec.tolist(),
        'thresholds': prc_thresholds.tolist(),
        'average_precision': float(pr_auc)
    }

    # Summary metrics
    curve_data['summary_metrics'][name] = {
        'auroc': float(roc_auc),
        'auprc': float(pr_auc),
        'color': color,
        'n_roc_points': len(fpr),
        'n_prc_points': len(prec)
    }

#   format plots
roc_ax.plot([0, 1], [0, 1], 'k--', lw=1, alpha=0.5)  # diagonal line
roc_ax.set_xlim([0, 1])
roc_ax.set_ylim([0, 1])
roc_ax.set_xlabel("False Positive Rate")
roc_ax.set_ylabel("True Positive Rate")
roc_ax.set_title("ROC Curves (Scanorama-corrected test set)")
roc_ax.legend(loc="lower right")

pr_ax.set_xlim([0, 1])
pr_ax.set_ylim([0, 1])
pr_ax.set_xlabel("Recall")
pr_ax.set_ylabel("Precision")
pr_ax.set_title("Precision-Recall Curves (Scanorama-corrected test set)")
pr_ax.legend(loc="lower left")

# Remove top and right spines
for ax in (roc_ax, pr_ax):
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)

plt.tight_layout()

#   save plots
plt.savefig(OUTDIR / "roc_prc_scanorama.png", dpi=300, bbox_inches='tight')
plt.savefig(OUTDIR / "roc_prc_scanorama.pdf", dpi=300, bbox_inches='tight')
plt.show()

#   Save curve data in multiple formats
print(f"\n  Saving curve data...")
```

```
# 1. Save as JSON (human-readable, cross-platform)
json_path = OUTDIR / "curve_data_scanorama.json"
with open(json_path, 'w') as f:
    json.dump(curve_data, f, indent=2)
print(f"    JSON: {json_path}")

# 2. Save as pickle (Python-specific but preserves exact numpy arrays)
pickle_path = OUTDIR / "curve_data_scanorama.pkl"
with open(pickle_path, 'wb') as f:
    pickle.dump(curve_data, f)
print(f"    Pickle: {pickle_path}")

# 3. Save individual CSV files for each curve type
csv_dir = OUTDIR / "csv_curves"
csv_dir.mkdir(exist_ok=True)

# ROC curves CSV
roc_csv_data = []
for model_name, roc_data in curve_data['roc_curves'].items():
    for i, (fpr, tpr, threshold) in enumerate(zip(roc_data['fpr'],␣
 ↪roc_data['tpr'], roc_data['thresholds'])):
        roc_csv_data.append({
            'model': model_name,
            'point_index': i,
            'fpr': fpr,
            'tpr': tpr,
            'threshold': threshold,
            'auc': roc_data['auc']
        })

roc_df = pd.DataFrame(roc_csv_data)
roc_csv_path = csv_dir / "roc_curves_scanorama.csv"
roc_df.to_csv(roc_csv_path, index=False)
print(f"    ROC CSV: {roc_csv_path}")

# PRC curves CSV
prc_csv_data = []
for model_name, prc_data in curve_data['prc_curves'].items():
    for i, (prec, rec, threshold) in enumerate(zip(prc_data['precision'],␣
 ↪prc_data['recall'], prc_data['thresholds'])):
        prc_csv_data.append({
            'model': model_name,
            'point_index': i,
            'precision': prec,
            'recall': rec,
            'threshold': threshold,
```

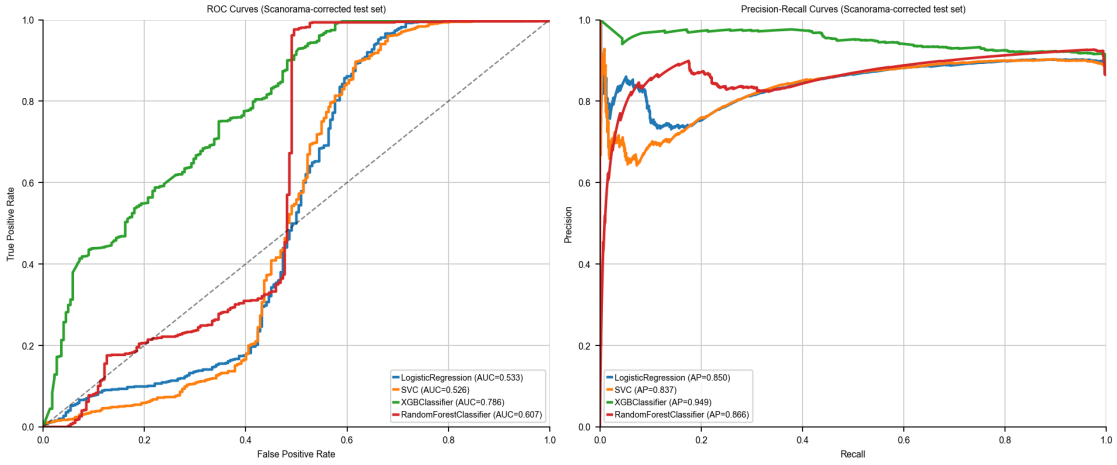
```
            'average_precision': prc_data['average_precision']
        })

prc_df = pd.DataFrame(prc_csv_data)
prc_csv_path = csv_dir / "prc_curves_scanorama.csv"
prc_df.to_csv(prc_csv_path, index=False)
print(f"    PRC CSV: {prc_csv_path}")

# 4. Save summary metrics as CSV
summary_df = pd.DataFrame(curve_data['summary_metrics']).T
summary_csv_path = OUTDIR / "summary_metrics_scanorama.csv"
summary_df.to_csv(summary_csv_path)
print(f"    Summary CSV: {summary_csv_path}")

# 5. Create a simple loading script template
loading_script = '''#!/usr/bin/env python3
"""
Example script to load and recreate the ROC/PRC curves from saved data
"""
import json
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from pathlib import Path

# Load the curve data
with open('curve_data_scanorama.json', 'r') as f:
    curve_data = json.load(f)

# Or load from CSV
roc_df = pd.read_csv('csv_curves/roc_curves_scanorama.csv')
prc_df = pd.read_csv('csv_curves/prc_curves_scanorama.csv')

# Recreate the plots
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 5))

# Plot ROC curves from JSON data
for model_name, roc_data in curve_data['roc_curves'].items():
    ax1.plot(roc_data['fpr'], roc_data['tpr'],
             label=f"{model_name} (AUC={roc_data['auc']:.3f})", lw=2)

ax1.plot([0, 1], [0, 1], 'k--', alpha=0.5)
ax1.set_xlabel('False Positive Rate')
ax1.set_ylabel('True Positive Rate')
ax1.set_title('ROC Curves')
ax1.legend()
```

```
# Plot PRC curves from JSON data
for model_name, prc_data in curve_data['prc_curves'].items():
    ax2.plot(prc_data['recall'], prc_data['precision'],
             label=f"{model_name} (AP={prc_data['average_precision']:.3f})",␣
 ↪lw=2)

ax2.set_xlabel('Recall')
ax2.set_ylabel('Precision')
ax2.set_title('Precision-Recall Curves')
ax2.legend()

plt.tight_layout()
plt.show()

# Alternative: Plot from CSV data
# for model in roc_df['model'].unique():
#     model_data = roc_df[roc_df['model'] == model]
#     ax1.plot(model_data['fpr'], model_data['tpr'], label=model)
'''

script_path = OUTDIR / "load_and_plot_curves.py"
with open(script_path, 'w') as f:
    f.write(loading_script)
print(f"    Loading script: {script_path}")

print(f"\n All files saved to: {OUTDIR}")
print(f"\nFiles created:")
print(f"    Plots:")
print(f"        roc_prc_scanorama.png")
print(f"        roc_prc_scanorama.pdf")
print(f"    Curve Data:")
print(f"        curve_data_scanorama.json (complete data)")
print(f"        curve_data_scanorama.pkl (Python binary)")
print(f"        summary_metrics_scanorama.csv (summary table)")
print(f"        csv_curves/roc_curves_scanorama.csv (ROC points)")
print(f"        csv_curves/prc_curves_scanorama.csv (PRC points)")
print(f"    Script:")
print(f"        load_and_plot_curves.py (example loading code)")

print(f"\n Data structure:")
print(f"   • ROC: FPR, TPR, thresholds, AUC for each model")
print(f"   • PRC: Precision, Recall, thresholds, AP for each model")
print(f"   • Metadata: Features used, sample counts, etc.")
print(f"\n You can now recreate these plots exactly using the saved curve␣
 ↪points!")

#   Print curve data summary
```

```
print(f"\n Curve Data Summary:")
for model_name in curve_data['summary_metrics'].keys():
    roc_points = curve_data['summary_metrics'][model_name]['n_roc_points']
    prc_points = curve_data['summary_metrics'][model_name]['n_prc_points']
    auroc = curve_data['summary_metrics'][model_name]['auroc']
    auprc = curve_data['summary_metrics'][model_name]['auprc']
    print(f"   {model_name:20s}: {roc_points:3d} ROC points, {prc_points:3d}␣
 ↪PRC points, "
          f"AUROC={auroc:.3f}, AUPRC={auprc:.3f}")
```

```
Checking original data…
Type: <class 'pandas.core.frame.DataFrame'>
Shape: (1649, 13027)
Data types of first few columns: Mrpl15     float32
Lypla1     float32
Tcea1      float32
Atp6v1h    float32
Rb1cc1     float32
dtype: object
Any non-numeric columns? True
NaN count per column (first 5): [0, 0, 0, 0, 0]
Total NaN values: 0
Converting to numeric efficiently…

Expression shape: (1649, 13026)
Gender values: [0. 1.]
NaN in expression data: 3298 out of 21479874 values
NaN in gender: 0 out of 1649 values
Found 2 columns that are all NaN. Removing them…

Final shapes - Expression: (1649, 13024), Gender: 1649
Gender distribution: [ 222 1427]

Male samples: 222, Female samples: 1427

Applying Scanorama batch correction…
Found 13024 genes among all datasets
[[0.        0.9954955]
 [0.        0.       ]]
Processing datasets (0, 1)
Scanorama failed: setting an array element with a sequence.
Falling back to simple batch correction…

Success! Final shape: (1649, 13024)

Original shapes:
  Training: (6648, 14)
  Test: (1649, 13024)
```

```
Extracting 14 columns from test data

Aligned shapes:
  Training: (6648, 14)
  Test: (1649, 14)

Training LogisticRegression…
  → AUROC: 0.533, AUPRC: 0.850

Training SVC…
  → AUROC: 0.526, AUPRC: 0.837

Training XGBClassifier…
  → AUROC: 0.786, AUPRC: 0.949

Training RandomForestClassifier…

/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [18:04:10] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)

  → AUROC: 0.607, AUPRC: 0.866
```




```
  Saving curve data…
     JSON:
/Users/haley/Desktop/send_tooo/AAA_final/scanorama/curve_data_scanorama.json
     Pickle:
/Users/haley/Desktop/send_tooo/AAA_final/scanorama/curve_data_scanorama.pkl
     ROC CSV: /Users/haley/Desktop/send_tooo/AAA_final/scanorama/csv_curves/roc_
```

```
curves_scanorama.csv
    PRC CSV: /Users/haley/Desktop/send_tooo/AAA_final/scanorama/csv_curves/prc_
curves_scanorama.csv
    Summary CSV:
/Users/haley/Desktop/send_tooo/AAA_final/scanorama/summary_metrics_scanorama.csv
    Loading script:
/Users/haley/Desktop/send_tooo/AAA_final/scanorama/load_and_plot_curves.py

 All files saved to: /Users/haley/Desktop/send_tooo/AAA_final/scanorama

Files created:
    Plots:
        roc_prc_scanorama.png
        roc_prc_scanorama.pdf
    Curve Data:
        curve_data_scanorama.json (complete data)
        curve_data_scanorama.pkl (Python binary)
        summary_metrics_scanorama.csv (summary table)
        csv_curves/roc_curves_scanorama.csv (ROC points)
        csv_curves/prc_curves_scanorama.csv (PRC points)
    Script:
        load_and_plot_curves.py (example loading code)

 Data structure:
   • ROC: FPR, TPR, thresholds, AUC for each model
   • PRC: Precision, Recall, thresholds, AP for each model
   • Metadata: Features used, sample counts, etc.

 You can now recreate these plots exactly using the saved curve points!

 Curve Data Summary:
   LogisticRegression  : 275 ROC points, 1650 PRC points, AUROC=0.533,
AUPRC=0.850
   SVC                 : 295 ROC points, 1644 PRC points, AUROC=0.526,
AUPRC=0.837
   XGBClassifier       : 344 ROC points, 1136 PRC points, AUROC=0.786,
AUPRC=0.949
   RandomForestClassifier: 352 ROC points, 1439 PRC points, AUROC=0.607,
AUPRC=0.866
```

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[20]:
```
reboot_training_data = ffrc.sample(frac=0.6, random_state=25)
reboot_testing_data = ffrc.drop(reboot_training_data.index)

rbY_train=reboot_training_data["y"]
rbX_train=reboot_training_data.drop(["y"],axis=1)
```

```
rbY_test=reboot_testing_data["y"]
rbX_test=reboot_testing_data.drop(["y"],axis=1)
```

[21]:
```
from sklearn.model_selection import cross_val_score, StratifiedKFold,␣
 ↪cross_validate
from sklearn.pipeline import Pipeline
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler

# # Assuming rbX_train, rbY_train, rbX_test, rbY_test are your data
# rbX = np.concatenate((rbX_train, rbX_test), axis=0)
# rbY = np.concatenate((rbY_train, rbY_test), axis=0)

# Your models
models = [
    ('LR', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪LogisticRegression(max_iter=1000, random_state=551))])),
    ('SVM', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪SVC(kernel='linear', probability=True, random_state=551))])),
    ('XGB', Pipeline([('scaler', StandardScaler()), ('model', XGBClassifier( ␣
 ↪eval_metric='logloss', n_estimators=100, learning_rate=0.05,␣
 ↪max_depth=10,random_state=551))])),
    ('RF', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪RandomForestClassifier(max_depth=10, random_state=41))]))
]

scores = {name: {'accuracy': [], 'f1': []} for name, _ in models}

# 5-Fold Cross-validation
cv = StratifiedKFold(n_splits=5, shuffle=True, random_state=41)

for name, model in models:
    # Change 'f1_macro' to 'f1_weighted' for multi-class scenario with␣
 ↪consideration for class imbalance
    cv_results = cross_validate(model, full_X_train, full_Y_train, cv=cv,␣
 ↪scoring=['accuracy', 'f1_weighted'])

    scores[name]['accuracy'] = cv_results['test_accuracy']
    scores[name]['f1'] = cv_results['test_f1_weighted']
```

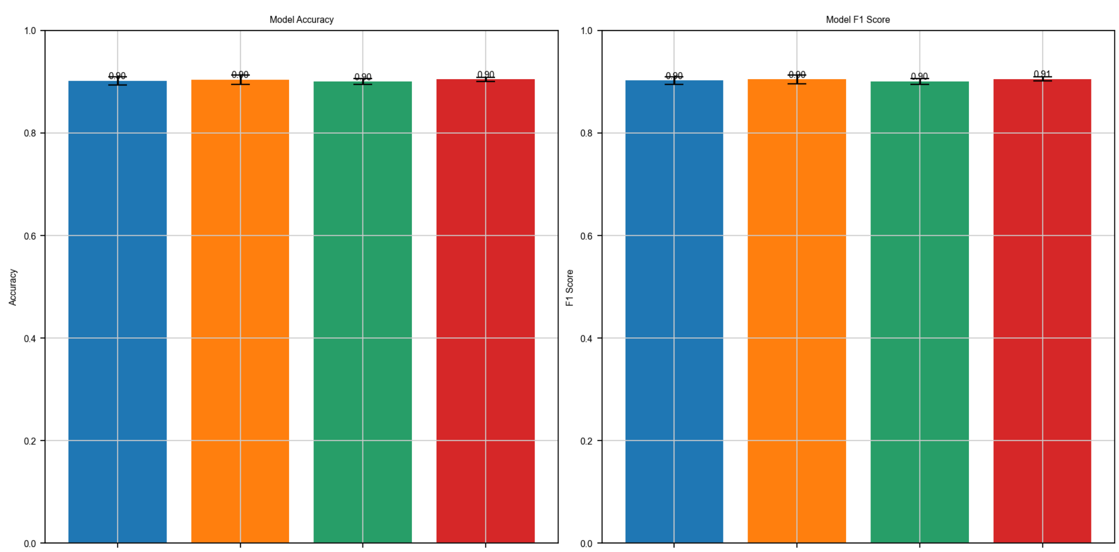
```
# Print results
for name in scores.keys():
    mean_accuracy = np.mean(scores[name]['accuracy'])
    std_accuracy = np.std(scores[name]['accuracy'])
    mean_f1 = np.mean(scores[name]['f1'])
    std_f1 = np.std(scores[name]['f1'])

    print(f"Model: {name}")
    print(f"  Accuracy: Mean = {mean_accuracy:.2f}, Std = {std_accuracy:.2f}")
    print(f"  F1 Score: Mean = {mean_f1:.2f}, Std = {std_f1:.2f}")
```

```
Model: LR
  Accuracy: Mean = 0.90, Std = 0.01
  F1 Score: Mean = 0.90, Std = 0.01
Model: SVM
  Accuracy: Mean = 0.90, Std = 0.01
  F1 Score: Mean = 0.90, Std = 0.01
Model: XGB
  Accuracy: Mean = 0.90, Std = 0.01
  F1 Score: Mean = 0.90, Std = 0.01
Model: RF
  Accuracy: Mean = 0.90, Std = 0.01
  F1 Score: Mean = 0.91, Std = 0.01
```

[23]:
```
from sklearn.model_selection import cross_val_score, StratifiedKFold,␣
 ↪cross_validate
from sklearn.pipeline import Pipeline
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler

# Assuming rbX_train, rbY_train, rbX_test, rbY_test are your data


# Your models
models = [
    ('LR', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪LogisticRegression(max_iter=1000, random_state=551))])),
    ('SVM', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪SVC(kernel='linear', probability=True, random_state=551))])),
    ('XGB', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪XGBClassifier(use_label_encoder=False, eval_metric='logloss',␣
 ↪n_estimators=100, learning_rate=0.05, max_depth=10,random_state=551))])),
```

```
    ('RF', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪RandomForestClassifier(max_depth=10, random_state=41))]))
]

scores = {name: {'accuracy': [], 'f1': []} for name, _ in models}

# 5-Fold Cross-validation
cv = StratifiedKFold(n_splits=5, shuffle=True, random_state=551)

for name, model in models:
    # Change 'f1_macro' to 'f1_weighted' for multi-class scenario with␣
 ↪consideration for class imbalance
    cv_results = cross_validate(model, full_X_train, full_Y_train, cv=cv,␣
 ↪scoring=['accuracy', 'f1_weighted'])

    scores[name]['accuracy'] = cv_results['test_accuracy']
    scores[name]['f1'] = cv_results['test_f1_weighted']

# Plotting
fig, ax = plt.subplots(1, 2, figsize=(12, 6))

# Accuracy Plot
for i, name in enumerate(scores.keys()):
    mean_accuracy = np.mean(scores[name]['accuracy'])
    std_accuracy = np.std(scores[name]['accuracy'])
    bar = ax[0].bar(name, mean_accuracy, yerr=std_accuracy, capsize=7)
    ax[0].text(bar[0].get_x() + bar[0].get_width() / 2, bar[0].get_height(),␣
 ↪f'{mean_accuracy:.2f}', ha='center', va='bottom', fontsize=7)
ax[0].set_title('Model Accuracy', fontsize=7)
ax[0].set_ylabel('Accuracy', fontsize=7)
ax[0].tick_params(axis='both', which='major', labelsize=7)
ax[0].set_ylim([0, 1])

# F1 Score Plot
for i, name in enumerate(scores.keys()):
    mean_f1 = np.mean(scores[name]['f1'])
    std_f1 = np.std(scores[name]['f1'])
    bar = ax[1].bar(name, mean_f1, yerr=std_f1, capsize=7)
    ax[1].text(bar[0].get_x() + bar[0].get_width() / 2, bar[0].get_height(),␣
 ↪f'{mean_f1:.2f}', ha='center', va='bottom', fontsize=7)
ax[1].set_title('Model F1 Score', fontsize=7)
ax[1].set_ylabel('F1 Score', fontsize=7)
ax[1].tick_params(axis='both', which='major', labelsize=7)
ax[1].set_ylim([0, 1])

plt.tight_layout()
plt.show()
```

```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:28:27] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:28:27] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:28:27] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:28:27] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:28:27] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```



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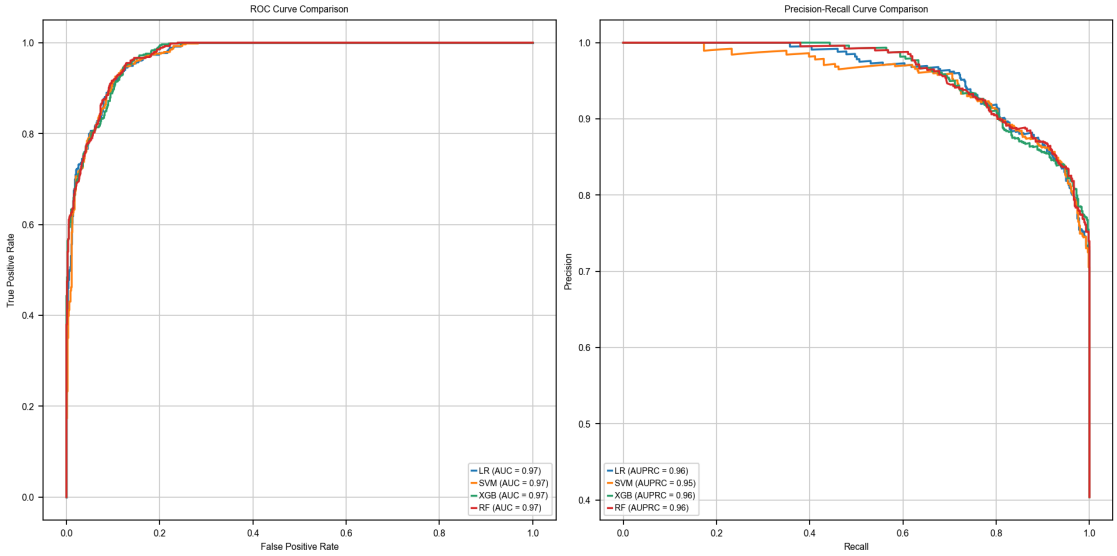
[24]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score, average_precision_score, roc_curve,␣
 ↪precision_recall_curve
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline

# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'



# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(full_X_train, full_Y_train,␣
 ↪test_size=0.2, random_state=551, stratify=full_Y_train)

# Your models
models = [
    ('LR', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪LogisticRegression(max_iter=1000, random_state=551))])),
    ('SVM', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪SVC(kernel='linear', probability=True, random_state=551))])),
    ('XGB', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪XGBClassifier(use_label_encoder=False, eval_metric='logloss',␣
 ↪n_estimators=100, learning_rate=0.05, max_depth=10,random_state=551))])),
    ('RF', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪RandomForestClassifier(max_depth=10, random_state=41))]))
]

# DataFrames to store all ROC and PRC data
roc_data_list = []
prc_data_list = []
```

```
# Plot settings
plt.figure(figsize=(12, 6))
roc_ax = plt.subplot(1, 2, 1)
prc_ax = plt.subplot(1, 2, 2)

for name, model in models:
    # Fit the model on the full training data
    model.fit(X_train, y_train)

    # Predict probabilities on the test set
    y_prob = model.predict_proba(X_test)[:, 1]

    # ROC Curve
    fpr, tpr, _ = roc_curve(y_test, y_prob)
    roc_auc = roc_auc_score(y_test, y_prob)
    roc_ax.plot(fpr, tpr, label=f'{name} (AUC = {roc_auc:.2f})')

    # Save ROC data
    roc_data_list.append(pd.DataFrame({'Model': name, 'fpr': fpr, 'tpr': tpr}))

    # Precision-Recall Curve
    precision, recall, _ = precision_recall_curve(y_test, y_prob)
    pr_auc = average_precision_score(y_test, y_prob)
    prc_ax.plot(recall, precision, label=f'{name} (AUPRC = {pr_auc:.2f})')

    # Save PRC data
    prc_data_list.append(pd.DataFrame({'Model': name, 'precision': precision,␣
 ↪'recall': recall}))

# ROC Axis labels
roc_ax.set_title('ROC Curve Comparison')
roc_ax.set_xlabel('False Positive Rate')
roc_ax.set_ylabel('True Positive Rate')
roc_ax.legend(loc="lower right")

# PRC Axis labels
prc_ax.set_title('Precision-Recall Curve Comparison')
prc_ax.set_xlabel('Recall')
prc_ax.set_ylabel('Precision')
prc_ax.legend(loc="lower left")

plt.tight_layout()
plt.show()

# Combine all ROC and PRC data and save to CSV files
roc_data = pd.concat(roc_data_list, ignore_index=True)
prc_data = pd.concat(prc_data_list, ignore_index=True)
```

```
roc_data.to_csv('auroc_data.csv', index=False)
prc_data.to_csv('prc_data.csv', index=False)
```

```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:37:07] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```



[98]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score, average_precision_score, roc_curve,␣
 ↪precision_recall_curve
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline

# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
```

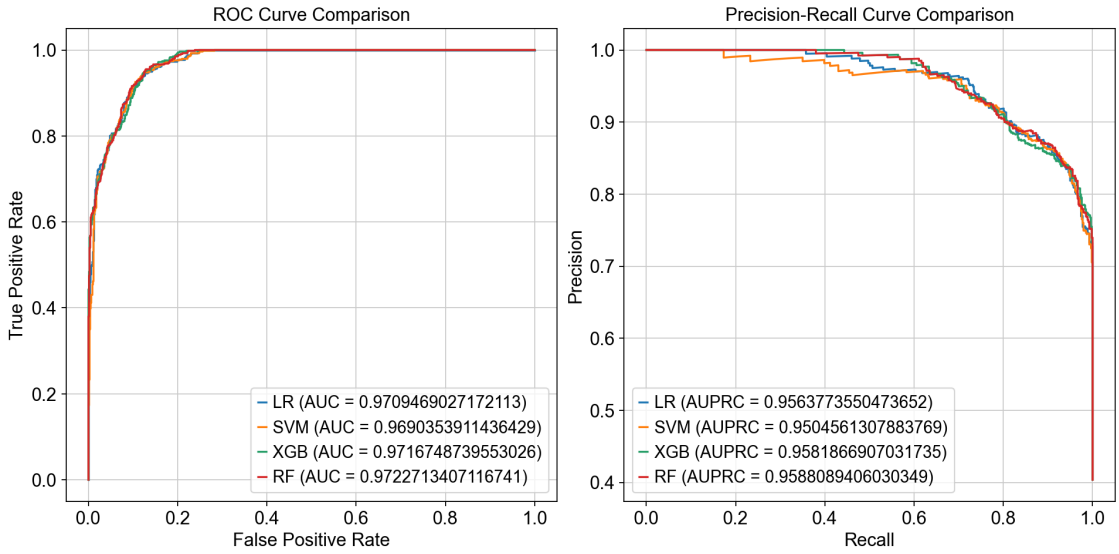
```
rcParams['font.weight'] = 'normal'

# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(full_X_train, full_Y_train,␣
 ↪test_size=0.2, random_state=551, stratify=full_Y_train)

# Your models
models = [
    ('LR', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪LogisticRegression(max_iter=1000, random_state=551))])),
    ('SVM', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪SVC(kernel='linear', probability=True, random_state=551))])),
    ('XGB', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪XGBClassifier(use_label_encoder=False, eval_metric='logloss',␣
 ↪n_estimators=100, learning_rate=0.05, max_depth=10,random_state=551))])),
    ('RF', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪RandomForestClassifier(max_depth=10, random_state=41))]))
]

# DataFrames to store all ROC and PRC data
roc_data_list = []
prc_data_list = []

# Dictionary to store metrics for printing
metrics_dict = {}

# Plot settings
plt.figure(figsize=(12, 6))
roc_ax = plt.subplot(1, 2, 1)
prc_ax = plt.subplot(1, 2, 2)

for name, model in models:
    # Fit the model on the full training data
    model.fit(X_train, y_train)

    # Predict probabilities on the test set
    y_prob = model.predict_proba(X_test)[:, 1]

    # ROC Curve
    fpr, tpr, _ = roc_curve(y_test, y_prob)
    roc_auc = roc_auc_score(y_test, y_prob)
    roc_ax.plot(fpr, tpr, label=f'{name} (AUC = {roc_auc})')

    # Save ROC data
    roc_data_list.append(pd.DataFrame({'Model': name, 'fpr': fpr, 'tpr': tpr}))

    # Precision-Recall Curve
```

```
    precision, recall, _ = precision_recall_curve(y_test, y_prob)
    pr_auc = average_precision_score(y_test, y_prob)
    prc_ax.plot(recall, precision, label=f'{name} (AUPRC = {pr_auc})')

    # Save PRC data
    prc_data_list.append(pd.DataFrame({'Model': name, 'precision': precision,␣
 ↪'recall': recall}))

    # Store metrics for printing
    metrics_dict[name] = {'AUROC': roc_auc, 'AUPRC': pr_auc}

    # Print metrics with full precision
    print(f'{name}: AUROC = {roc_auc}, AUPRC = {pr_auc}')

# ROC Axis labels
roc_ax.set_title('ROC Curve Comparison')
roc_ax.set_xlabel('False Positive Rate')
roc_ax.set_ylabel('True Positive Rate')
roc_ax.legend(loc="lower right")

# PRC Axis labels
prc_ax.set_title('Precision-Recall Curve Comparison')
prc_ax.set_xlabel('Recall')
prc_ax.set_ylabel('Precision')
prc_ax.legend(loc="lower left")

plt.tight_layout()
plt.show()

# Combine all ROC and PRC data and save to CSV files
roc_data = pd.concat(roc_data_list, ignore_index=True)
prc_data = pd.concat(prc_data_list, ignore_index=True)

roc_data.to_csv('auroc_data.csv', index=False)
prc_data.to_csv('prc_data.csv', index=False)

# Save metrics to CSV with full precision
metrics_df = pd.DataFrame.from_dict(metrics_dict, orient='index').reset_index()
metrics_df.columns = ['Model', 'AUROC', 'AUPRC']
metrics_df.to_csv('model_metrics_full_precision.csv', index=False)

print("\nMetrics Summary:")
print(metrics_df)
```

```
LR: AUROC = 0.9709469027172113, AUPRC = 0.9563773550473652
SVM: AUROC = 0.9690353911436429, AUPRC = 0.9504561307883769
XGB: AUROC = 0.9716748739553026, AUPRC = 0.9581866907031735
```

```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [08:54:32] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```

```
RF: AUROC = 0.9722713407116741, AUPRC = 0.9588089406030349
```



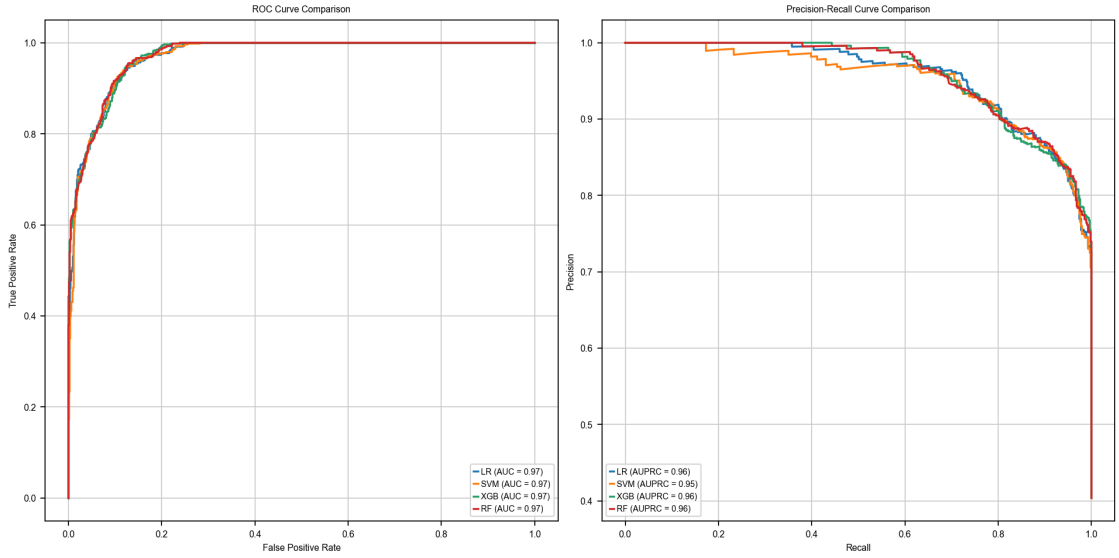

```
Metrics Summary:
  Model  AUROC  AUPRC
0    LR  0.971  0.956
1   SVM  0.969  0.950
2   XGB  0.972  0.958
3    RF  0.972  0.959
```

[25]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import roc_auc_score, average_precision_score, roc_curve,␣
 ↪precision_recall_curve
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
```

```
from sklearn.pipeline import Pipeline

# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'



# Split data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(full_X_train, full_Y_train,␣
 ↪test_size=0.2, random_state=551, stratify=  full_Y_train)

# Your models
models = [
    ('LR', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪LogisticRegression(max_iter=1000, random_state=551))])),
    ('SVM', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪SVC(kernel='linear', probability=True, random_state=551))])),
    ('XGB', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪XGBClassifier(use_label_encoder=False, eval_metric='logloss',␣
 ↪n_estimators=100, learning_rate=0.05, max_depth=10,random_state=551))])),
    ('RF', Pipeline([('scaler', StandardScaler()), ('model',␣
 ↪RandomForestClassifier(max_depth=10, random_state=41))]))
]

# Plot settings
plt.figure(figsize=(12, 6))
roc_ax = plt.subplot(1, 2, 1)
prc_ax = plt.subplot(1, 2, 2)

for name, model in models:
    # Fit the model on the full training data
    model.fit(X_train, y_train)

    # Predict probabilities on the test set
    y_prob = model.predict_proba(X_test)[:, 1]

    # ROC Curve
    fpr, tpr, _ = roc_curve(y_test, y_prob)
    roc_auc = roc_auc_score(y_test, y_prob)
    roc_ax.plot(fpr, tpr, label=f'{name} (AUC = {roc_auc:.2f})')

    # Precision-Recall Curve
    precision, recall, _ = precision_recall_curve(y_test, y_prob)
    pr_auc = average_precision_score(y_test, y_prob)
    prc_ax.plot(recall, precision, label=f'{name} (AUPRC = {pr_auc:.2f})')
```

```
# ROC Axis labels
roc_ax.set_title('ROC Curve Comparison')
roc_ax.set_xlabel('False Positive Rate')
roc_ax.set_ylabel('True Positive Rate')
roc_ax.legend(loc="lower right")

# PRC Axis labels
prc_ax.set_title('Precision-Recall Curve Comparison')
prc_ax.set_xlabel('Recall')
prc_ax.set_ylabel('Precision')
prc_ax.legend(loc="lower left")

plt.tight_layout()
plt.show()
```

```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [22:37:55] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```

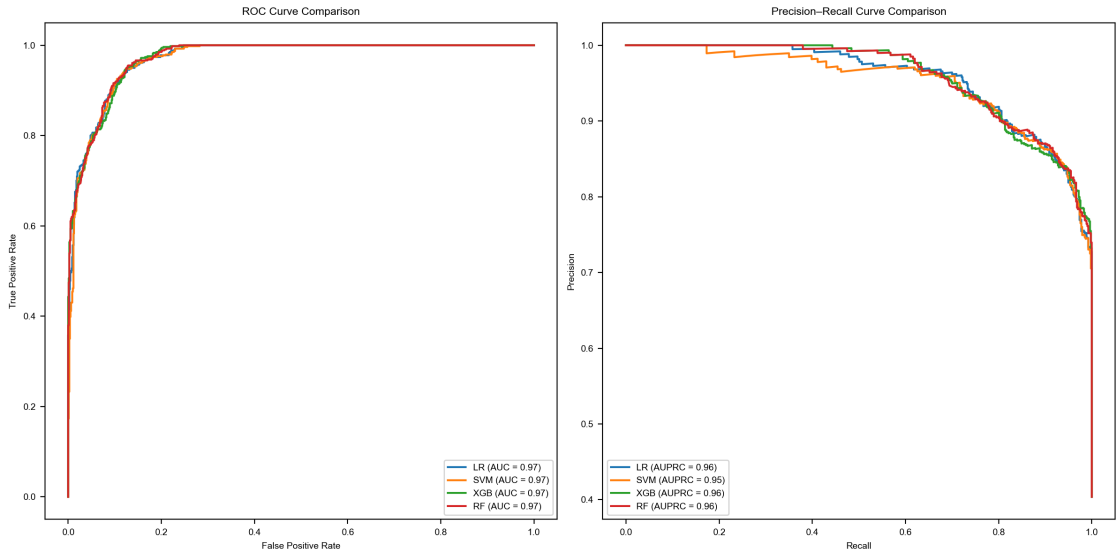


[86]:
```
# Jupyter-friendly notebook cell
# ------------------------------------------------------------
# Train four classifiers, draw ROC & PR curves, **and**
# save every (x, y) point used to construct the curves
# ------------------------------------------------------------
```

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from pathlib import Path

from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import (
    roc_auc_score, average_precision_score,
    roc_curve, precision_recall_curve
)
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline

#    global matplotlib settings
rcParams["font.family"] = "Arial"
rcParams["font.size"]   = 7
rcParams["font.weight"] = "normal"

#    data split
X_train, X_test, y_train, y_test = train_test_split(
    full_X_train, full_Y_train,
    test_size   = 0.20,
    random_state= 551,
    stratify    = full_Y_train
)

#    model definitions
models = [
    ("LR",
     Pipeline([
         ("scaler", StandardScaler()),
         ("model",  LogisticRegression(max_iter=1_000, random_state=551))
     ])),
    ("SVM",
     Pipeline([
         ("scaler", StandardScaler()),
         ("model",  SVC(kernel="linear", probability=True, random_state=551))
     ])),
    ("XGB",
     Pipeline([
         ("scaler", StandardScaler()),
```

```
        ("model",  XGBClassifier(
                        use_label_encoder=False,
                        eval_metric="logloss",
                        n_estimators=100,
                        learning_rate=0.05,
                        max_depth=10,
                        random_state=551))
    ])),
    ("RF",
     Pipeline([
        ("scaler", StandardScaler()),
        ("model",  RandomForestClassifier(max_depth=10, random_state=41))
     ]))
]

#   containers for saving curve points
roc_points = []   # list of DataFrames
pr_points  = []

#   plotting setup
fig, (roc_ax, prc_ax) = plt.subplots(1, 2, figsize=(12, 6))

for name, model in models:
    # Fit model
    model.fit(X_train, y_train)

    # Probability predictions
    y_prob = model.predict_proba(X_test)[:, 1]

    #   ROC
    fpr, tpr, _ = roc_curve(y_test, y_prob)
    roc_auc      = roc_auc_score(y_test, y_prob)
    roc_ax.plot(fpr, tpr, label=f"{name} (AUC = {roc_auc:.2f})")

    # Save ROC points
    roc_points.append(pd.DataFrame({
        "model": name,
        "fpr":   fpr,
        "tpr":   tpr
    }))

    #   PRC
    precision, recall, _ = precision_recall_curve(y_test, y_prob)
    pr_auc               = average_precision_score(y_test, y_prob)
    prc_ax.plot(recall, precision, label=f"{name} (AUPRC = {pr_auc:.2f})")

    # Save PR points
```

```
    pr_points.append(pd.DataFrame({
        "model":     name,
        "recall":    recall,
        "precision": precision
    }))

#    finalise plots
roc_ax.set_title("ROC Curve Comparison")
roc_ax.set_xlabel("False Positive Rate")
roc_ax.set_ylabel("True Positive Rate")
roc_ax.legend(loc="lower right")

prc_ax.set_title("Precision-Recall Curve Comparison")
prc_ax.set_xlabel("Recall")
prc_ax.set_ylabel("Precision")
prc_ax.legend(loc="lower left")

plt.tight_layout()
plt.show()

#    save curve points to CSV
OUT_DIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/fig3_curve_points")
OUT_DIR.mkdir(exist_ok=True)

pd.concat(roc_points, ignore_index=True).to_csv(OUT_DIR / "roc_curve_points.
  ↪csv", index=False)
pd.concat(pr_points,  ignore_index=True).to_csv(OUT_DIR / "pr_curve_points.
  ↪csv",  index=False)

print(f"Saved full ROC & PR curve coordinates to {OUT_DIR.resolve()}")
```



```
Saved full ROC & PR curve coordinates to
/Users/haley/Desktop/send_tooo/AAA_final/fig3_curve_points
```

9 bootstrap auroc,auprc

[56]:
```python
#!/usr/bin/env python3
"""Bootstrapped evaluation of four classical classifiers on binary labels.

Inputs (must be pre-loaded in the Python session):
    - full_X_train : pandas DataFrame, shape (n_samples, n_features)
    - full_Y_train : pandas Series or 1-D array of length n_samples
    - realtest     : pandas DataFrame, shape (n_test_samples, n_features)
    - realtest_y   : pandas Series or 1-D array of length n_test_samples

Outputs (saved in the working directory):
    - bootstrap_roc_auc.csv  - mean AUROC + 95% CI for each model
    - bootstrap_prc_auc.csv - mean AUPRC + 95% CI for each model

Each CSV has three rows (mean, lower CI, upper CI) and one column per model.
"""

from __future__ import annotations

import warnings
from pathlib import Path
from typing import Tuple, List

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt  # noqa: F401  - left here if you later add␣
↪plots
from matplotlib import rcParams
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, average_precision_score
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier

# ---------------------------------------------------------------------------
# Global configuration
# ---------------------------------------------------------------------------

N_BOOTSTRAPS: int = 100
```

```
RANDOM_SEED: int = 551
OUTPUT_DIR: Path = Path("/Users/haley/Desktop/send_tooo/AAA_final/fig4")  #␣
 ↪Change this if you want the CSVs elsewhere

# Matplotlib defaults - handy if you decide to visualise later
rcParams.update({
    "font.family": "Arial",
    "font.size": 7,
    "font.weight": "normal",
})

# Silence XGBoost warnings that clutter the console
warnings.filterwarnings("ignore", category=UserWarning, module="xgboost")

# ---------------------------------------------------------------------------
# Utility functions
# ---------------------------------------------------------------------------

def bootstrap_metrics(
    model,
    X_train: pd.DataFrame,
    y_train: pd.Series,
    X_test: pd.DataFrame,
    y_test: pd.Series,
    n_bootstraps: int = N_BOOTSTRAPS,
    seed: int = RANDOM_SEED,
) -> Tuple[Tuple[float, float, float], Tuple[float, float, float]]:
    """Compute bootstrapped AUROC and AUPRC for *model*.

    Returns
    -------
    roc_stats : (mean, lower_ci, upper_ci)
    prc_stats : (mean, lower_ci, upper_ci)
    """

    rng = np.random.default_rng(seed)
    roc_scores: List[float] = []
    prc_scores: List[float] = []

    for _ in range(n_bootstraps):
        # Sample with replacement from the training set
        resample_idx = rng.choice(len(X_train), size=len(X_train), replace=True)

        X_resampled = X_train.iloc[resample_idx]
        y_resampled = y_train.iloc[resample_idx]

        # Standardise per-bootstrap to avoid information leakage
```

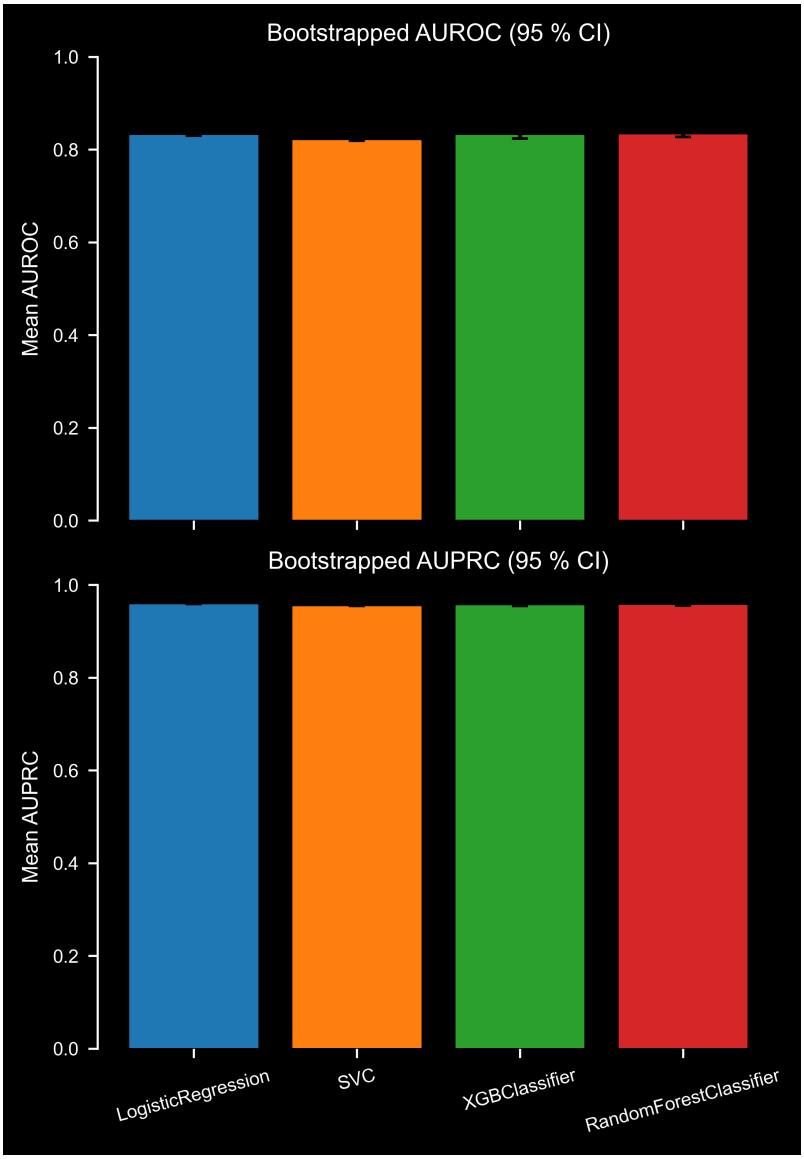
```
        scaler = StandardScaler()
        X_resampled_scaled = scaler.fit_transform(X_resampled)
        X_test_scaled = scaler.transform(X_test)

        # Fit and predict
        model.fit(X_resampled_scaled, y_resampled)
        y_prob = model.predict_proba(X_test_scaled)[:, 1]

        roc_scores.append(roc_auc_score(y_test, y_prob))
        prc_scores.append(average_precision_score(y_test, y_prob))

    roc_arr = np.asarray(roc_scores)
    prc_arr = np.asarray(prc_scores)

    roc_stats = (
        float(roc_arr.mean()),
        float(np.percentile(roc_arr, 2.5)),
        float(np.percentile(roc_arr, 97.5)),
    )
    prc_stats = (
        float(prc_arr.mean()),
        float(np.percentile(prc_arr, 2.5)),
        float(np.percentile(prc_arr, 97.5)),
    )
    return roc_stats, prc_stats

# ---------------------------------------------------------------------------
# Main evaluation pipeline
# ---------------------------------------------------------------------------

def main() -> None:
    """Run bootstrap evaluation and save CSV summaries."""

    # These variables must already be defined elsewhere (e.g. notebook or␣
 ↪import)
    try:
        global full_X_train, full_Y_train, realtest, realtest_y  # type: ignore
    except NameError as exc:
        raise RuntimeError(
            "full_X_train, full_Y_train, realtest, realtest_y need to be in␣
 ↪scope "
            "before running this script."
        ) from exc

    models = [
        LogisticRegression(max_iter=1000, n_jobs=-1, random_state=RANDOM_SEED),
        SVC(kernel="linear", probability=True, random_state=RANDOM_SEED),
```

```
        XGBClassifier(
            random_state=RANDOM_SEED,
            use_label_encoder=False,
            eval_metric="logloss",
            n_estimators=100,
            learning_rate=0.05,
            max_depth=10,
        ),
        RandomForestClassifier(max_depth=10, random_state=RANDOM_SEED),
    ]

    roc_results = {}
    prc_results = {}

    for clf in models:
        roc_stats, prc_stats = bootstrap_metrics(
            clf, full_X_train, full_Y_train, realtest, realtest_y
        )
        name = clf.__class__.__name__
        roc_results[name] = roc_stats
        prc_results[name] = prc_stats
        print(f"{name:>22}: AUROC={roc_stats[0]:.3f}  AUPRC={prc_stats[0]:.3f}")

    # Save to CSV
    roc_df = pd.DataFrame(roc_results, index=["Mean AUROC", "Lower CI", "Upper␣
↪CI"]).T
    prc_df = pd.DataFrame(prc_results, index=["Mean AUPRC", "Lower CI", "Upper␣
↪CI"]).T

    OUTPUT_DIR.mkdir(parents=True, exist_ok=True)
    roc_df.to_csv(OUTPUT_DIR / "bootstrap_roc_auc.csv", index_label="Model")
    prc_df.to_csv(OUTPUT_DIR / "bootstrap_prc_auc.csv", index_label="Model")

    print("\nSaved bootstrap_roc_auc.csv and bootstrap_prc_auc.csv to",␣
↪OUTPUT_DIR.resolve())


if __name__ == "__main__":
    main()
```

```
    LogisticRegression: AUROC=0.833  AUPRC=0.960
                   SVC: AUROC=0.822  AUPRC=0.956
         XGBClassifier: AUROC=0.833  AUPRC=0.958
RandomForestClassifier: AUROC=0.834  AUPRC=0.958

Saved bootstrap_roc_auc.csv and bootstrap_prc_auc.csv to
/Users/haley/Desktop/send_tooo/AAA_final/fig4
```

[58]:
```
#!/usr/bin/env python3
"""
Bar plots of AUROC and AUPRC (mean ± 95 % CI) on a **white** background.
X-axis baseline and dashed y-axis grid are removed.
"""

import pandas as pd
import matplotlib.pyplot as plt
from pathlib import Path

#   1.  Read results
roc_df = pd.read_csv(Path("bootstrap_roc_auc.csv"), index_col="Model")
prc_df = pd.read_csv(Path("bootstrap_prc_auc.csv"), index_col="Model")

models = roc_df.index.tolist()
prc_df = prc_df.loc[models]  # ensure same order

def extract(df, col):
    mean = df[col].values
    err  = [mean - df["Lower CI"].values,
            df["Upper CI"].values - mean]
    return mean, err

roc_mean, roc_err = extract(roc_df, "Mean AUROC")
prc_mean, prc_err = extract(prc_df, "Mean AUPRC")

#   2.  Plotting setup
colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]   # blue, orange, green,␣
 ↪red

fig, axes = plt.subplots(2, 1, figsize=(4.2, 6), dpi=300, sharex=True)

# Helper to style each subplot
def style_axis(ax, ylabel, title, means, yerr):
    ax.bar(models, means, yerr=yerr, capsize=3,
           color=colors, edgecolor="black", linewidth=0.6)
    ax.set_ylabel(ylabel, fontsize=8)
    ax.set_title(title, fontsize=9, pad=6)
    ax.set_ylim(0, 1)
    # Remove x-axis baseline and any grid lines
    ax.spines["bottom"].set_visible(False)
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)
    # No grid
    ax.grid(False)
```

```
style_axis(axes[0], "Mean AUROC", "Bootstrapped AUROC (95 % CI)", roc_mean,␣
 ↪roc_err)
style_axis(axes[1], "Mean AUPRC", "Bootstrapped AUPRC (95 % CI)", prc_mean,␣
 ↪prc_err)

plt.xticks(rotation=15, ha="center", fontsize=7)
plt.tight_layout()
plt.show()
```



[33]:
```
# Optional: Print results
print("ROC AUC Data:")
```

```
print(roc_auc_df)
print("\nPRC AUC Data:")
print(prc_auc_df)
```

```
ROC AUC Data:
                          Mean AUROC  Lower CI  Upper CI
LogisticRegression          0.833158  0.829910  0.835949
SVC                         0.822421  0.818697  0.826163
XGBClassifier               0.833681  0.824071  0.843689
RandomForestClassifier      0.835185  0.827522  0.844919

PRC AUC Data:
                          Mean AUPRC  Lower CI  Upper CI
LogisticRegression          0.959903  0.958873  0.960731
SVC                         0.956253  0.954741  0.957541
XGBClassifier               0.957919  0.954751  0.961573
RandomForestClassifier      0.958576  0.955422  0.961641
```

[49]:
```
full_X_train
```

[49]:
```
n              Rpl35   Rps27rt  Rpl9-ps6     Rps27     Uba52     Lars2  \
Cell_1678   1.098612  0.693147  0.000000  0.000000  1.098612  0.693147
Cell_3705   0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
Cell_5187   1.945910  1.386294  1.098612  0.693147  0.693147  0.000000
Cell_1921   1.945910  0.693147  1.098612  1.098612  1.098612  0.693147
Cell_1575   2.639057  2.890372  1.945910  1.098612  1.791759  1.098612
…                …         …         …         …         …         …
Cell_2934   2.197225  1.945910  0.693147  1.791759  0.000000  0.693147
Cell_2191   1.386294  0.693147  0.000000  0.693147  0.693147  1.386294
Cell_6618   1.791759  1.098612  0.693147  0.693147  0.000000  0.693147
Cell_318    1.609438  1.945910  0.000000  0.000000  0.000000  0.000000
Cell_5252   0.000000  0.000000  0.000000  0.000000  0.000000  0.000000

n            Gm42418  Uty  Kdm5d  Eif2s3y     Ddx3y      Xist
Cell_1678   2.639057  0.0    0.0      0.0  0.000000  0.000000
Cell_3705   2.079442  0.0    0.0      0.0  0.000000  1.791759
Cell_5187   3.367296  0.0    0.0      0.0  0.000000  2.397895
Cell_1921   2.995732  0.0    0.0      0.0  0.693147  0.000000
Cell_1575   3.496508  0.0    0.0      0.0  0.000000  0.000000
…                …  …    …        …        …         …
Cell_2934   2.708050  0.0    0.0      0.0  0.000000  2.079442
```

```
Cell_2191  3.332205  0.0    0.0      0.0  0.000000  0.000000
Cell_6618  2.833213  0.0    0.0      0.0  0.000000  2.079442
Cell_318   2.197225  0.0    0.0      0.0  0.000000  0.000000
Cell_5252  0.693147  0.0    0.0      0.0  0.000000  0.693147

[6648 rows x 12 columns]
```

[55]:
```
full_X_train
```

[55]:
```
n              Xist     Ddx3y   Gm42418  Eif2s3y   Rps27rt  Rpl9-ps6  Kdm5d  \
Cell_1678  0.000000  0.000000  4.045352      0.0  1.671058  0.000000    0.0
Cell_3705  4.309744  0.000000  4.642370      0.0  0.000000  0.000000    0.0
Cell_5187  3.324866  0.000000  4.331086      0.0  2.201503  1.849880    0.0
Cell_1921  0.000000  1.265771  3.899357      0.0  1.265771  1.806919    0.0
Cell_1575  0.000000  0.000000  4.420726      0.0  3.798758  2.797547    0.0
…             …        …       …        …        …       …     …
Cell_2934  2.839474  0.000000  3.502957      0.0  2.695019  1.194215    0.0
Cell_2191  0.000000  0.000000  4.309315      0.0  1.313221  0.000000    0.0
Cell_6618  3.282452  0.000000  4.087791      0.0  2.119384  1.539660    0.0
Cell_318   0.000000  0.000000  4.049656      0.0  3.767767  0.000000    0.0
Cell_5252  2.096515  0.000000  2.096515      0.0  0.000000  0.000000    0.0

n              Uba52     Rpl35  Rpl36a-ps1  Uty     Wdr89     Lars2     Rps27
Cell_1678  2.265462  2.265462    0.000000  0.0  0.000000  1.671058  0.000000
Cell_3705  0.000000  0.000000    0.000000  0.0  0.000000  0.000000  0.000000
Cell_5187  1.302785  2.837743    0.000000  0.0  0.000000  0.000000  1.302785
Cell_1921  1.806919  2.789627    1.265771  0.0  1.265771  1.265771  1.806919
Cell_1575  2.627344  3.537362    2.163574  0.0  1.271835  1.813976  1.813976
…             …        …          …  …        …        …        …
Cell_2934  0.000000  2.965672    1.723112  0.0  0.000000  1.194215  2.526115
Cell_2191  1.313221  2.214233    1.313221  0.0  0.000000  2.214233  1.313221
Cell_6618  0.000000  2.960883    0.000000  0.0  0.000000  1.539660  1.539660
Cell_318   0.000000  3.373787    0.000000  0.0  0.000000  0.000000  0.000000
Cell_5252  0.000000  0.000000    2.096515  0.0  0.000000  0.000000  0.000000

[6648 rows x 14 columns]
```

[51]:
```
scaler = StandardScaler()
full_X_train_scaled=scaler.fit_transform(full_X_train)
realtest_scaled=scaler.transform(realtest)
```

10 fig4-ab

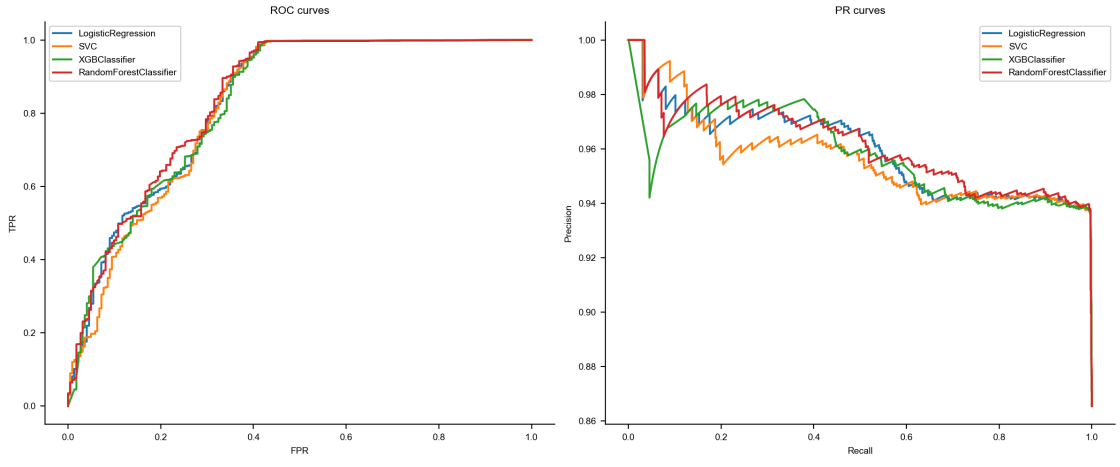
[81]:
```
#!/usr/bin/env python3
"""
Save *all* ROC and PR curve points in two master CSVs:
```

```
      all_roc_points.csv   # columns: model, fpr, tpr
      all_prc_points.csv   # columns: model, recall, precision

It also produces a small summary (AUROC / AUPRC) table.
"""

from pathlib import Path
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rcParams

from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    roc_curve,
    auc,
    precision_recall_curve,
    average_precision_score,
)
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier  # pip install xgboost if missing

#   global config
rcParams.update({"font.family": "Arial", "font.size": 7})
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/curve_outputs")
OUTDIR.mkdir(exist_ok=True)

colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]

models = [
    LogisticRegression(max_iter=1000, random_state=551),
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=551,
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   scale data once
```

```
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s  = scaler.transform(realtest)

#   containers
roc_rows, prc_rows = [], []
roc_summary, prc_summary = [], []

#   fit, predict, collect points
for model in models:
    name = model.__class__.__name__
    print("Training", name)
    model.fit(X_train_s, full_Y_train)
    y_prob = model.predict_proba(X_test_s)[:, 1]

    # ROC
    fpr, tpr, _ = roc_curve(realtest_y, y_prob)
    roc_auc = auc(fpr, tpr)
    roc_rows.append(pd.DataFrame({"model": name, "fpr": fpr, "tpr": tpr}))
    roc_summary.append({"model": name, "auc": roc_auc})

    # PR
    prec, rec, _ = precision_recall_curve(realtest_y, y_prob)
    pr_auc = average_precision_score(realtest_y, y_prob)
    prc_rows.append(pd.DataFrame({"model": name, "recall": rec, "precision":␣
 ↪prec}))
    prc_summary.append({"model": name, "auprc": pr_auc})

#   write master CSVs
pd.concat(roc_rows, ignore_index=True).to_csv(OUTDIR / "all_roc_points.csv",␣
 ↪index=False)
pd.concat(prc_rows, ignore_index=True).to_csv(OUTDIR / "all_prc_points.csv",␣
 ↪index=False)

pd.DataFrame(roc_summary).to_csv(OUTDIR / "roc_auc_summary.csv", index=False)
pd.DataFrame(prc_summary).to_csv(OUTDIR / "prc_auc_summary.csv", index=False)

print("  Saved:")
for fn in ["all_roc_points.csv", "all_prc_points.csv",
           "roc_auc_summary.csv", "prc_auc_summary.csv"]:
    print("    ", OUTDIR / fn)

#   (optional) quick plot from the master CSVs
plt.figure(figsize=(12, 5))
roc_ax = plt.subplot(1, 2, 1)
pr_ax = plt.subplot(1, 2, 2)
```

```
roc_pts = pd.read_csv(OUTDIR / "all_roc_points.csv")
prc_pts = pd.read_csv(OUTDIR / "all_prc_points.csv")

for name, color in zip([m.__class__.__name__ for m in models], colors):
    roc_sub = roc_pts[roc_pts.model == name]
    prc_sub = prc_pts[prc_pts.model == name]

    roc_ax.plot(roc_sub.fpr, roc_sub.tpr, label=name, color=color)
    pr_ax.plot(prc_sub.recall, prc_sub.precision, label=name, color=color)

roc_ax.set_title("ROC curves");   roc_ax.set_xlabel("FPR"); roc_ax.
 ↪set_ylabel("TPR")
pr_ax.set_title("PR curves");     pr_ax.set_xlabel("Recall"); pr_ax.
 ↪set_ylabel("Precision")
for ax in (roc_ax, pr_ax):
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)
    ax.legend(fontsize=7)

plt.tight_layout(); plt.show()
```

```
Training LogisticRegression
Training SVC
Training XGBClassifier
Training RandomForestClassifier
  Saved:
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_roc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_prc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/roc_auc_summary.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/prc_auc_summary.csv
```



[47]:
```
#!/usr/bin/env python3
"""
Save *all* ROC and PR curve points in two master CSVs:

      all_roc_points.csv   # columns: model, fpr, tpr
      all_prc_points.csv   # columns: model, recall, precision

It also produces a small summary (AUROC / AUPRC) table.
Additionally prints prediction counts and percentages for each model.
"""

from pathlib import Path
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rcParams

from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    roc_curve,
    auc,
    precision_recall_curve,
    average_precision_score,
)
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier  # pip install xgboost if missing

#   global config
rcParams.update({"font.family": "Arial", "font.size": 7})
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/curve_outputs")
OUTDIR.mkdir(exist_ok=True)

colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]

models = [
    LogisticRegression(max_iter=1000, random_state=551),
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=551,
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
```

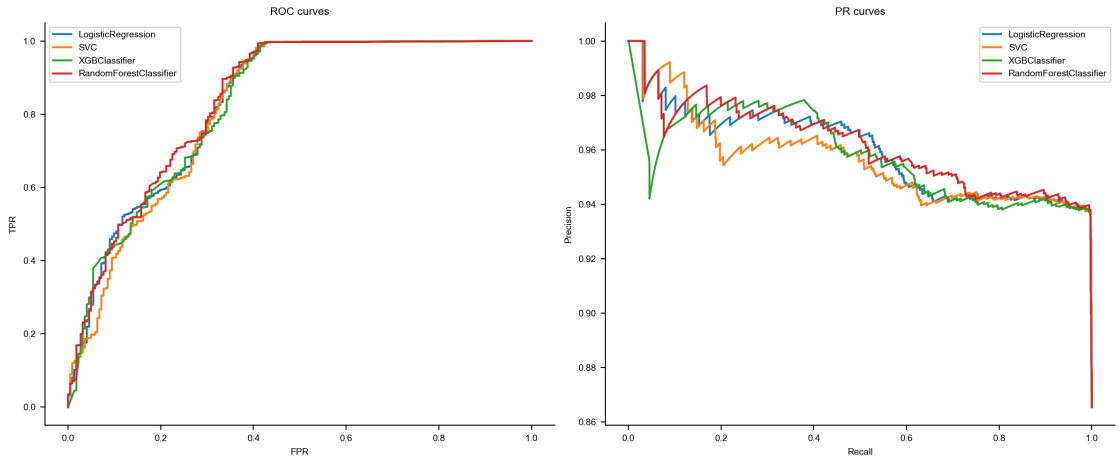
```
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   scale data once
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s  = scaler.transform(realtest)

#   Calculate actual counts in test data
actual_female = (realtest_y == 0).sum()  # Assuming 0 = female
actual_male = (realtest_y == 1).sum()    # Assuming 1 = male
total_test = len(realtest_y)

print("=" * 70)
print("ACTUAL TEST DATA DISTRIBUTION")
print("=" * 70)
print(f"Total test samples: {total_test}")
print(f"Actual Female (0): {actual_female} ({actual_female/total_test*100:.
 ↪1f}%)")
print(f"Actual Male (1):   {actual_male} ({actual_male/total_test*100:.1f}%)")
print()

#   containers
roc_rows, prc_rows = [], []
roc_summary, prc_summary = [], []

#   fit, predict, collect points
for i, model in enumerate(models):
    name = model.__class__.__name__
    print("=" * 70)
    print(f"MODEL {i+1}: {name}")
    print("=" * 70)

    # Train model
    model.fit(X_train_s, full_Y_train)

    # Get predictions (not just probabilities)
    y_pred = model.predict(X_test_s)
    y_prob = model.predict_proba(X_test_s)[:, 1]

    # Count predictions
    pred_female = (y_pred == 0).sum()
    pred_male = (y_pred == 1).sum()

    # Print prediction results
    print(f"Predicted Female (0): {pred_female} ({pred_female/total_test*100:.
 ↪1f}%)")
```

```
    print(f"Predicted Male (1):   {pred_male} ({pred_male/total_test*100:.
↪1f}%)")
    print()

    # Calculate accuracy for each class
    correct_female = ((y_pred == 0) & (realtest_y == 0)).sum()
    correct_male = ((y_pred == 1) & (realtest_y == 1)).sum()

    if actual_female > 0:
        female_accuracy = correct_female / actual_female * 100
        print(f"Female prediction accuracy: {correct_female}/{actual_female}␣
↪({female_accuracy:.1f}%)")

    if actual_male > 0:
        male_accuracy = correct_male / actual_male * 100
        print(f"Male prediction accuracy:   {correct_male}/{actual_male}␣
↪({male_accuracy:.1f}%)")

    overall_accuracy = (correct_female + correct_male) / total_test * 100
    print(f"Overall accuracy: {overall_accuracy:.1f}%")

    # ROC
    fpr, tpr, _ = roc_curve(realtest_y, y_prob)
    roc_auc = auc(fpr, tpr)
    roc_rows.append(pd.DataFrame({"model": name, "fpr": fpr, "tpr": tpr}))
    roc_summary.append({"model": name, "auc": roc_auc})
    print(f"ROC AUC: {roc_auc:.3f}")

    # PR
    prec, rec, _ = precision_recall_curve(realtest_y, y_prob)
    pr_auc = average_precision_score(realtest_y, y_prob)
    prc_rows.append(pd.DataFrame({"model": name, "recall": rec, "precision":␣
↪prec}))
    prc_summary.append({"model": name, "auprc": pr_auc})
    print(f"PR AUC:  {pr_auc:.3f}")
    print()

#   write master CSVs
pd.concat(roc_rows, ignore_index=True).to_csv(OUTDIR / "all_roc_points.csv",␣
↪index=False)
pd.concat(prc_rows, ignore_index=True).to_csv(OUTDIR / "all_prc_points.csv",␣
↪index=False)

pd.DataFrame(roc_summary).to_csv(OUTDIR / "roc_auc_summary.csv", index=False)
pd.DataFrame(prc_summary).to_csv(OUTDIR / "prc_auc_summary.csv", index=False)
```

```
print("=" * 70)
print("  Saved:")
for fn in ["all_roc_points.csv", "all_prc_points.csv",
           "roc_auc_summary.csv", "prc_auc_summary.csv"]:
    print("    ", OUTDIR / fn)

#   (optional) quick plot from the master CSVs
plt.figure(figsize=(12, 5))
roc_ax = plt.subplot(1, 2, 1)
pr_ax = plt.subplot(1, 2, 2)

roc_pts = pd.read_csv(OUTDIR / "all_roc_points.csv")
prc_pts = pd.read_csv(OUTDIR / "all_prc_points.csv")

for name, color in zip([m.__class__.__name__ for m in models], colors):
    roc_sub = roc_pts[roc_pts.model == name]
    prc_sub = prc_pts[prc_pts.model == name]

    roc_ax.plot(roc_sub.fpr, roc_sub.tpr, label=name, color=color)
    pr_ax.plot(prc_sub.recall, prc_sub.precision, label=name, color=color)

roc_ax.set_title("ROC curves");   roc_ax.set_xlabel("FPR"); roc_ax.
 ↪set_ylabel("TPR")
pr_ax.set_title("PR curves");     pr_ax.set_xlabel("Recall"); pr_ax.
 ↪set_ylabel("Precision")
for ax in (roc_ax, pr_ax):
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)
    ax.legend(fontsize=7)

plt.tight_layout(); plt.show()
```

```
======================================================================
ACTUAL TEST DATA DISTRIBUTION
======================================================================
Total test samples: 1649
Actual Female (0): 222 (13.5%)
Actual Male (1):   1427 (86.5%)

======================================================================
MODEL 1: LogisticRegression
======================================================================
Predicted Female (0): 332 (20.1%)
Predicted Male (1):   1317 (79.9%)

Female prediction accuracy: 146/222 (65.8%)
Male prediction accuracy:   1241/1427 (87.0%)
```

```
Overall accuracy: 84.1%
ROC AUC: 0.833
PR AUC:  0.960

======================================================================
MODEL 2: SVC
======================================================================
Predicted Female (0): 275 (16.7%)
Predicted Male (1):   1374 (83.3%)

Female prediction accuracy: 143/222 (64.4%)
Male prediction accuracy:   1295/1427 (90.7%)
Overall accuracy: 87.2%
ROC AUC: 0.823
PR AUC:  0.957

======================================================================
MODEL 3: XGBClassifier
======================================================================
Predicted Female (0): 386 (23.4%)
Predicted Male (1):   1263 (76.6%)

Female prediction accuracy: 146/222 (65.8%)
Male prediction accuracy:   1187/1427 (83.2%)
Overall accuracy: 80.8%
ROC AUC: 0.830
PR AUC:  0.957

======================================================================
MODEL 4: RandomForestClassifier
======================================================================
Predicted Female (0): 179 (10.9%)
Predicted Male (1):   1470 (89.1%)

Female prediction accuracy: 134/222 (60.4%)
Male prediction accuracy:   1382/1427 (96.8%)
Overall accuracy: 91.9%
ROC AUC: 0.840
PR AUC:  0.962

======================================================================
  Saved:
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_roc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_prc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/roc_auc_summary.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/prc_auc_summary.csv
```



11 misclassified labels

[105]:
```
#!/usr/bin/env python3
"""
Identify and save misclassified samples for each model:
    - Males misclassified as females
    - Females misclassified as males

Saves cell barcodes (not indices) and actual/predicted labels to CSV files.
"""

from pathlib import Path
import pandas as pd
import numpy as np

from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier  # pip install xgboost if missing

#   global config
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/misclassified")
OUTDIR.mkdir(parents=True, exist_ok=True)

models = [
    LogisticRegression(max_iter=1000, random_state=551),
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=551,
```

```
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   scale data once
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s  = scaler.transform(realtest)

#   Calculate actual counts in test data
actual_female = (realtest_y == 0).sum()  # 0 = female
actual_male = (realtest_y == 1).sum()    # 1 = male
total_test = len(realtest_y)

print("=" * 70)
print("ACTUAL TEST DATA DISTRIBUTION")
print("=" * 70)
print(f"Total test samples: {total_test}")
print(f"Actual Female (0): {actual_female} ({actual_female/total_test*100:.
 ↪1f}%)")
print(f"Actual Male (1):   {actual_male} ({actual_male/total_test*100:.1f}%)")
print()

#   fit, predict, save misclassified
for i, model in enumerate(models):
    name = model.__class__.__name__
    print("=" * 70)
    print(f"MODEL {i+1}: {name}")
    print("=" * 70)

    # Train model
    model.fit(X_train_s, full_Y_train)

    # Get predictions
    y_pred = model.predict(X_test_s)

    # Count predictions
    pred_female = (y_pred == 0).sum()
    pred_male = (y_pred == 1).sum()

    # Print prediction results
```

```
   print(f"Predicted Female (0): {pred_female} ({pred_female/total_test*100:.
↪1f}%)")
   print(f"Predicted Male (1):   {pred_male} ({pred_male/total_test*100:.
↪1f}%)")
   print()

   # Calculate accuracy for each class
   correct_female = ((y_pred == 0) & (realtest_y == 0)).sum()
   correct_male = ((y_pred == 1) & (realtest_y == 1)).sum()

   if actual_female > 0:
       female_accuracy = correct_female / actual_female * 100
       print(f"Female prediction accuracy: {correct_female}/{actual_female}␣
↪({female_accuracy:.1f}%)")

   if actual_male > 0:
       male_accuracy = correct_male / actual_male * 100
       print(f"Male prediction accuracy:   {correct_male}/{actual_male}␣
↪({male_accuracy:.1f}%)")

   overall_accuracy = (correct_female + correct_male) / total_test * 100
   print(f"Overall accuracy: {overall_accuracy:.1f}%")

   #   Find misclassified samples
   # Male misclassified as Female (actual=1, predicted=0)
   male_as_female_mask = (realtest_y == 1) & (y_pred == 0)

   # Female misclassified as Male (actual=0, predicted=1)
   female_as_male_mask = (realtest_y == 0) & (y_pred == 1)

   # Get cell barcodes instead of numeric indices
   # Assuming realtest has cell barcodes as index
   male_as_female_cells = realtest.index[male_as_female_mask].tolist()
   female_as_male_cells = realtest.index[female_as_male_mask].tolist()

   print(f"\nMisclassification Summary:")
   print(f"  Males misclassified as Females: {len(male_as_female_cells)}")
   print(f"  Females misclassified as Males: {len(female_as_male_cells)}")

   #   Save misclassified cells to CSV
   # Create dataframes with cell barcodes, actual label, and predicted label
   male_as_female_df = pd.DataFrame({
       'cell_barcode': male_as_female_cells,
       'actual_label': 1,  # male
       'predicted_label': 0  # female
   })
```

```
    female_as_male_df = pd.DataFrame({
        'cell_barcode': female_as_male_cells,
        'actual_label': 0,  # female
        'predicted_label': 1  # male
    })

    # Save to files
    male_as_female_file = OUTDIR / f"{name}_male_misclassified_as_female.csv"
    female_as_male_file = OUTDIR / f"{name}_female_misclassified_as_male.csv"

    male_as_female_df.to_csv(male_as_female_file, index=False)
    female_as_male_df.to_csv(female_as_male_file, index=False)

    print(f"\nSaved misclassified cell barcodes:")
    print(f"    {male_as_female_file.name}")
    print(f"    {female_as_male_file.name}")

    #   Also save a combined misclassification file
    all_misclassified = pd.concat([
        male_as_female_df.assign(misclassification_type='male_as_female'),
        female_as_male_df.assign(misclassification_type='female_as_male')
    ]).sort_values('cell_barcode')

    combined_file = OUTDIR / f"{name}_all_misclassified.csv"
    all_misclassified.to_csv(combined_file, index=False)
    print(f"    {combined_file.name}")
    print()

#   Create summary of all models' misclassifications
print("=" * 70)
print("CREATING MISCLASSIFICATION SUMMARY")
print("=" * 70)

summary_data = []
for model in models:
    name = model.__class__.__name__

    # Read the saved files to get counts
    male_as_female_file = OUTDIR / f"{name}_male_misclassified_as_female.csv"
    female_as_male_file = OUTDIR / f"{name}_female_misclassified_as_male.csv"

    male_as_female_count = len(pd.read_csv(male_as_female_file))
    female_as_male_count = len(pd.read_csv(female_as_male_file))

    summary_data.append({
        'model': name,
        'male_as_female': male_as_female_count,
```

```
        'female_as_male': female_as_male_count,
        'total_misclassified': male_as_female_count + female_as_male_count
    })

summary_df = pd.DataFrame(summary_data)
summary_file = OUTDIR / "misclassification_summary.csv"
summary_df.to_csv(summary_file, index=False)

print(f"  Saved misclassification summary: {summary_file.name}")
print("\nSummary:")
print(summary_df.to_string(index=False))
```

```
======================================================================
ACTUAL TEST DATA DISTRIBUTION
======================================================================
Total test samples: 1649
Actual Female (0): 222 (13.5%)
Actual Male (1):   1427 (86.5%)

======================================================================
MODEL 1: LogisticRegression
======================================================================
Predicted Female (0): 332 (20.1%)
Predicted Male (1):   1317 (79.9%)

Female prediction accuracy: 146/222 (65.8%)
Male prediction accuracy:   1241/1427 (87.0%)
Overall accuracy: 84.1%

Misclassification Summary:
  Males misclassified as Females: 186
  Females misclassified as Males: 76

Saved misclassified cell barcodes:
    LogisticRegression_male_misclassified_as_female.csv
    LogisticRegression_female_misclassified_as_male.csv
    LogisticRegression_all_misclassified.csv

======================================================================
MODEL 2: SVC
======================================================================
Predicted Female (0): 275 (16.7%)
Predicted Male (1):   1374 (83.3%)

Female prediction accuracy: 143/222 (64.4%)
Male prediction accuracy:   1295/1427 (90.7%)
Overall accuracy: 87.2%
```

```
Misclassification Summary:
  Males misclassified as Females: 132
  Females misclassified as Males: 79

Saved misclassified cell barcodes:
    SVC_male_misclassified_as_female.csv
    SVC_female_misclassified_as_male.csv
    SVC_all_misclassified.csv

======================================================================
MODEL 3: XGBClassifier
======================================================================

/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [10:50:50] WARNING:
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)

Predicted Female (0): 386 (23.4%)
Predicted Male (1):   1263 (76.6%)

Female prediction accuracy: 146/222 (65.8%)
Male prediction accuracy:   1187/1427 (83.2%)
Overall accuracy: 80.8%

Misclassification Summary:
  Males misclassified as Females: 240
  Females misclassified as Males: 76

Saved misclassified cell barcodes:
    XGBClassifier_male_misclassified_as_female.csv
    XGBClassifier_female_misclassified_as_male.csv
    XGBClassifier_all_misclassified.csv

======================================================================
MODEL 4: RandomForestClassifier
======================================================================
Predicted Female (0): 179 (10.9%)
Predicted Male (1):   1470 (89.1%)

Female prediction accuracy: 134/222 (60.4%)
Male prediction accuracy:   1382/1427 (96.8%)
Overall accuracy: 91.9%

Misclassification Summary:
  Males misclassified as Females: 45
  Females misclassified as Males: 88
```

```
Saved misclassified cell barcodes:
    RandomForestClassifier_male_misclassified_as_female.csv
    RandomForestClassifier_female_misclassified_as_male.csv
    RandomForestClassifier_all_misclassified.csv

======================================================================
CREATING MISCLASSIFICATION SUMMARY
======================================================================
 Saved misclassification summary: misclassification_summary.csv

Summary:
                  model  male_as_female  female_as_male  total_misclassified
    LogisticRegression             186              76                  262
                   SVC             132              79                  211
         XGBClassifier             240              76                  316
RandomForestClassifier              45              88                  133
```

[121]:
```python
#!/usr/bin/env python3
"""
Create AnnData object with RandomForest misclassification information
"""

import pandas as pd
import numpy as np
import scanpy as sc
import anndata
from pathlib import Path

#   Step 1: Load and process the original data (your existing code)
print("Loading original data...")
realmat = sc.read_mtx('matrix.mtx')
realfeature = pd.read_csv('features.tsv', sep='\t', header=None)
realmat = realmat[0:32285]
realtag = pd.read_csv('tag.csv')
actt = realfeature.loc[realfeature[2] == 'Gene Expression']
celltag = pd.read_csv('barcodes.tsv', sep='\t', header=None)

# Create AnnData object
adata = anndata.AnnData(X=realmat.X.T)
lol = list(celltag[0])
adata.obs['cell'] = lol
lmao = list(actt[1])
adata.var['gene_ids'] = lmao

# Scanpy settings
sc.settings.verbosity = 3
```

```
sc.logging.print_header()
sc.settings.set_figure_params(dpi=80, facecolor='white', fontsize=7)

# Filter cells and genes
sc.pp.filter_cells(adata, min_genes=100)
sc.pp.filter_genes(adata, min_cells=3)

# Mitochondrial genes QC
adata.var['mt'] = adata.var_names.str.startswith('mt-')
sc.pp.calculate_qc_metrics(adata, qc_vars=['mt'], percent_top=None,␣
 ↪log1p=False, inplace=True)

# Set gene IDs as index
adata.var.index = adata.var['gene_ids'].values
adata.var.index.name = None
adata.var_names_make_unique()

# Normalize and log transform
sc.pp.normalize_total(adata, target_sum=1e4)
sc.pp.log1p(adata)

#   Step 2: Process gender information
print("\nProcessing gender information...")
METT = adata.X
dense_matrix = METT.toarray()
METT = pd.DataFrame(dense_matrix, columns=adata.var_names, index=adata.
 ↪obs['cell'].values)
METT['cell'] = adata.obs['cell'].values

# Join with tag information
realtag.index = realtag['cell_barcode'].values
result = METT.join(realtag[['feature_call']], how='left')
result = result.dropna(subset=['feature_call'])

# Initialize and update gender
result['gender'] = None
result.loc[result['feature_call'] == 'CMO305', 'gender'] = 1  # Male
result.loc[result['feature_call'] == 'CMO306', 'gender'] = 0  # Female

#   Step 3: Load RandomForest misclassification results
print("\nLoading RandomForest misclassification data...")
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/misclassified")

# Read the RandomForest misclassification files
rf_all_misclass = pd.read_csv(OUTDIR /␣
 ↪"RandomForestClassifier_all_misclassified.csv")
```

```
rf_male_as_female = pd.read_csv(OUTDIR /␣
 ↪"RandomForestClassifier_male_misclassified_as_female.csv")
rf_female_as_male = pd.read_csv(OUTDIR /␣
 ↪"RandomForestClassifier_female_misclassified_as_male.csv")

print(f"Total misclassified cells: {len(rf_all_misclass)}")
print(f"  - Males misclassified as females: {len(rf_male_as_female)}")
print(f"  - Females misclassified as males: {len(rf_female_as_male)}")

#   Step 4: Add misclassification info to AnnData
print("\nAdding misclassification info to AnnData...")

# First, add the actual gender labels to all cells that have them
# Use NaN for numeric columns and empty string for string columns
adata.obs['actual_gender'] = np.nan  # Use NaN instead of None for numeric
adata.obs['actual_gender_label'] = ''  # Use empty string instead of None

# Map gender information from result dataframe
for idx, row in result.iterrows():
    if idx in adata.obs['cell'].values:
        cell_idx = adata.obs[adata.obs['cell'] == idx].index[0]
        adata.obs.loc[cell_idx, 'actual_gender'] = float(row['gender'])
        adata.obs.loc[cell_idx, 'actual_gender_label'] = 'Male' if␣
 ↪row['gender'] == 1 else 'Female'

# Add RandomForest prediction and misclassification status
adata.obs['rf_predicted_gender'] = np.nan  # Use NaN for numeric
adata.obs['rf_predicted_gender_label'] = ''  # Use empty string
adata.obs['rf_misclassified'] = False
adata.obs['rf_misclass_type'] = ''  # Use empty string

# Mark misclassified cells
for _, row in rf_all_misclass.iterrows():
    cell_barcode = row['cell_barcode']
    if cell_barcode in adata.obs['cell'].values:
        cell_idx = adata.obs[adata.obs['cell'] == cell_barcode].index[0]
        adata.obs.loc[cell_idx, 'rf_predicted_gender'] =␣
 ↪float(row['predicted_label'])
        adata.obs.loc[cell_idx, 'rf_predicted_gender_label'] = 'Male' if␣
 ↪row['predicted_label'] == 1 else 'Female'
        adata.obs.loc[cell_idx, 'rf_misclassified'] = True
        adata.obs.loc[cell_idx, 'rf_misclass_type'] =␣
 ↪row['misclassification_type']

# For correctly classified cells, predicted = actual
```

```
correct_mask = (adata.obs['actual_gender'].notna()) & (~adata.
 ↪obs['rf_misclassified'])
adata.obs.loc[correct_mask, 'rf_predicted_gender'] = adata.obs.
 ↪loc[correct_mask, 'actual_gender']
adata.obs.loc[correct_mask, 'rf_predicted_gender_label'] = adata.obs.
 ↪loc[correct_mask, 'actual_gender_label']

#   Step 5: Add summary statistics to uns
print("\nAdding summary statistics...")
adata.uns['rf_misclassification'] = {
    'total_misclassified': len(rf_all_misclass),
    'male_as_female': len(rf_male_as_female),
    'female_as_male': len(rf_female_as_male),
    'misclassified_cells': {
        'male_as_female': rf_male_as_female['cell_barcode'].tolist(),
        'female_as_male': rf_female_as_male['cell_barcode'].tolist()
    }
}

# Count cells with gender info
has_gender = adata.obs['actual_gender'].notna().sum()
total_cells = len(adata.obs)
print(f"\nCells with gender information: {has_gender}/{total_cells}")

#   Step 6: Convert data types before saving
print("\nConverting data types for h5ad compatibility...")

# Convert string columns to categorical to save space and ensure compatibility
string_cols = ['actual_gender_label', 'rf_predicted_gender_label',␣
 ↪'rf_misclass_type']
for col in string_cols:
    # Replace empty strings with a proper category
    adata.obs[col] = adata.obs[col].replace('', 'Unknown')
    adata.obs[col] = pd.Categorical(adata.obs[col])

# Ensure numeric columns are float type
adata.obs['actual_gender'] = adata.obs['actual_gender'].astype('float32')
adata.obs['rf_predicted_gender'] = adata.obs['rf_predicted_gender'].
 ↪astype('float32')

#   Step 7: Save the AnnData object
#   Step 7: Save the AnnData object
output_file = "adata_with_rf_misclassification.h5ad"
print(f"\nSaving AnnData to {output_file}...")
adata.write_h5ad(output_file)

#   Step 8: Create visualization-ready subset
```

```
print("\nCreating subset with only cells that have gender labels...")
# Filter to only cells with gender information (not Unknown)
adata_gender = adata[adata.obs['actual_gender_label'] != 'Unknown'].copy()

# Add colors for visualization
adata_gender.uns['actual_gender_colors'] = ['#FF69B4', '#4169E1']  # Pink for␣
 ↪Female, Blue for Male
adata_gender.uns['rf_misclassified_colors'] = ['#90EE90', '#FF6347']  # Light␣
 ↪green for correct, Tomato for misclassified

output_file_gender = "adata_gender_only_with_rf_misclass.h5ad"
print(f"Saving gender-only AnnData to {output_file_gender}...")
adata_gender.write_h5ad(output_file_gender)

#   Print summary
print("\n" + "="*70)
print("SUMMARY")
print("="*70)
print(f"Total cells in AnnData: {len(adata.obs)}")
print(f"Cells with gender labels: {has_gender}")
print(f"Cells without gender labels: {total_cells - has_gender}")
print(f"\nRandomForest misclassification:")
print(f"  - Total misclassified: {len(rf_all_misclass)}")
print(f"  - Males → Females: {len(rf_male_as_female)}")
print(f"  - Females → Males: {len(rf_female_as_male)}")
print(f"\nOutput files created:")
print(f"  1. {output_file} (all cells)")
print(f"  2. {output_file_gender} (only cells with gender labels)")

#   Optional: Create a quick visualization
print("\nYou can now load the data and visualize misclassifications:")
print(">>> adata = sc.read_h5ad('adata_gender_only_with_rf_misclass.h5ad')")
print(">>> sc.pl.umap(adata, color=['actual_gender_label', 'rf_misclassified',␣
 ↪'rf_misclass_type'])")
```

```
Loading original data…
scanpy==1.10.2 anndata==0.10.8 umap==0.5.6 numpy==1.26.4 scipy==1.13.1
pandas==2.2.2 scikit-learn==1.5.1 statsmodels==0.14.2 pynndescent==0.5.13
filtered out 3 cells that have less than 100 genes expressed
filtered out 19261 genes that are detected in less than 3 cells
normalizing counts per cell
    finished (0:00:00)

Processing gender information…

Loading RandomForest misclassification data…
Total misclassified cells: 133
```

```
  - Males misclassified as females: 45
  - Females misclassified as males: 88

Adding misclassification info to AnnData…

Adding summary statistics…

Cells with gender information: 1649/1649

Converting data types for h5ad compatibility…

Saving AnnData to adata_with_rf_misclassification.h5ad…

Creating subset with only cells that have gender labels…
Saving gender-only AnnData to adata_gender_only_with_rf_misclass.h5ad…

======================================================================
SUMMARY
======================================================================
Total cells in AnnData: 1649
Cells with gender labels: 1649
Cells without gender labels: 0

RandomForest misclassification:
  - Total misclassified: 133
  - Males → Females: 45
  - Females → Males: 88

Output files created:
  1. adata_with_rf_misclassification.h5ad (all cells)
  2. adata_gender_only_with_rf_misclass.h5ad (only cells with gender labels)

You can now load the data and visualize misclassifications:
>>> adata = sc.read_h5ad('adata_gender_only_with_rf_misclass.h5ad')
>>> sc.pl.umap(adata, color=['actual_gender_label', 'rf_misclassified',
'rf_misclass_type'])
```

[123]:
```python
import scanpy as sc
import numpy as np

# Load the AnnData
adata = sc.read_h5ad('adata_with_rf_misclassification.h5ad')

# Example 1: Get all misclassified cells
misclassified_cells = adata[adata.obs['rf_misclassified'] == True]
print(f"Number of misclassified cells: {len(misclassified_cells)}")
```

```
# Example 2: Get males misclassified as females
male_as_female = adata[adata.obs['rf_misclass_type'] == 'male_as_female']
print(f"Males misclassified as females: {len(male_as_female)}")

# Example 3: View the actual vs predicted for a specific cell
cell_barcode = 'AAACCCAAGAAACCCA-1'  # Example - replace with a real barcode
if cell_barcode in adata.obs['cell'].values:
    cell_data = adata[adata.obs['cell'] == cell_barcode].obs
    print(f"\nCell: {cell_barcode}")
    print(f"Actual: {cell_data['actual_gender_label'].iloc[0]}")
    print(f"Predicted: {cell_data['rf_predicted_gender_label'].iloc[0]}")
else:
    print(f"\nCell {cell_barcode} not found in data")

# Example 4: Get summary statistics
summary = adata.uns['rf_misclassification']
print(f"\nTotal misclassified: {summary['total_misclassified']}")
print(f"Male → Female: {summary['male_as_female']}")
print(f"Female → Male: {summary['female_as_male']}")

# Example 5: Get list of all cell barcodes that were misclassified (corrected)
# Convert to lists first, then concatenate
male_as_female_list = list(summary['misclassified_cells']['male_as_female'])
female_as_male_list = list(summary['misclassified_cells']['female_as_male'])
all_misclass_barcodes = male_as_female_list + female_as_male_list

print(f"\nTotal misclassified cell barcodes: {len(all_misclass_barcodes)}")
print(f"First 5 misclassified barcodes: {all_misclass_barcodes[:5]}")

# Alternative method using numpy concatenate
all_misclass_barcodes_np = np.concatenate([
    summary['misclassified_cells']['male_as_female'],
    summary['misclassified_cells']['female_as_male']
])
print(f"\nUsing numpy concatenate: {len(all_misclass_barcodes_np)} barcodes")

# Example 6: Get actual cell barcodes from the obs dataframe (more reliable)
print("\n--- Getting misclassified cells directly from obs ---")
misclass_barcodes_from_obs = adata.obs[adata.obs['rf_misclassified'] ==␣
 ↪True]['cell'].tolist()
print(f"Misclassified cells from obs: {len(misclass_barcodes_from_obs)}")
print(f"First 5: {misclass_barcodes_from_obs[:5]}")

# Example 7: Analyze misclassification patterns
print("\n--- Misclassification Analysis ---")
# Get gender distribution
print(f"Total females: {(adata.obs['actual_gender_label'] == 'Female').sum()}")
```

```
print(f"Total males: {(adata.obs['actual_gender_label'] == 'Male').sum()}")

# Calculate misclassification rates
total_females = (adata.obs['actual_gender_label'] == 'Female').sum()
total_males = (adata.obs['actual_gender_label'] == 'Male').sum()
female_misclass_rate = summary['female_as_male'] / total_females * 100
male_misclass_rate = summary['male_as_female'] / total_males * 100

print(f"\nMisclassification rates:")
print(f"Female → Male: {summary['female_as_male']}/{total_females}␣
 ↪({female_misclass_rate:.1f}%)")
print(f"Male → Female: {summary['male_as_female']}/{total_males}␣
 ↪({male_misclass_rate:.1f}%)")

# Example 8: Look at a specific misclassified cell
print("\n--- Example misclassified cell ---")
if len(male_as_female) > 0:
    example_cell = male_as_female.obs.iloc[0]
    print(f"Cell barcode: {example_cell['cell']}")
    print(f"Actual gender: {example_cell['actual_gender_label']}␣
 ↪({example_cell['actual_gender']})")
    print(f"RF predicted: {example_cell['rf_predicted_gender_label']}␣
 ↪({example_cell['rf_predicted_gender']})")
    print(f"Misclass type: {example_cell['rf_misclass_type']}")
```

```
Number of misclassified cells: 133
Males misclassified as females: 45

Cell AAACCCAAGAAACCCA-1 not found in data

Total misclassified: 133
Male → Female: 45
Female → Male: 88

Total misclassified cell barcodes: 133
First 5 misclassified barcodes: ['AACCAACAGATACGAT-1', 'AACTTCTTCGCGTGCA-1',
'AAGTACCTCCTTCACG-1', 'AATGAAGGTGGAATGC-1', 'ACAAGCTAGATAACAC-1']

Using numpy concatenate: 133 barcodes

--- Getting misclassified cells directly from obs ---
Misclassified cells from obs: 133
First 5: ['AAAGGGCTCCTTCACG-1', 'AAATGGAAGTACCCTA-1', 'AACAGGGTCGAACTCA-1',
'AACCAACAGATACGAT-1', 'AACTTCTTCGCGTGCA-1']

--- Misclassification Analysis ---
Total females: 222
```

```
Total males: 1427

Misclassification rates:
Female → Male: 88/222 (39.6%)
Male → Female: 45/1427 (3.2%)

--- Example misclassified cell ---
Cell barcode: AACCAACAGATACGAT-1
Actual gender: Male (1.0)
RF predicted: Female (0.0)
Misclass type: male_as_female
```

[ ]:

[ ]:

[45]:
```python
#!/usr/bin/env python3
"""
Save *all* ROC and PR curve points in two master CSVs:

      all_roc_points.csv   # columns: model, fpr, tpr
      all_prc_points.csv   # columns: model, recall, precision

It also produces a small summary (AUROC / AUPRC) table and confusion matrices␣
 ↪for each model.
"""

from pathlib import Path
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rcParams
import seaborn as sns

from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    roc_curve,
    auc,
    precision_recall_curve,
    average_precision_score,
    confusion_matrix,
    classification_report,
)
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier  # pip install xgboost if missing
```

```
#   global config
rcParams.update({"font.family": "Arial", "font.size": 7})
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/curve_outputs")
OUTDIR.mkdir(exist_ok=True)

colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]

models = [
    LogisticRegression(max_iter=1000, random_state=551),
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=551,
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   scale data once
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s  = scaler.transform(realtest)

#   containers
roc_rows, prc_rows = [], []
roc_summary, prc_summary = [], []
confusion_matrices = {}

#   fit, predict, collect points
for model in models:
    name = model.__class__.__name__
    print("Training", name)
    model.fit(X_train_s, full_Y_train)
    y_prob = model.predict_proba(X_test_s)[:, 1]
    y_pred = model.predict(X_test_s)  # For confusion matrix

    # ROC
    fpr, tpr, _ = roc_curve(realtest_y, y_prob)
    roc_auc = auc(fpr, tpr)
    roc_rows.append(pd.DataFrame({"model": name, "fpr": fpr, "tpr": tpr}))
    roc_summary.append({"model": name, "auc": roc_auc})

    # PR
```

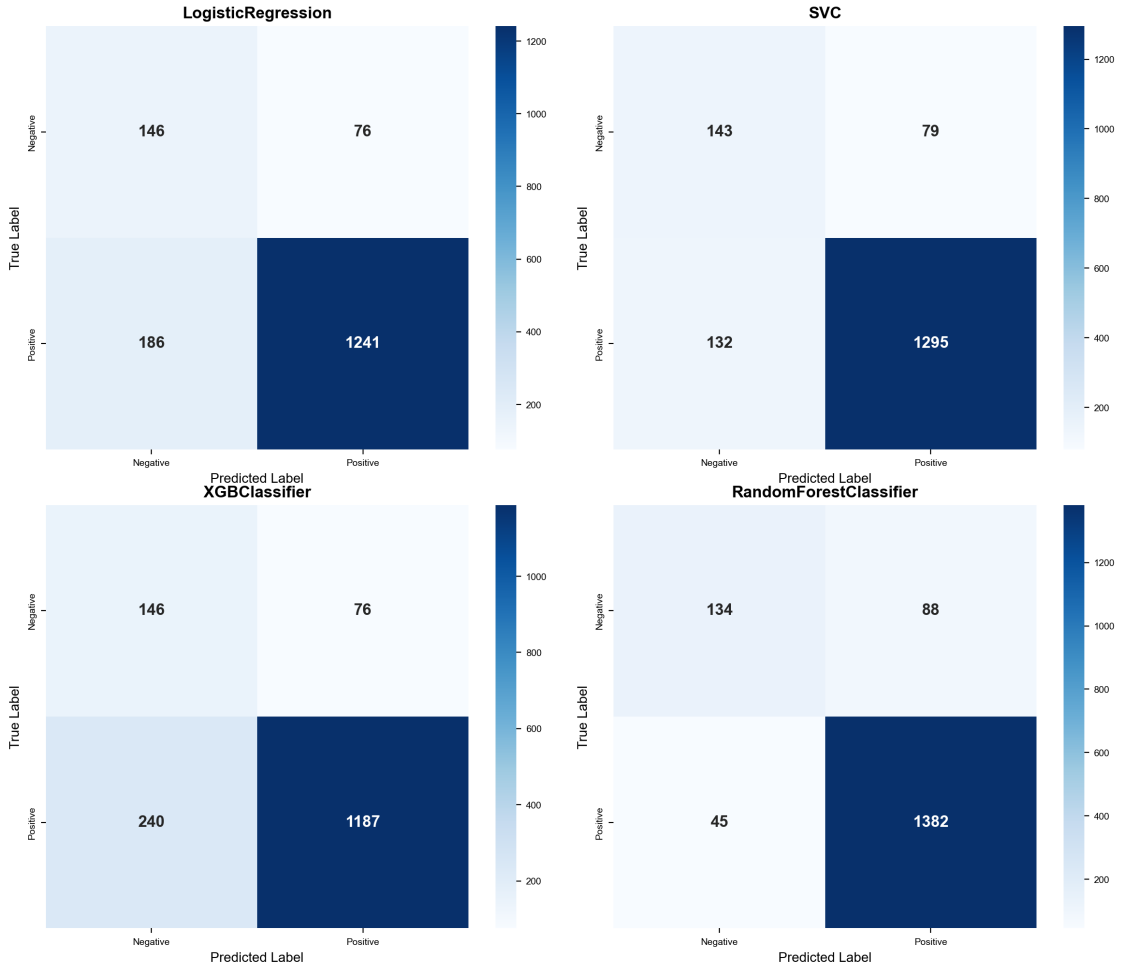
```
    prec, rec, _ = precision_recall_curve(realtest_y, y_prob)
    pr_auc = average_precision_score(realtest_y, y_prob)
    prc_rows.append(pd.DataFrame({"model": name, "recall": rec, "precision":␣
 ↪prec}))
    prc_summary.append({"model": name, "auprc": pr_auc})

    # Confusion Matrix
    cm = confusion_matrix(realtest_y, y_pred)
    confusion_matrices[name] = cm

    # Save confusion matrix as CSV
    cm_df = pd.DataFrame(cm,
                         index=['True Neg', 'True Pos'],
                         columns=['Pred Neg', 'Pred Pos'])
    cm_df.to_csv(OUTDIR / f"confusion_matrix_{name}.csv")

    # Print classification report
    print(f"\nClassification Report for {name}:")
    print(classification_report(realtest_y, y_pred))

#   write master CSVs
pd.concat(roc_rows, ignore_index=True).to_csv(OUTDIR / "all_roc_points.csv",␣
 ↪index=False)
pd.concat(prc_rows, ignore_index=True).to_csv(OUTDIR / "all_prc_points.csv",␣
 ↪index=False)

pd.DataFrame(roc_summary).to_csv(OUTDIR / "roc_auc_summary.csv", index=False)
pd.DataFrame(prc_summary).to_csv(OUTDIR / "prc_auc_summary.csv", index=False)

print("\n  Saved:")
for fn in ["all_roc_points.csv", "all_prc_points.csv",
           "roc_auc_summary.csv", "prc_auc_summary.csv"]:
    print("    ", OUTDIR / fn)

#   plot confusion matrices
# Create a figure with 4 subplots (2x2 grid) for the 4 models
fig, axes = plt.subplots(2, 2, figsize=(12, 10))
axes = axes.ravel()

print("\n Creating confusion matrices for 4 models:")
for idx, name in enumerate(confusion_matrices.keys()):
    cm = confusion_matrices[name]
    print(f"   {idx+1}. {name}")

    # Plot confusion matrix
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
                xticklabels=['Negative', 'Positive'],
```

```
                yticklabels=['Negative', 'Positive'],
                ax=axes[idx], cbar=True, square=True,
                annot_kws={"size": 12, "weight": "bold"})

    axes[idx].set_title(name, fontsize=12, weight='bold')
    axes[idx].set_xlabel('Predicted Label', fontsize=10)
    axes[idx].set_ylabel('True Label', fontsize=10)

plt.tight_layout()
plt.savefig(OUTDIR / "confusion_matrices_all_4models.png", dpi=300,␣
 ↪bbox_inches='tight')
plt.show()

print("  All 4 confusion matrices displayed and saved!")

#   plot ROC and PR curves
plt.figure(figsize=(12, 5))
roc_ax = plt.subplot(1, 2, 1)
pr_ax = plt.subplot(1, 2, 2)

roc_pts = pd.read_csv(OUTDIR / "all_roc_points.csv")
prc_pts = pd.read_csv(OUTDIR / "all_prc_points.csv")

for name, color in zip([m.__class__.__name__ for m in models], colors):
    roc_sub = roc_pts[roc_pts.model == name]
    prc_sub = prc_pts[prc_pts.model == name]

    roc_ax.plot(roc_sub.fpr, roc_sub.tpr, label=name, color=color)
    pr_ax.plot(prc_sub.recall, prc_sub.precision, label=name, color=color)

roc_ax.set_title("ROC curves");   roc_ax.set_xlabel("FPR"); roc_ax.
 ↪set_ylabel("TPR")
pr_ax.set_title("PR curves");     pr_ax.set_xlabel("Recall"); pr_ax.
 ↪set_ylabel("Precision")
for ax in (roc_ax, pr_ax):
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)
    ax.legend(fontsize=7)

plt.tight_layout()
plt.savefig(OUTDIR / "roc_pr_curves.png", dpi=300, bbox_inches='tight')
plt.show()

#   create individual confusion matrix plots
for model_name, cm in confusion_matrices.items():
    plt.figure(figsize=(6, 5))
```

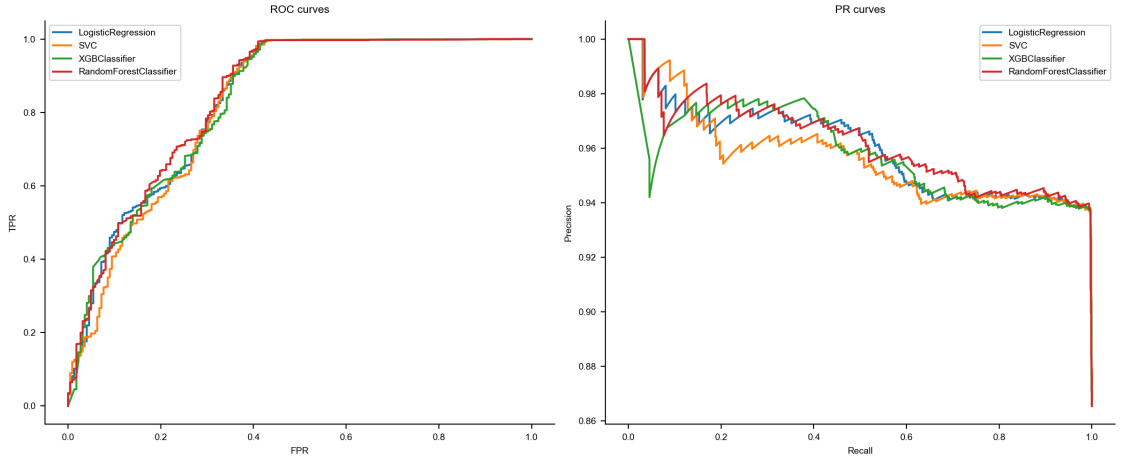
```
    # Create a simple heatmap
    sns.heatmap(cm, annot=True, fmt='d', cmap='Blues',
                xticklabels=['Negative', 'Positive'],
                yticklabels=['Negative', 'Positive'],
                cbar=True, square=True,
                annot_kws={"size": 14})

    plt.title(model_name, fontsize=14, pad=20)
    plt.xlabel('Predicted Label', fontsize=12)
    plt.ylabel('True Label', fontsize=12)

    plt.tight_layout()
    plt.savefig(OUTDIR / f"confusion_matrix_{model_name}.png", dpi=300,␣
 ↪bbox_inches='tight')
    plt.close()

print(f"\n  All confusion matrices saved to {OUTDIR}")
print("   Individual plots and CSVs created for each model")
```

```
Training LogisticRegression

Classification Report for LogisticRegression:
              precision    recall  f1-score   support

         0.0       0.44      0.66      0.53       222
         1.0       0.94      0.87      0.90      1427

    accuracy                           0.84      1649
   macro avg       0.69      0.76      0.72      1649
weighted avg       0.87      0.84      0.85      1649

Training SVC

Classification Report for SVC:
              precision    recall  f1-score   support

         0.0       0.52      0.64      0.58       222
         1.0       0.94      0.91      0.92      1427

    accuracy                           0.87      1649
   macro avg       0.73      0.78      0.75      1649
weighted avg       0.89      0.87      0.88      1649

Training XGBClassifier

Classification Report for XGBClassifier:
              precision    recall  f1-score   support
```

```
         0.0       0.38      0.66      0.48       222
         1.0       0.94      0.83      0.88      1427

    accuracy                           0.81      1649
   macro avg       0.66      0.74      0.68      1649
weighted avg       0.86      0.81      0.83      1649

Training RandomForestClassifier

Classification Report for RandomForestClassifier:
              precision    recall  f1-score   support

         0.0       0.75      0.60      0.67       222
         1.0       0.94      0.97      0.95      1427

    accuracy                           0.92      1649
   macro avg       0.84      0.79      0.81      1649
weighted avg       0.91      0.92      0.92      1649


  Saved:
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_roc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_prc_points.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/roc_auc_summary.csv
    /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/prc_auc_summary.csv

 Creating confusion matrices for 4 models:
  1. LogisticRegression
  2. SVC
  3. XGBClassifier
  4. RandomForestClassifier
```




```
All 4 confusion matrices displayed and saved!
```



```
  All confusion matrices saved to
/Users/haley/Desktop/send_tooo/AAA_final/curve_outputs
   Individual plots and CSVs created for each model
```

[86]:
```
#!/usr/bin/env python3
"""
Save *all* ROC and PR curve points in two master CSVs, plus calculate
class-specific metrics (F1, AUROC, AUPRC) for male (1) and female (0).
Focus on Random Forest performance visualization.

      all_roc_points.csv   # columns: model, fpr, tpr
      all_prc_points.csv   # columns: model, recall, precision
      class_metrics.csv    # columns: model, class, f1, auroc, auprc
"""

from pathlib import Path
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from matplotlib import rcParams

from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (
    roc_curve,
    auc,
    precision_recall_curve,
    average_precision_score,
    f1_score,
    precision_score,
    recall_score,
    roc_auc_score,
)
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier  # pip install xgboost if missing

#   global config
rcParams.update({"font.family": "Arial", "font.size": 7})
OUTDIR = Path("/Users/haley/Desktop/send_tooo/AAA_final/curve_outputs")
OUTDIR.mkdir(exist_ok=True)

colors = ["#1f77b4", "#ff7f0e", "#2ca02c", "#d62728"]

models = [
    LogisticRegression(max_iter=1000, random_state=551),
```

```
    SVC(kernel="linear", probability=True, random_state=551),
    XGBClassifier(
        random_state=42,
        use_label_encoder=False,
        eval_metric="logloss",
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
    ),
    RandomForestClassifier(max_depth=10, random_state=41),
]

#   scale data once
scaler = StandardScaler()
X_train_s = scaler.fit_transform(full_X_train)
X_test_s  = scaler.transform(realtest)

#   containers
roc_rows, prc_rows = [], []
roc_summary, prc_summary = [], []
class_metrics = []

#   fit, predict, collect points
for model in models:
    name = model.__class__.__name__
    print("Training", name)
    model.fit(X_train_s, full_Y_train)
    y_prob = model.predict_proba(X_test_s)[:, 1]
    y_pred = model.predict(X_test_s)

    # Overall ROC
    fpr, tpr, _ = roc_curve(realtest_y, y_prob)
    roc_auc = auc(fpr, tpr)
    roc_rows.append(pd.DataFrame({"model": name, "fpr": fpr, "tpr": tpr}))
    roc_summary.append({"model": name, "auc": roc_auc})

    # Overall PR
    prec, rec, _ = precision_recall_curve(realtest_y, y_prob)
    pr_auc = average_precision_score(realtest_y, y_prob)
    prc_rows.append(pd.DataFrame({"model": name, "recall": rec, "precision":␣
 ↪prec}))
    prc_summary.append({"model": name, "auprc": pr_auc})

    # Class-specific metrics
    for class_label, class_name in [(0, "Female"), (1, "Male")]:
        # Create binary mask for current class
        y_true_binary = (realtest_y == class_label).astype(int)
```

```
        y_pred_binary = (y_pred == class_label).astype(int)

        # F1 score for this class
        f1 = f1_score(y_true_binary, y_pred_binary)

        # AUROC for this class (one-vs-rest)
        # For class 0 (female), we need prob of being female = 1 - prob of␣
 ↪being male
        if class_label == 0:
            y_prob_class = 1 - y_prob
        else:
            y_prob_class = y_prob

        auroc = roc_auc_score(y_true_binary, y_prob_class)

        # AUPRC for this class
        auprc = average_precision_score(y_true_binary, y_prob_class)

        # Store metrics
        class_metrics.append({
            "model": name,
            "class": class_name,
            "class_label": class_label,
            "f1": f1,
            "auroc": auroc,
            "auprc": auprc,
            "precision": precision_score(y_true_binary, y_pred_binary),
            "recall": recall_score(y_true_binary, y_pred_binary)
        })

#   write master CSVs
pd.concat(roc_rows, ignore_index=True).to_csv(OUTDIR / "all_roc_points.csv",␣
 ↪index=False)
pd.concat(prc_rows, ignore_index=True).to_csv(OUTDIR / "all_prc_points.csv",␣
 ↪index=False)

pd.DataFrame(roc_summary).to_csv(OUTDIR / "roc_auc_summary.csv", index=False)
pd.DataFrame(prc_summary).to_csv(OUTDIR / "prc_auc_summary.csv", index=False)

# Save class-specific metrics
class_metrics_df = pd.DataFrame(class_metrics)
class_metrics_df.to_csv(OUTDIR / "class_metrics.csv", index=False)

print("  Saved:")
for fn in ["all_roc_points.csv", "all_prc_points.csv",
           "roc_auc_summary.csv", "prc_auc_summary.csv", "class_metrics.csv"]:
    print("    ", OUTDIR / fn)
```

```
#   Create 3 separate bar plots for Random Forest only
# Filter for Random Forest only
rf_metrics = class_metrics_df[class_metrics_df["model"] ==␣
 ↪"RandomForestClassifier"]

metrics = ["f1", "auroc", "auprc"]
metric_names = ["F1 Score", "AUROC", "AUPRC"]
gender_colors = {"Female": "#FF69B4", "Male": "#4169E1"}  # Pink for female,␣
 ↪blue for male

# Create 3 separate figures
for metric, metric_name in zip(metrics, metric_names):
    fig, ax = plt.subplots(figsize=(8, 6))

    # Prepare data
    x = np.arange(2)  # Two bars: Female and Male
    values = []
    labels = []
    colors_list = []

    for class_name in ["Female", "Male"]:
        value = rf_metrics[rf_metrics["class"] == class_name][metric].values[0]
        values.append(value)
        labels.append(class_name)
        colors_list.append(gender_colors[class_name])

    # Create bars
    bars = ax.bar(x, values, color=colors_list, width=0.6)

    # Add value labels on bars
    for i, (bar, v) in enumerate(zip(bars, values)):
        ax.text(bar.get_x() + bar.get_width()/2, v + 0.01,
                f'{v:.3f}', ha='center', va='bottom', fontsize=12,␣
 ↪fontweight='bold')

    # Customize plot
    ax.set_title(f"Random Forest {metric_name} by Gender", fontsize=16,␣
 ↪fontweight='bold')
    ax.set_xlabel("Gender", fontsize=14)
    ax.set_ylabel(metric_name, fontsize=14)
    ax.set_xticks(x)
    ax.set_xticklabels(labels, fontsize=12)
    ax.set_ylim(0.5, 1.1)
    ax.grid(True, alpha=0.3, axis='y')

    # Remove top and right spines
```

```
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)

    # Make y-axis labels larger
    ax.tick_params(axis='y', labelsize=11)

    plt.tight_layout()
    plt.savefig(OUTDIR / f"rf_{metric}_by_gender.png", dpi=300,␣
 ↪bbox_inches='tight')
    plt.show()

#   Print Random Forest summary
print("\n  Random Forest Class-Specific Metrics Summary:")
print("=" * 60)
print(rf_metrics[["class", "f1", "auroc", "auprc", "precision", "recall"]].
 ↪to_string(index=False))

#   Also create combined visualization
fig, axes = plt.subplots(1, 3, figsize=(15, 5))
fig.suptitle("Random Forest Performance by Gender", fontsize=16,␣
 ↪fontweight='bold')

for ax, (metric, metric_name) in zip(axes, zip(metrics, metric_names)):
    # Prepare data
    x = np.arange(2)
    values = []
    labels = []
    colors_list = []

    for class_name in ["Female", "Male"]:
        value = rf_metrics[rf_metrics["class"] == class_name][metric].values[0]
        values.append(value)
        labels.append(class_name)
        colors_list.append(gender_colors[class_name])

    # Create bars
    bars = ax.bar(x, values, color=colors_list, width=0.6)

    # Add value labels
    for i, (bar, v) in enumerate(zip(bars, values)):
        ax.text(bar.get_x() + bar.get_width()/2, v + 0.01,
                f'{v:.3f}', ha='center', va='bottom', fontsize=11,␣
 ↪fontweight='bold')

    # Customize
    ax.set_title(metric_name, fontsize=14)
    ax.set_xlabel("Gender", fontsize=12)
```

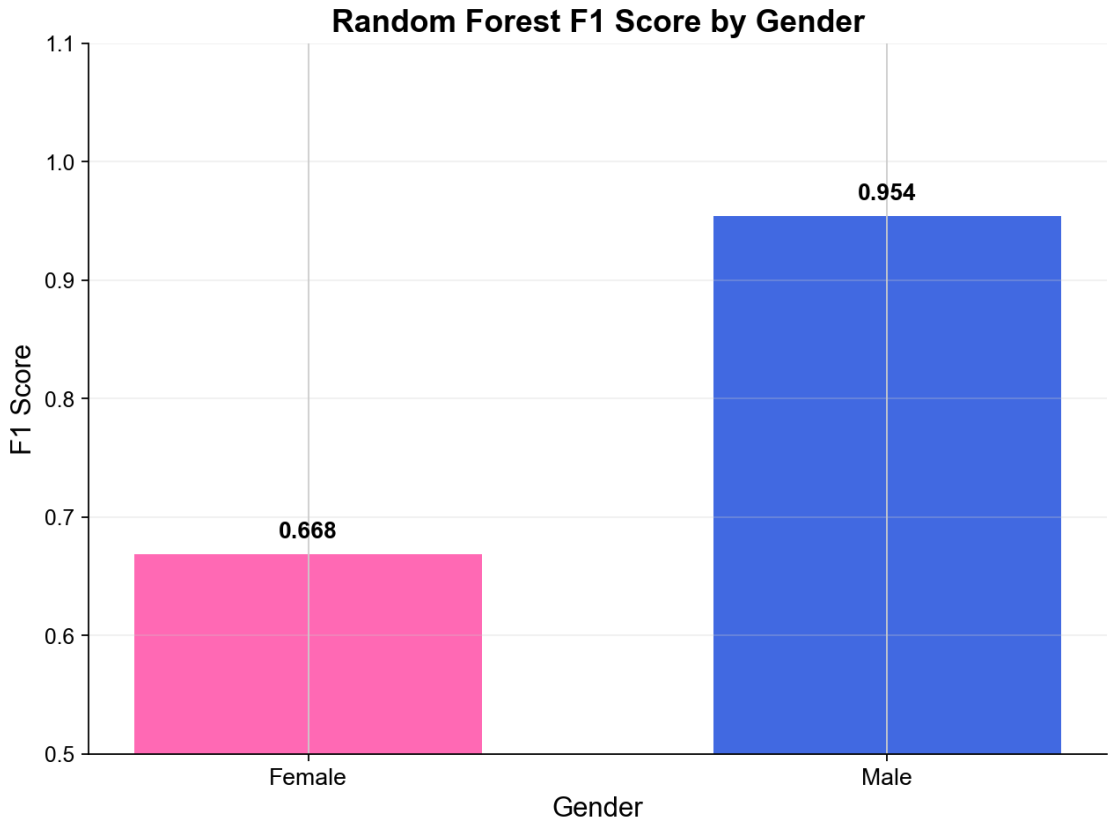
```
    ax.set_ylabel(metric_name, fontsize=12)
    ax.set_xticks(x)
    ax.set_xticklabels(labels, fontsize=11)
    ax.set_ylim(0.5, 1.1)
    ax.grid(True, alpha=0.3, axis='y')
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)

plt.tight_layout()
plt.savefig(OUTDIR / "rf_all_metrics_combined.png", dpi=300,␣
 ↪bbox_inches='tight')
plt.show()

#   Original ROC and PR curves (all models)
plt.figure(figsize=(12, 5))
roc_ax = plt.subplot(1, 2, 1)
pr_ax = plt.subplot(1, 2, 2)

roc_pts = pd.read_csv(OUTDIR / "all_roc_points.csv")
prc_pts = pd.read_csv(OUTDIR / "all_prc_points.csv")

for name, color in zip([m.__class__.__name__ for m in models], colors):
    roc_sub = roc_pts[roc_pts.model == name]
    prc_sub = prc_pts[prc_pts.model == name]

    roc_ax.plot(roc_sub.fpr, roc_sub.tpr, label=name, color=color)
    pr_ax.plot(prc_sub.recall, prc_sub.precision, label=name, color=color)

roc_ax.set_title("ROC curves");   roc_ax.set_xlabel("FPR"); roc_ax.
 ↪set_ylabel("TPR")
pr_ax.set_title("PR curves");     pr_ax.set_xlabel("Recall"); pr_ax.
 ↪set_ylabel("Precision")
for ax in (roc_ax, pr_ax):
    ax.spines["top"].set_visible(False)
    ax.spines["right"].set_visible(False)
    ax.legend(fontsize=7)

plt.tight_layout()
plt.savefig(OUTDIR / "roc_pr_curves.png", dpi=300, bbox_inches='tight')
plt.show()
```

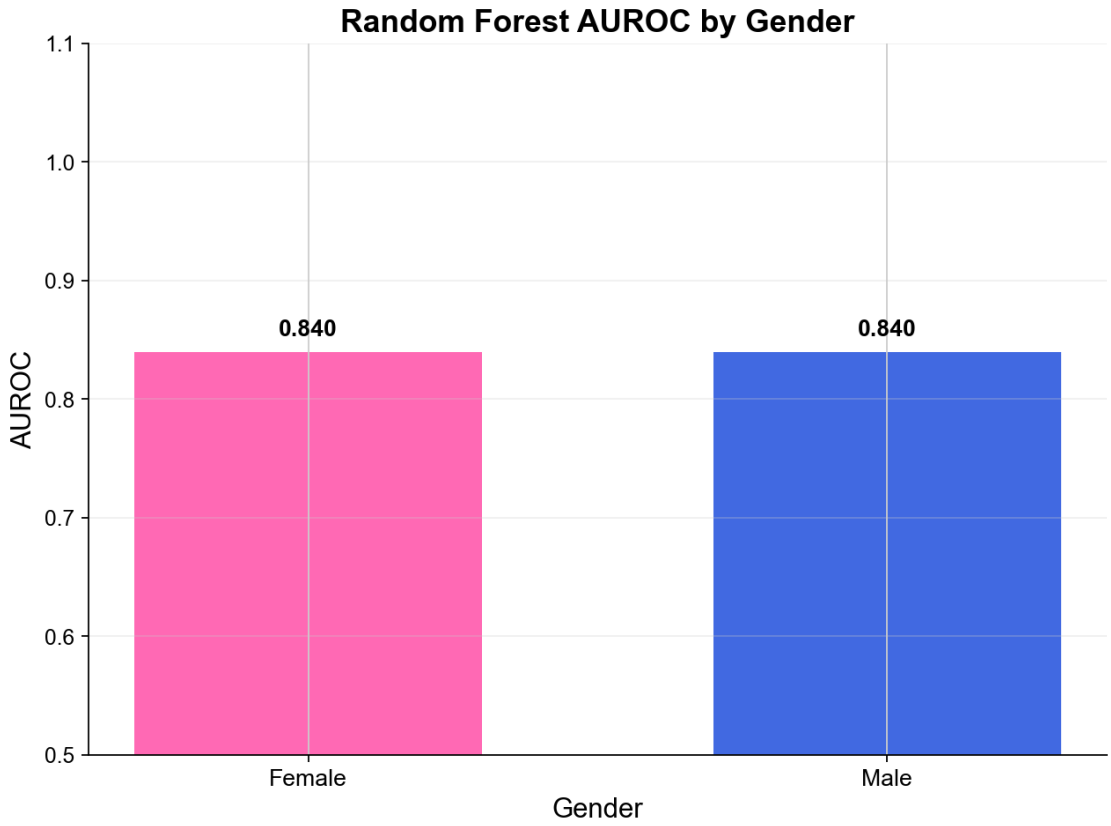
```
Training LogisticRegression
Training SVC
Training XGBClassifier
Training RandomForestClassifier
```

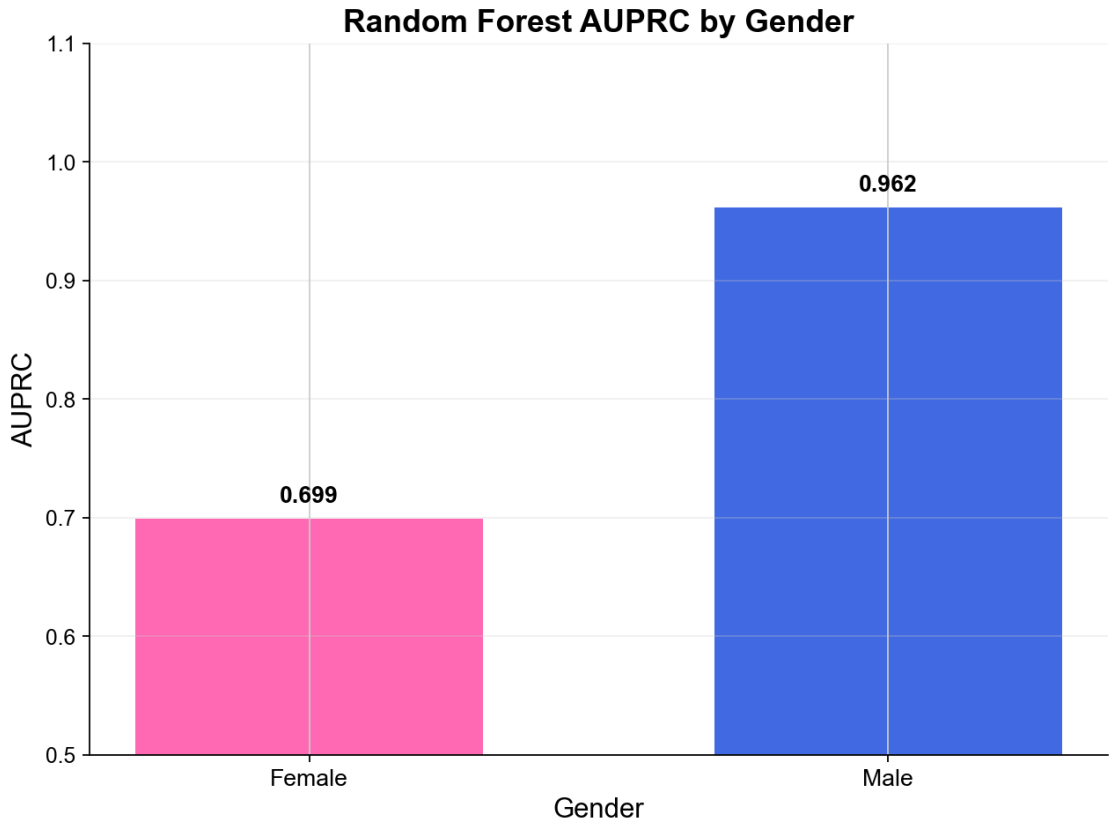
```
/Users/haley/Library/Python/3.9/lib/python/site-packages/xgboost/core.py:158:
UserWarning: [17:32:31] WARNING:
```

```
/Users/runner/work/xgboost/xgboost/src/learner.cc:740:
Parameters: { "use_label_encoder" } are not used.

  warnings.warn(smsg, UserWarning)
```

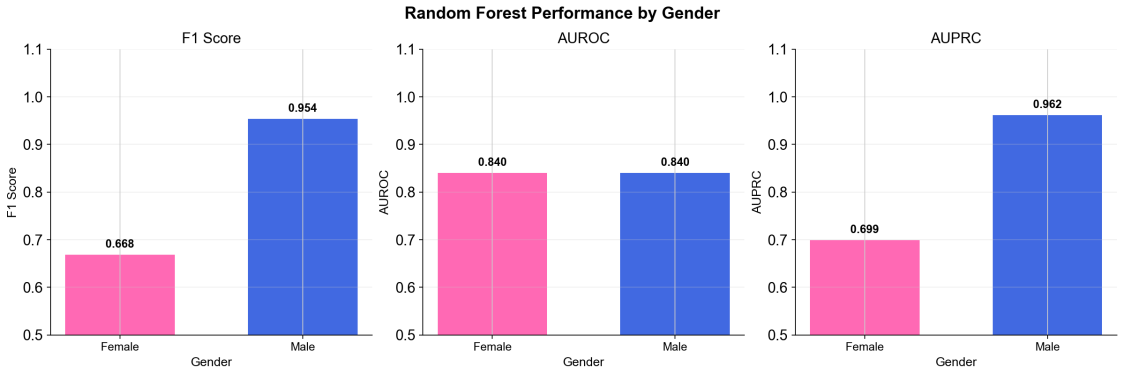
```
Saved:
   /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_roc_points.csv
   /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/all_prc_points.csv
   /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/roc_auc_summary.csv
   /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/prc_auc_summary.csv
   /Users/haley/Desktop/send_tooo/AAA_final/curve_outputs/class_metrics.csv
```

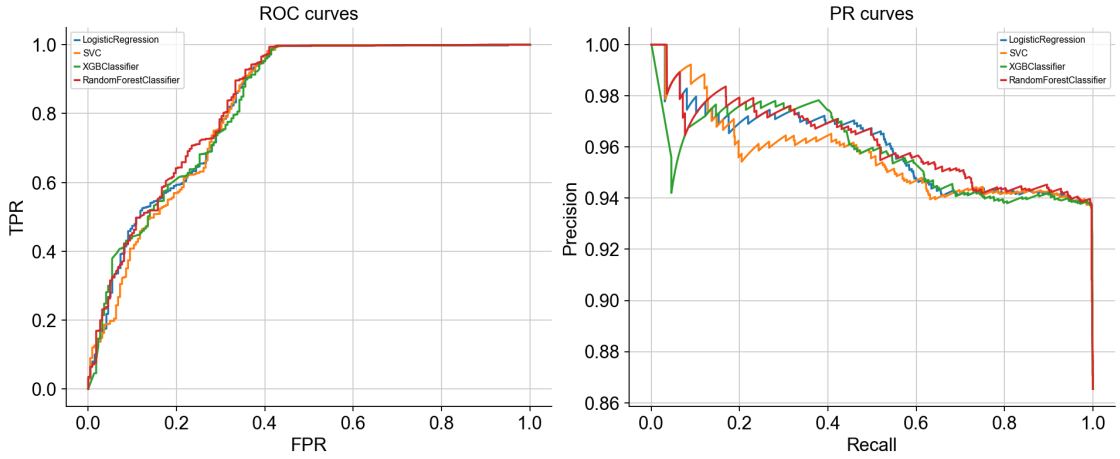



Random Forest AUROC by Gender
AUROC
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.840
0.840
Female
Male
Gender




```
 Random Forest Class-Specific Metrics Summary:
============================================================
 class       f1    auroc    auprc  precision   recall
Female 0.668329 0.839839 0.698761   0.748603 0.603604
  Male 0.954090 0.839839 0.961600   0.940136 0.968465
```



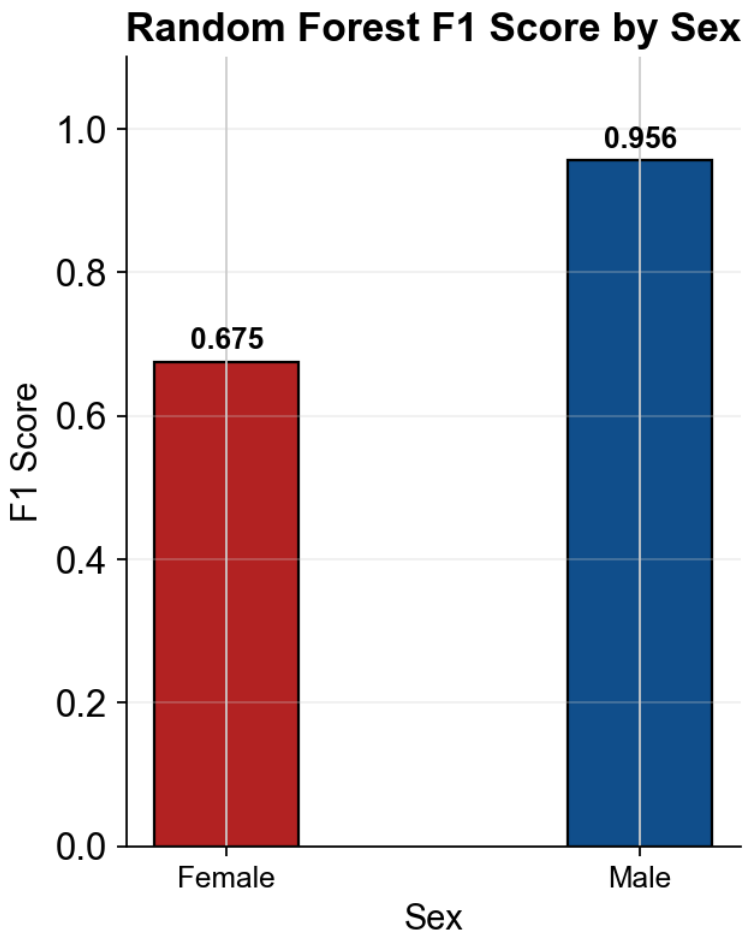


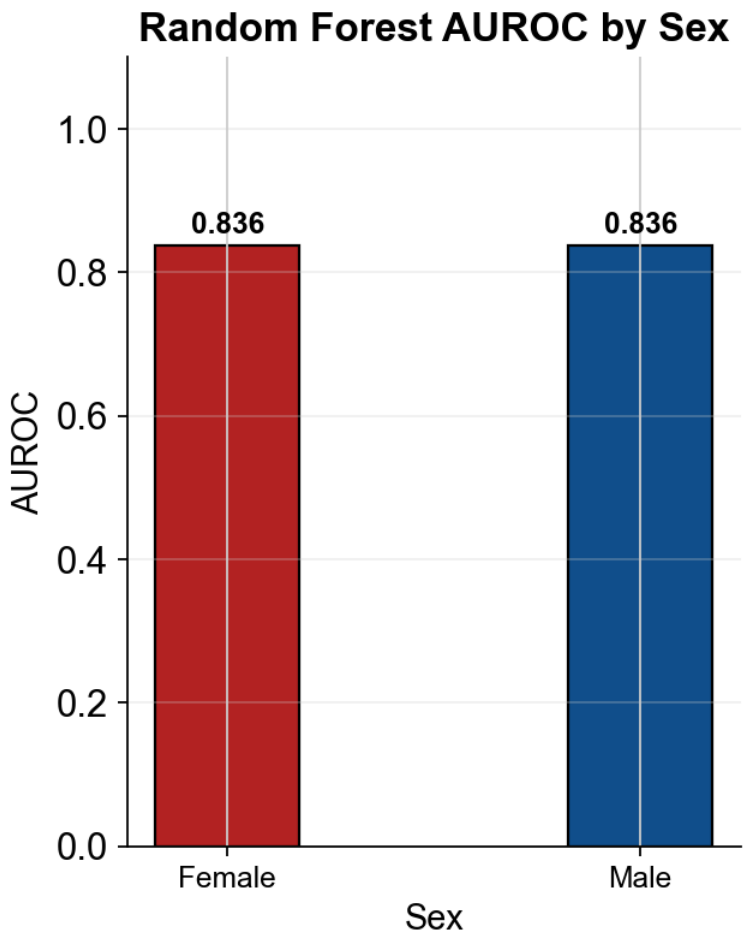
[95]:
```
#!/usr/bin/env python3
"""
Random-Forest (seed=97; 600×depth10×leaf2)
  overall / female AUROC & AUPRC
    (Sex,  ,     Y   0  )
-----------------------------------------------------------------
  full_X_train, full_Y_train, realtest, realtest_y
"""

from pathlib import Path
import numpy as np, pandas as pd
import matplotlib.pyplot as plt
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import (precision_score, recall_score, f1_score,
                             roc_auc_score, average_precision_score)
from sklearn.ensemble import RandomForestClassifier

# ========== 1.   ==========
# ↓↓↓
# full_X_train, full_Y_train, realtest, realtest_y
# ↑↑↑
scaler     = StandardScaler()
X_train_s  = scaler.fit_transform(full_X_train)
X_test_s   = scaler.transform(realtest)
y_train    = full_Y_train.astype(int)
y_test     = realtest_y.astype(int)

# ========== 2.   RF ==========
rf = RandomForestClassifier(
        n_estimators     = 600,
        max_depth        = 10,
```

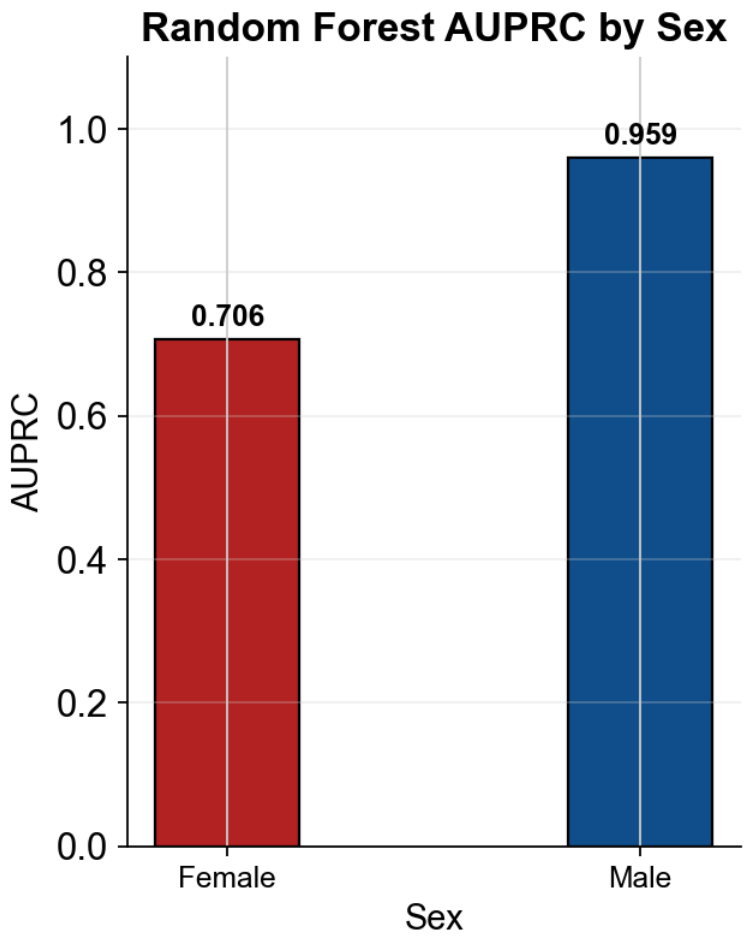
```
        min_samples_leaf = 2,
        random_state     = 97,
        n_jobs           = -1)
rf.fit(X_train_s, y_train)

# ========== 3.   &   ==========
prob_male = rf.predict_proba(X_test_s)[:, 1]
prob_fem  = 1 - prob_male
y_pred    = (prob_male >= 0.5).astype(int)

prec_f = precision_score(y_test, y_pred, pos_label=0)
rec_f  = recall_score   (y_test, y_pred, pos_label=0)
f1_f   = f1_score       (y_test, y_pred, pos_label=0)

overall_auc  = roc_auc_score(y_test, prob_male)
overall_aupr = average_precision_score(y_test, prob_male)
fem_auc      = roc_auc_score((y_test==0).astype(int), prob_fem)
fem_aupr     = average_precision_score((y_test==0).astype(int), prob_fem)

print("\n====    ====")
print(f"Overall  AUROC={overall_auc:.3f}  AUPRC={overall_aupr:.3f}")
print(f"Female   AUROC={fem_auc:.3f}  AUPRC={fem_aupr:.3f}")

print("\n====   (0.5) Female ====")
print(f"Precision={prec_f:.3f}  Recall={rec_f:.3f}  F1={f1_f:.3f}")

# ========== 4.    ==========
OUTDIR = Path("./curve_outputs"); OUTDIR.mkdir(exist_ok=True)
gender_colors = {"Female": "#B22222", "Male": "#104E8B"}

metrics = {
    "F1 Score": (f1_f,
                 f1_score(y_test, y_pred, pos_label=1)),
    "AUROC":    (fem_auc, overall_auc),
    "AUPRC":    (fem_aupr, overall_aupr)
}

for metric_name, (val_f, val_m) in metrics.items():
    fig, ax = plt.subplots(figsize=(4, 5))
    bars = ax.bar([0, 1], [val_f, val_m], width=0.35,
                  color=[gender_colors["Female"], gender_colors["Male"]],
                  edgecolor="black")

    for bar, v in zip(bars, [val_f, val_m]):
        ax.text(bar.get_x()+bar.get_width()/2, v+0.01,
                f"{v:.3f}", ha="center", va="bottom",
                fontsize=11, weight="bold")
```

```
    ax.set_xticks([0, 1])
    ax.set_xticklabels(["Female", "Male"], fontsize=11)
    ax.set_xlabel("Sex", fontsize=13)
    ax.set_ylabel(metric_name, fontsize=13)
    ax.set_title(f"Random Forest {metric_name} by Sex",
                 fontsize=15, weight="bold")

    ax.set_ylim(0, 1.1)            # ←  Y   0
    ax.grid(axis="y", alpha=0.3)
    ax.spines[['top','right']].set_visible(False)

    plt.tight_layout()
    plt.savefig(OUTDIR / f"rf_{metric_name.replace(' ','_').lower()}_by_sex.
↪png",
                dpi=300, bbox_inches="tight")
    plt.show()

print(f"\n      {OUTDIR.resolve()}")
```

```
====    ====
Overall  AUROC=0.836  AUPRC=0.959
Female   AUROC=0.836  AUPRC=0.706

====   (0.5) Female ====
Precision=0.773  Recall=0.599  F1=0.675
```


Random Forest F1 Score by Sex
F1 Score
1.0
0.8
0.6
0.4
0.2
0.0
0.675
0.956
Female
Male
Sex


Random Forest AUROC by Sex
1.0
0.8
0.6
0.4
0.2
0.0
AUROC
0.836
0.836
Female
Male
Sex




```
/Users/haley/Desktop/send_tooo/curve_outputs
```

[97]:
```
#!/usr/bin/env python3
"""
Train 4 models → 0.5   →      Female/Male
   True_Counts
  pred_counts.csv
"""

from pathlib import Path
import numpy as np, pandas as pd
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import f1_score, roc_auc_score, average_precision_score
from sklearn.linear_model  import LogisticRegression
from sklearn.svm           import SVC
from sklearn.ensemble      import RandomForestClassifier
from xgboost               import XGBClassifier
```

```
# ==========   ==========
#   ↓↓↓
# full_X_train, full_Y_train, realtest, realtest_y
# ↑↑↑
scaler     = StandardScaler()
X_train_s  = scaler.fit_transform(full_X_train)
X_test_s   = scaler.transform(realtest)
y_train    = full_Y_train.astype(int)
y_test     = realtest_y.astype(int)

# ==========   ==========
model_dict = {
    "LogReg":       LogisticRegression(max_iter=1000, random_state=42),
    "LinearSVC":    SVC(kernel="linear", probability=True, random_state=42),
    "XGBoost":      XGBClassifier(
                        eval_metric="logloss", random_state=42,
                        n_estimators=100, learning_rate=0.05, max_depth=10),
    "RandomForest": RandomForestClassifier(max_depth=10, random_state=42)
}

rows = []

# ---------- True Counts ----------
rows.append({
    "Model":   "True_Counts",
    "Female":  int((y_test == 0).sum()),
    "Male":    int((y_test == 1).sum()),
    "AUROC":   np.nan,
    "AUPRC":   np.nan,
    "F1":      np.nan
})

# ----------   +   ----------
for name, clf in model_dict.items():
    clf.fit(X_train_s, y_train)
    prob_male = clf.predict_proba(X_test_s)[:, 1]
    y_pred    = (prob_male >= 0.5).astype(int)

    rows.append({
        "Model":   name,
        "Female":  int((y_pred == 0).sum()),
        "Male":    int((y_pred == 1).sum()),
        "AUROC":   roc_auc_score(y_test, prob_male),
        "AUPRC":   average_precision_score(y_test, prob_male),
        "F1":      f1_score(y_test, y_pred)
    })
```

```
# ==========   ==========
out_df   = pd.DataFrame(rows)
out_path = Path("./pred_counts.csv")
out_df.to_csv(out_path, index=False)
print(out_df.to_string(index=False, float_format="%.3f"))
print(f"\n     {out_path.resolve()}")
```

```
      Model  Female  Male  AUROC  AUPRC    F1
True_Counts     222  1427    NaN    NaN   NaN
     LogReg     332  1317  0.833  0.960 0.905
  LinearSVC     297  1352  0.823  0.957 0.918
    XGBoost     386  1263  0.830  0.957 0.883
RandomForest     208  1441  0.837  0.959 0.946

     /Users/haley/Desktop/send_tooo/pred_counts.csv
```

[ ]:

[ ]:

[ ]:

[75]:
```
!pip install lightgbm scikit-learn
```

```
Defaulting to user installation because normal site-packages is not writeable
Collecting lightgbm
  Downloading lightgbm-4.6.0-py3-none-macosx_12_0_arm64.whl.metadata (17 kB)
Requirement already satisfied: scikit-learn in
/Users/haley/Library/Python/3.9/lib/python/site-packages (1.5.1)
Requirement already satisfied: numpy>=1.17.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from lightgbm)
(1.26.4)
Requirement already satisfied: scipy in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from lightgbm)
(1.13.1)
Requirement already satisfied: joblib>=1.2.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scikit-learn)
(1.4.2)
Requirement already satisfied: threadpoolctl>=3.1.0 in
/Users/haley/Library/Python/3.9/lib/python/site-packages (from scikit-learn)
(3.5.0)
Downloading lightgbm-4.6.0-py3-none-macosx_12_0_arm64.whl (1.6 MB)
                         1.6/1.6 MB
24.4 MB/s eta 0:00:00
Installing collected packages: lightgbm
Successfully installed lightgbm-4.6.0
```

```
[notice] A new release of pip is
available: 25.0.1 -> 25.1.1
[notice] To update, run:
/Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip
install --upgrade pip
```

[30]:
```
roc_data
```

[30]:
```
                        Model       fpr       tpr       auc
0          LogisticRegression  0.000000  0.000000  0.832816
1          LogisticRegression  0.000000  0.000701  0.832816
2          LogisticRegression  0.000000  0.030834  0.832816
3          LogisticRegression  0.004505  0.030834  0.832816
4          LogisticRegression  0.004505  0.065172  0.832816
…                         …       …         …         …
999    RandomForestClassifier  0.963964  1.000000  0.839839
1000   RandomForestClassifier  0.968468  1.000000  0.839839
1001   RandomForestClassifier  0.977477  1.000000  0.839839
1002   RandomForestClassifier  0.990991  1.000000  0.839839
1003   RandomForestClassifier  1.000000  1.000000  0.839839

[1004 rows x 4 columns]
```

[82]:
```
#!/usr/bin/env python3
"""
Train Random Forest on full train set, test on full test set.
Print true and predicted label counts (female/male).
"""

import pandas as pd
import numpy as np
from sklearn.ensemble import RandomForestClassifier

#   model setup
rf_model = RandomForestClassifier(max_depth=10, random_state=41)

#   train on full training set
print("Training Random Forest...")
rf_model.fit(full_X_train, full_Y_train)

#   predict on full test set
print("Making predictions...")
y_pred = rf_model.predict(realtest)

#   count true labels
true_female_count = np.sum(realtest_y == 0)
true_male_count = np.sum(realtest_y == 1)
```

```
#   count predicted labels
pred_female_count = np.sum(y_pred == 0)
pred_male_count = np.sum(y_pred == 1)

#   print results
print("\n" + "="*50)
print("TRUE LABEL COUNTS:")
print(f"  Female (0): {true_female_count}")
print(f"  Male (1):   {true_male_count}")
print(f"  Total:      {true_female_count + true_male_count}")

print("\nPREDICTED LABEL COUNTS:")
print(f"  Female (0): {pred_female_count}")
print(f"  Male (1):   {pred_male_count}")
print(f"  Total:      {pred_female_count + pred_male_count}")
print("="*50)

#   optional: accuracy
accuracy = np.mean(realtest_y == y_pred)
print(f"\nAccuracy: {accuracy:.4f}")
```

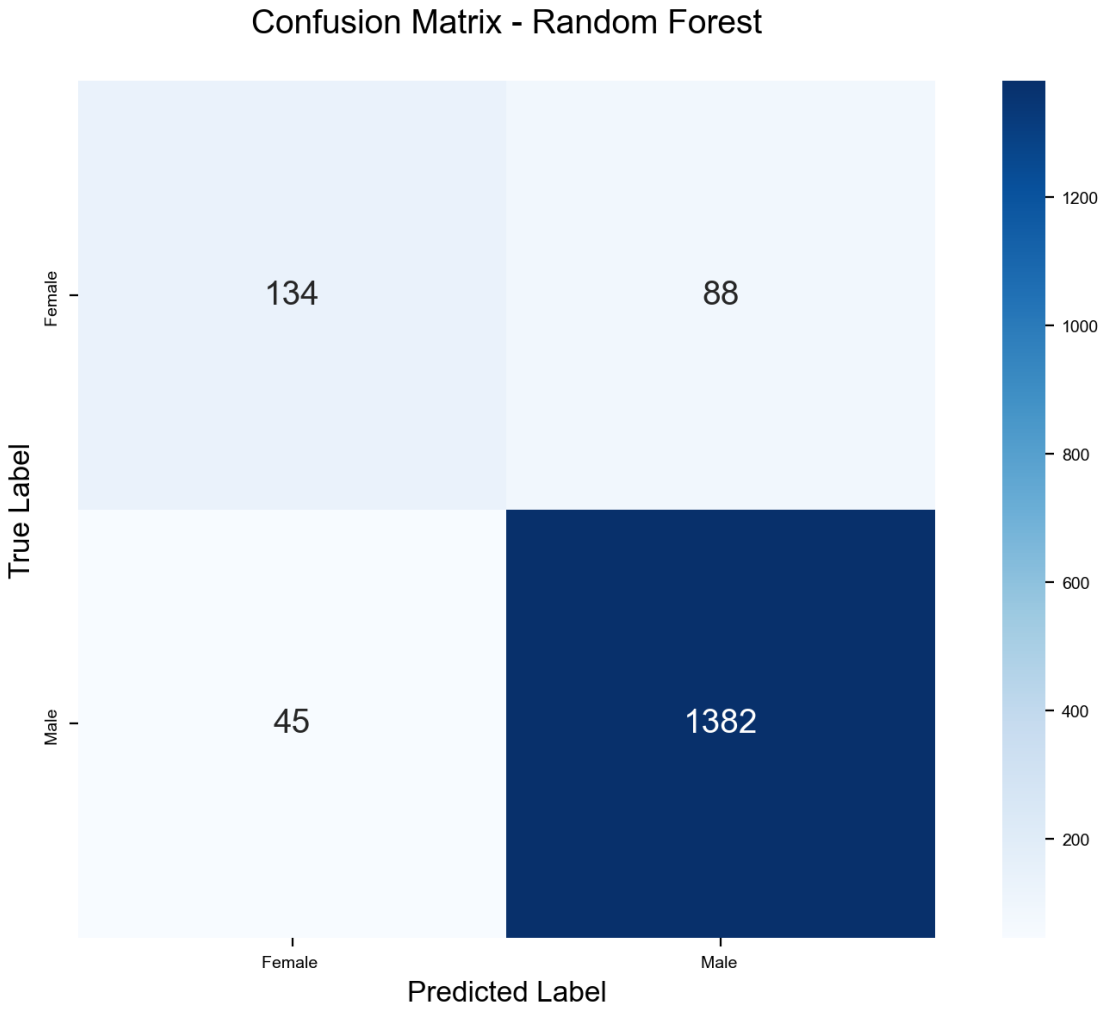
```
Training Random Forest…
Making predictions…

==================================================
TRUE LABEL COUNTS:
  Female (0): 222
  Male (1):   1427
  Total:      1649

PREDICTED LABEL COUNTS:
  Female (0): 179
  Male (1):   1470
  Total:      1649
==================================================

Accuracy: 0.9193
```

[85]:
```
#!/usr/bin/env python3
"""
Draw a confusion matrix for the Random Forest classification results.
"""

import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
```

```
from sklearn.metrics import confusion_matrix, classification_report

#   create confusion matrix
cm = confusion_matrix(realtest_y, y_pred)

#   plot confusion matrix
plt.figure(figsize=(8, 6))

# Plot heatmap with counts only
sns.heatmap(cm,
            annot=True,
            fmt='d',
            cmap='Blues',
            cbar=True,
            square=True,
            xticklabels=['Female ', 'Male '],
            yticklabels=['Female ', 'Male '],
            annot_kws={'size': 14})

plt.title('Confusion Matrix - Random Forest', fontsize=14, pad=20)
plt.xlabel('Predicted Label', fontsize=12)
plt.ylabel('True Label', fontsize=12)
plt.tight_layout()

#   print detailed metrics
print("\nCONFUSION MATRIX:")
print(cm)
print(f"\nTrue Negatives (TN):  {cm[0,0]}")
print(f"False Positives (FP): {cm[0,1]}")
print(f"False Negatives (FN): {cm[1,0]}")
print(f"True Positives (TP):  {cm[1,1]}")

#   calculate additional metrics
tn, fp, fn, tp = cm.ravel()
accuracy = (tp + tn) / (tp + tn + fp + fn)
precision = tp / (tp + fp) if (tp + fp) > 0 else 0
recall = tp / (tp + fn) if (tp + fn) > 0 else 0
specificity = tn / (tn + fp) if (tn + fp) > 0 else 0
f1_score = 2 * (precision * recall) / (precision + recall) if (precision +␣
 ↪recall) > 0 else 0

print(f"\nMETRICS:")
print(f"Accuracy:    {accuracy:.4f}")
print(f"Precision:   {precision:.4f}")
print(f"Recall:      {recall:.4f}")
print(f"Specificity: {specificity:.4f}")
print(f"F1-Score:    {f1_score:.4f}")
```

```
#   show classification report
print(f"\nCLASSIFICATION REPORT:")
print(classification_report(realtest_y, y_pred,
                            target_names=['Female (0)', 'Male (1)'],
                            digits=4))

plt.show()
```

```
CONFUSION MATRIX:
[[ 134   88]
 [  45 1382]]

True Negatives (TN):  134
False Positives (FP): 88
False Negatives (FN): 45
True Positives (TP):  1382

METRICS:
Accuracy:    0.9193
Precision:   0.9401
Recall:      0.9685
Specificity: 0.6036
F1-Score:    0.9541

CLASSIFICATION REPORT:
              precision    recall  f1-score   support

  Female (0)     0.7486    0.6036    0.6683       222
    Male (1)     0.9401    0.9685    0.9541      1427

    accuracy                         0.9193      1649
   macro avg     0.8444    0.7860    0.8112      1649
weighted avg     0.9144    0.9193    0.9156      1649
```

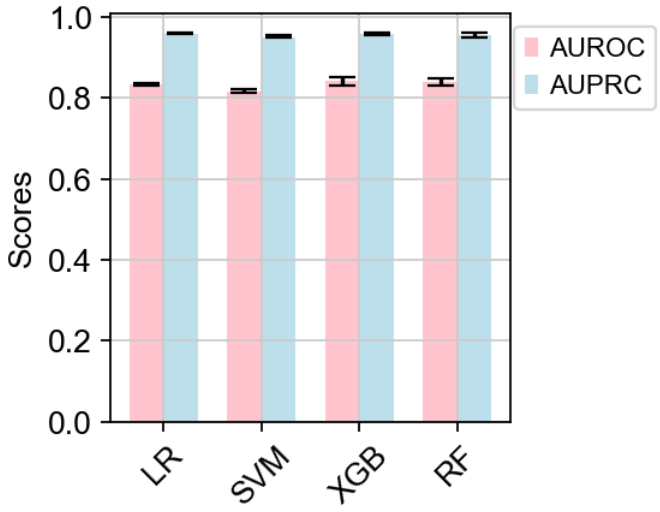


12 fig1 drawing mouse

[452]:
```
import matplotlib.pyplot as plt
import numpy as np

# ROC AUC Data
auroc_data = {
    'LogisticRegression': [0.833374, 0.830398, 0.835730],
    'SVC': [0.816254, 0.811984, 0.821324],
    'XGBClassifier': [0.842595, 0.831601, 0.851632],
    'RandomForestClassifier': [0.839546, 0.829966, 0.849857]
}

# PRC AUC Data
```

```
auprc_data = {
    'LogisticRegression': [0.959603, 0.958579, 0.960437],
    'SVC': [0.951278, 0.949247, 0.954626],
    'XGBClassifier': [0.959140, 0.955415, 0.962364],
    'RandomForestClassifier': [0.957209, 0.950502, 0.961562]
}

# Changing the model names
new_names = {
    'LogisticRegression': 'LR',
    'SVC': 'SVM',
    'XGBClassifier': 'XGB',
    'RandomForestClassifier': 'RF'
}

auroc_data = {new_names.get(k, k): v for k, v in auroc_data.items()}
auprc_data = {new_names.get(k, k): v for k, v in auprc_data.items()}

# Prepare data for plotting
model_names = list(auroc_data.keys())
auroc_means = [auroc_data[name][0] for name in model_names]
auroc_errors = [(auroc_data[name][0] - auroc_data[name][1], auroc_data[name][2]-␣
 ↪- auroc_data[name][0]) for name in model_names]
auprc_means = [auprc_data[name][0] for name in model_names]
auprc_errors = [(auprc_data[name][0] - auprc_data[name][1], auprc_data[name][2]-␣
 ↪- auprc_data[name][0]) for name in model_names]

# Plot settings
bar_width = 0.35
opacity = 0.8
error_config = {'capsize': 5}

# Creating the bar plot with the original figure size
fig, ax = plt.subplots(figsize=(4, 2.83))  # Set the figure size here as␣
 ↪provided
bar1 = ax.bar(np.arange(len(model_names)) - bar_width/2, auroc_means, bar_width,
              alpha=opacity, color='lightpink', yerr=np.array(auroc_errors).T,
              error_kw=error_config, label='AUROC')

bar2 = ax.bar(np.arange(len(model_names)) + bar_width/2, auprc_means, bar_width,
              alpha=opacity, color='lightblue', yerr=np.array(auprc_errors).T,
              error_kw=error_config, label='AUPRC')

# Add some text for labels and axes ticks
ax.set_ylabel('Scores', fontsize=12)
ax.set_xticks(np.arange(len(model_names)))
ax.set_xticklabels(model_names, fontsize=12)
```

```
ax.tick_params(axis='y', labelsize=12)
ax.legend(loc='upper right', bbox_to_anchor=(1.4,1), fontsize=10)

plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



13 wtwt experimental(test data performance)

[48]:
```
adata1
```

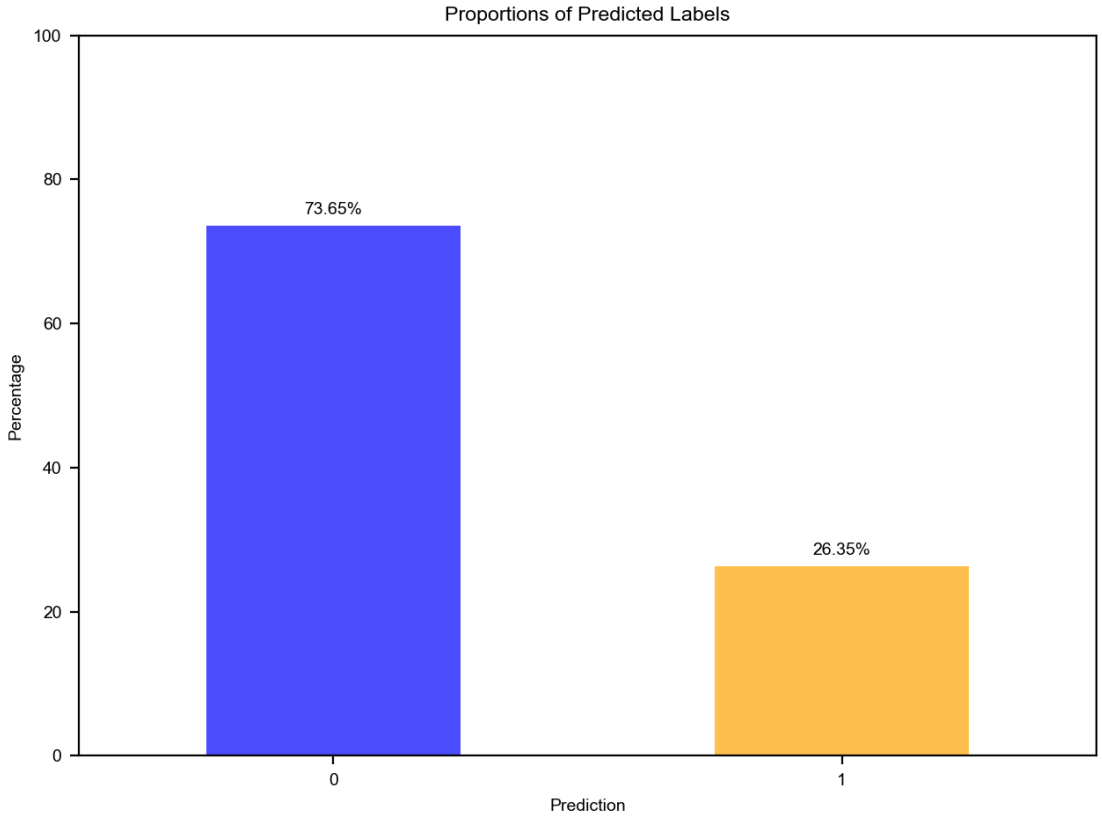
[48]:
```
View of AnnData object with n_obs × n_vars = 8268 × 20902
    obs: 'dataset', 'sample', 'n_genes', 'n_genes_by_counts', 'total_counts',
'total_counts_mt', 'pct_counts_mt', 'conditions'
    var: 'gene_ids', 'feature_types', 'n_cells', 'mt', 'n_cells_by_counts',
'mean_counts', 'pct_dropout_by_counts', 'total_counts', 'highly_variable',
'means', 'dispersions', 'dispersions_norm'
    uns: 'hvg', 'log1p'
```

[35]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, precision_recall_curve,␣
 ↪average_precision_score, roc_curve, auc
import matplotlib.pyplot as plt
```

```
plt.style.use("default")
# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'

# Define model
# model =  RandomForestClassifier(max_depth=10, random_state=41)
model =   RandomForestClassifier(max_depth=10, random_state=41)
np.random.seed(42)  # For reproducibility



# Scale the training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Scale the test data
adata1_scaled = scaler.transform(extracted_columns_1)

# Fit the model on the training data
model.fit(full_X_train_scaled, full_Y_train)

# Predict labels for adata1
predicted_labels = model.predict(adata1_scaled)

# Save predictions to a CSV file
output_df = pd.DataFrame({"Prediction": predicted_labels})
output_df.to_csv("predicted_labels_jun16.csv", index=False)
print("Predicted labels saved to 'predicted_labels_jun16.csv'.")

# Calculate percentages for the bar plot
label_counts = pd.Series(predicted_labels).value_counts(normalize=True) * 100 ␣
 ↪# Convert to percentages

# Create a bar plot
label_counts.plot(kind='bar', color=['blue', 'orange'], alpha=0.7)
plt.xlabel("Prediction")
plt.ylabel("Percentage")
plt.title("Proportions of Predicted Labels")
plt.xticks([0, 1], labels=['0', '1'], rotation=0)
plt.ylim(0, 100)  # Ensure the y-axis ranges from 0 to 100
plt.tight_layout()

# Add percentage labels on the bars
for i, v in enumerate(label_counts):
```

```
    plt.text(i, v + 1, f"{v:.2f}%", ha='center', va='bottom', fontsize=7)

# Save and show the plot
plt.savefig("prediction_percentage_barplot.png", dpi=300)
plt.show()

print("Bar plot of predicted label percentages saved to␣
 ↪'prediction_percentage_barplot.png'.")
```

```
Predicted labels saved to 'predicted_labels_jun16.csv'.
```




```
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot.png'.
```

[46]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.svm import LinearSVC
```

```
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, precision_recall_curve,␣
 ↪average_precision_score, roc_curve, auc
from sklearn.model_selection import cross_val_score, cross_val_predict
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
 ↪f1_score
import os
import warnings
warnings.filterwarnings('ignore')

# Set style and global font properties
plt.style.use("default")
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'

# Create output directory
output_dir = "/Users/haley/Desktop/send_tooo/AAA_final/wtwt"
os.makedirs(output_dir, exist_ok=True)
print(f"Output directory created/verified: {output_dir}")

# Define number of cores for parallel processing
n_cores = -1  # Use all available cores

# Define models
models = {
    "LogisticRegression": LogisticRegression(
        max_iter=1000,
        n_jobs=n_cores,
        random_state=41
    ),
    "LinearSVC": LinearSVC(
        dual=False,  # Better for many features
        random_state=41
    ),
    "XGBClassifier": XGBClassifier(
        eval_metric='logloss',
        n_estimators=100,
        learning_rate=0.05,
        max_depth=10,
        n_jobs=n_cores,
        random_state=41
    ),
    "RandomForestClassifier": RandomForestClassifier(
        max_depth=10,
        n_jobs=n_cores,
```

```
        random_state=66
    ),
}

# Scale the training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Scale the test data
adata1_scaled = scaler.transform(extracted_columns_1)

# Dictionary to store results
results = {}
predictions = {}
probabilities = {}
cv_scores = {}

# Train each model and make predictions
print("\nTraining models and making predictions...\n")

for model_name, model in models.items():
    print(f"Training {model_name}...")

    # Fit the model
    model.fit(full_X_train_scaled, full_Y_train)

    # Make predictions
    predicted_labels = model.predict(adata1_scaled)
    predictions[model_name] = predicted_labels

    # Get prediction probabilities (if available)
    if hasattr(model, "predict_proba"):
        predicted_probs = model.predict_proba(adata1_scaled)[:, 1]
    elif hasattr(model, "decision_function"):
        # For SVM, convert decision function to probabilities using sigmoid
        decision_values = model.decision_function(adata1_scaled)
        predicted_probs = 1 / (1 + np.exp(-decision_values))
    else:
        predicted_probs = predicted_labels.astype(float)

    probabilities[model_name] = predicted_probs

    # Perform cross-validation on training data to get performance metrics
    cv_accuracy = cross_val_score(model, full_X_train_scaled, full_Y_train,␣
↪cv=5, scoring='accuracy')
    cv_precision = cross_val_score(model, full_X_train_scaled, full_Y_train,␣
↪cv=5, scoring='precision')
```

```
    cv_recall = cross_val_score(model, full_X_train_scaled, full_Y_train, cv=5,␣
↪scoring='recall')
    cv_f1 = cross_val_score(model, full_X_train_scaled, full_Y_train, cv=5,␣
↪scoring='f1')
    cv_roc_auc = cross_val_score(model, full_X_train_scaled, full_Y_train,␣
↪cv=5, scoring='roc_auc')

    # Store cross-validation scores
    cv_scores[model_name] = {
        'accuracy': cv_accuracy,
        'precision': cv_precision,
        'recall': cv_recall,
        'f1': cv_f1,
        'roc_auc': cv_roc_auc
    }

    # Store results
    results[model_name] = {
        'predictions': predicted_labels,
        'probabilities': predicted_probs,
        'cv_accuracy': cv_accuracy.mean(),
        'cv_precision': cv_precision.mean(),
        'cv_recall': cv_recall.mean(),
        'cv_f1': cv_f1.mean(),
        'cv_roc_auc': cv_roc_auc.mean()
    }

    # Save predictions and probabilities to CSV in the specified folder
    output_df = pd.DataFrame({
        "Prediction": predicted_labels,
        "Probability": predicted_probs
    })
    output_file = os.path.join(output_dir,␣
↪f"predicted_labels_probs_{model_name}_jun16.csv")
    output_df.to_csv(output_file, index=False)
    print(f"  - Predictions and probabilities saved to '{output_file}'")
    print(f"  - CV Accuracy: {cv_accuracy.mean():.4f} (+/- {cv_accuracy.std() *␣
↪2:.4f})")
    print(f"  - CV ROC-AUC: {cv_roc_auc.mean():.4f} (+/- {cv_roc_auc.std() * 2:.
↪4f})\n")

# Create performance comparison table
print("\nModel Performance Summary (Cross-Validation):")
print("-" * 70)
performance_df = pd.DataFrame({
    model_name: {
```

```
        'Accuracy': f"{results[model_name]['cv_accuracy']:.4f}",
        'Precision': f"{results[model_name]['cv_precision']:.4f}",
        'Recall': f"{results[model_name]['cv_recall']:.4f}",
        'F1-Score': f"{results[model_name]['cv_f1']:.4f}",
        'ROC-AUC': f"{results[model_name]['cv_roc_auc']:.4f}"
    } for model_name in models.keys()
}).T
print(performance_df)

# Save performance summary to CSV in the output folder
performance_file = os.path.join(output_dir, "model_performance_summary.csv")
performance_df.to_csv(performance_file)
print(f"\nPerformance summary saved to '{performance_file}'")

# Create visualizations
# 1. Bar plot comparing prediction distributions
fig, axes = plt.subplots(2, 2, figsize=(10, 8))
axes = axes.ravel()

for idx, (model_name, preds) in enumerate(predictions.items()):
    ax = axes[idx]
    label_counts = pd.Series(preds).value_counts(normalize=True) * 100

    bars = ax.bar([0, 1], label_counts.sort_index(), color=['blue', 'orange'],␣
 ↪alpha=0.7)
    ax.set_xlabel("Prediction")
    ax.set_ylabel("Percentage")
    ax.set_title(f"{model_name} - Predicted Labels")
    ax.set_xticks([0, 1])
    ax.set_xticklabels(['0', '1'])
    ax.set_ylim(0, 100)

    # Add percentage labels on bars
    for bar, count in zip(bars, label_counts.sort_index()):
        height = bar.get_height()
        ax.text(bar.get_x() + bar.get_width()/2., height + 1,
                f'{count:.1f}%', ha='center', va='bottom', fontsize=7)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "all_models_prediction_distributions.
 ↪png"), dpi=300)
plt.show()

# 2. Performance metrics comparison plot
metrics = ['cv_accuracy', 'cv_precision', 'cv_recall', 'cv_f1', 'cv_roc_auc']
metric_names = ['Accuracy', 'Precision', 'Recall', 'F1-Score', 'ROC-AUC']
```

```
fig, ax = plt.subplots(figsize=(10, 6))
x = np.arange(len(metric_names))
width = 0.2

for i, model_name in enumerate(models.keys()):
    values = [results[model_name][metric] for metric in metrics]
    ax.bar(x + i*width, values, width, label=model_name)

ax.set_xlabel('Metrics')
ax.set_ylabel('Score')
ax.set_title('Model Performance Comparison (Cross-Validation)')
ax.set_xticks(x + width * 1.5)
ax.set_xticklabels(metric_names)
ax.legend()
ax.set_ylim(0, 1.1)

# Add value labels on bars
for i, model_name in enumerate(models.keys()):
    values = [results[model_name][metric] for metric in metrics]
    for j, v in enumerate(values):
        ax.text(j + i*width, v + 0.01, f'{v:.3f}', ha='center', va='bottom',␣
 ↪fontsize=6)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "model_performance_comparison.png"),␣
 ↪dpi=300)
plt.show()

# 3. Box plot for cross-validation scores
fig, axes = plt.subplots(1, 5, figsize=(15, 4))
metrics_for_box = ['accuracy', 'precision', 'recall', 'f1', 'roc_auc']
metric_names_for_box = ['Accuracy', 'Precision', 'Recall', 'F1-Score',␣
 ↪'ROC-AUC']

for idx, (metric, metric_name) in enumerate(zip(metrics_for_box,␣
 ↪metric_names_for_box)):
    ax = axes[idx]
    data_to_plot = [cv_scores[model_name][metric] for model_name in models.
 ↪keys()]
    bp = ax.boxplot(data_to_plot, labels=list(models.keys()), patch_artist=True)

    # Color the boxes
    colors = ['lightblue', 'lightgreen', 'lightcoral', 'lightyellow']
    for patch, color in zip(bp['boxes'], colors):
        patch.set_facecolor(color)

    ax.set_title(metric_name)
```

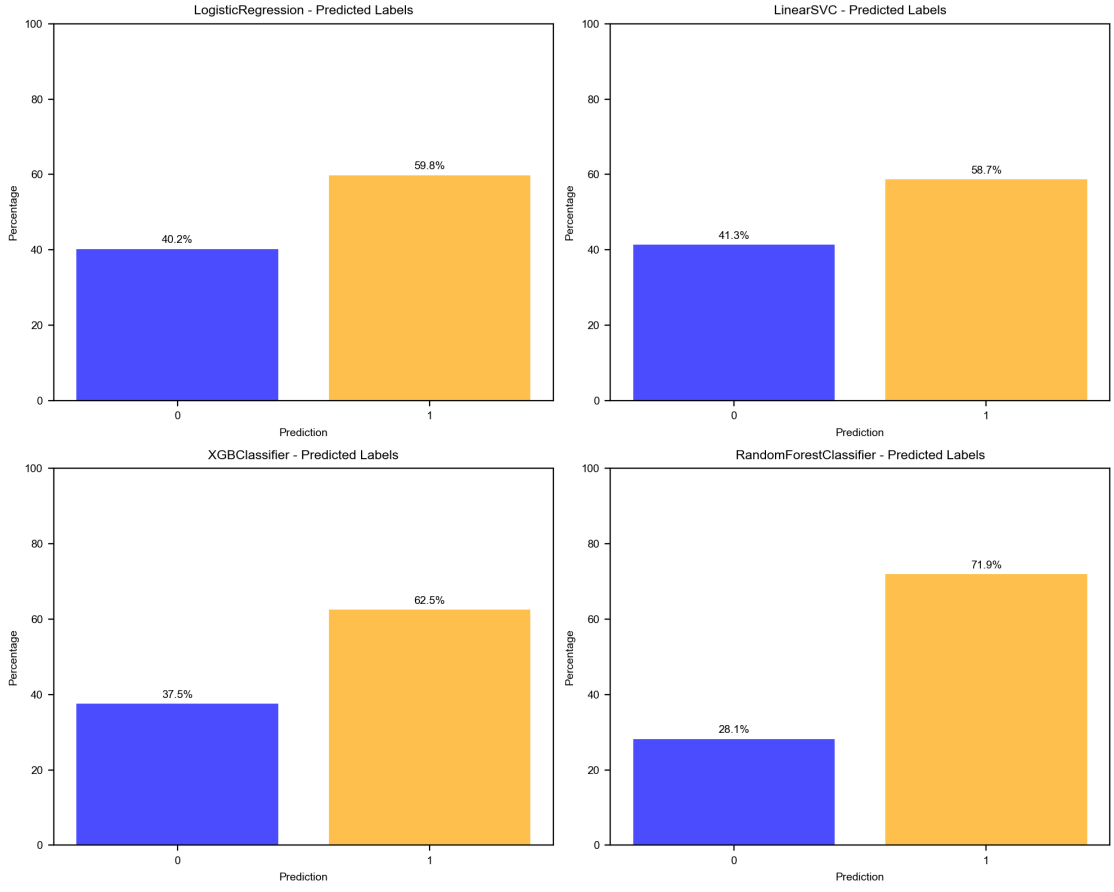
```
    ax.set_ylabel('Score')
    ax.tick_params(axis='x', rotation=45)
    ax.set_ylim(0, 1.1)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "cv_scores_boxplot.png"), dpi=300)
plt.show()

# 4. Create ensemble predictions (majority voting) and average probabilities
ensemble_predictions = np.zeros_like(predictions['LogisticRegression'])
ensemble_probabilities = np.zeros_like(probabilities['LogisticRegression'])

for model_preds in predictions.values():
    ensemble_predictions += model_preds

for model_probs in probabilities.values():
    ensemble_probabilities += model_probs

# Majority voting for predictions
ensemble_predictions = (ensemble_predictions >= len(models) / 2).astype(int)
# Average probabilities
ensemble_probabilities = ensemble_probabilities / len(models)

# Save ensemble predictions and probabilities
ensemble_df = pd.DataFrame({
    "Prediction": ensemble_predictions,
    "Probability": ensemble_probabilities
})
ensemble_file = os.path.join(output_dir, "predicted_labels_probs_ensemble_jun16.
 ↪csv")
ensemble_df.to_csv(ensemble_file, index=False)
print(f"\nEnsemble predictions (majority voting) and probabilities saved to␣
 ↪'{ensemble_file}'")

# Plot ensemble predictions
plt.figure(figsize=(6, 4))
ensemble_counts = pd.Series(ensemble_predictions).value_counts(normalize=True)␣
 ↪* 100
bars = plt.bar([0, 1], ensemble_counts.sort_index(), color=['blue', 'orange'],␣
 ↪alpha=0.7)
plt.xlabel("Prediction")
plt.ylabel("Percentage")
plt.title("Ensemble Model - Predicted Labels (Majority Voting)")
plt.xticks([0, 1], labels=['0', '1'])
plt.ylim(0, 100)

# Add percentage labels
```

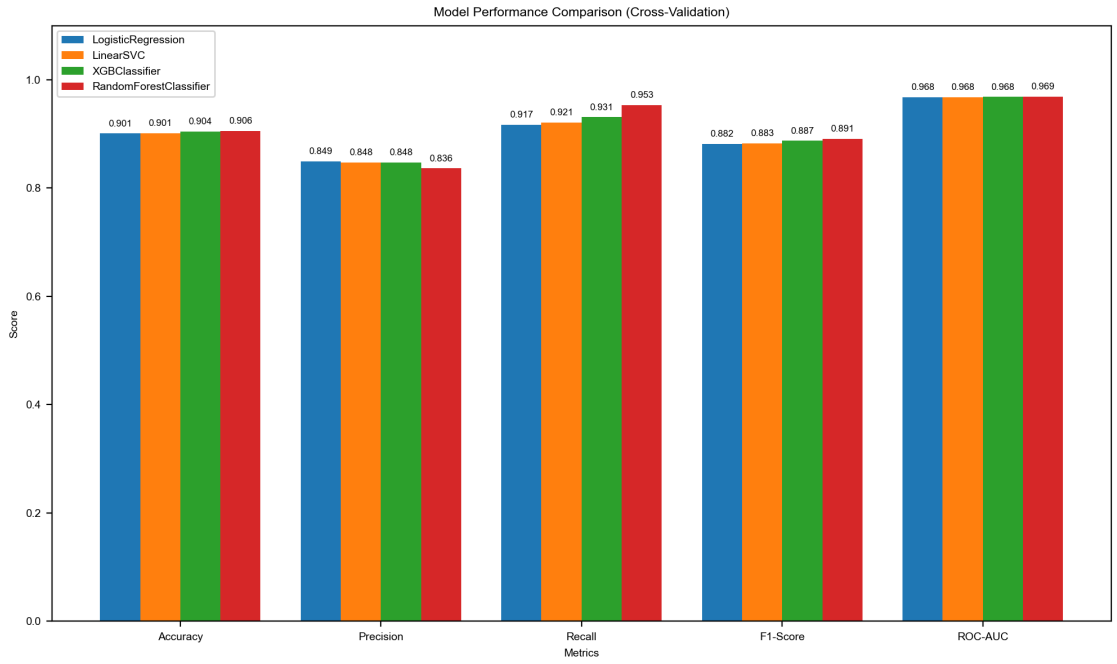
```
for bar, count in zip(bars, ensemble_counts.sort_index()):
    height = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2., height + 1,
            f'{count:.1f}%', ha='center', va='bottom', fontsize=7)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "ensemble_prediction_barplot.png"),␣
 ↪dpi=300)
plt.show()

# 5. Add probability distribution plots
fig, axes = plt.subplots(2, 2, figsize=(10, 8))
axes = axes.ravel()

for idx, (model_name, probs) in enumerate(probabilities.items()):
    ax = axes[idx]
    ax.hist(probs, bins=50, alpha=0.7, color='purple', edgecolor='black')
    ax.set_xlabel("Probability")
    ax.set_ylabel("Frequency")
    ax.set_title(f"{model_name} - Probability Distribution")
    ax.axvline(x=0.5, color='red', linestyle='--', alpha=0.5)

    # Add statistics
    ax.text(0.95, 0.95, f'Mean: {np.mean(probs):.3f}\nStd: {np.std(probs):.3f}',
            transform=ax.transAxes, verticalalignment='top',␣
 ↪horizontalalignment='right',
            bbox=dict(boxstyle='round', facecolor='white', alpha=0.8),␣
 ↪fontsize=7)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "probability_distributions.png"), dpi=300)
plt.show()

# Plot ensemble probability distribution
plt.figure(figsize=(6, 4))
plt.hist(ensemble_probabilities, bins=50, alpha=0.7, color='green',␣
 ↪edgecolor='black')
plt.xlabel("Probability")
plt.ylabel("Frequency")
plt.title("Ensemble Model - Probability Distribution")
plt.axvline(x=0.5, color='red', linestyle='--', alpha=0.5)

# Add statistics
plt.text(0.95, 0.95, f'Mean: {np.mean(ensemble_probabilities):.3f}\nStd: {np.
 ↪std(ensemble_probabilities):.3f}',
        transform=plt.gca().transAxes, verticalalignment='top',␣
 ↪horizontalalignment='right',
```

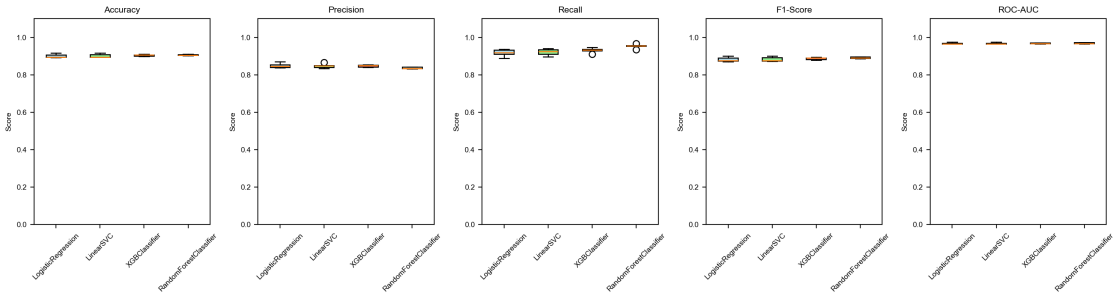
```
        bbox=dict(boxstyle='round', facecolor='white', alpha=0.8), fontsize=7)

plt.tight_layout()
plt.savefig(os.path.join(output_dir, "ensemble_probability_distribution.png"),␣
 ↪dpi=300)
plt.show()

print(f"\nAll files have been saved to: {output_dir}")
print("\nSaved files:")
print("- predicted_labels_probs_LogisticRegression_jun16.csv")
print("- predicted_labels_probs_LinearSVC_jun16.csv")
print("- predicted_labels_probs_XGBClassifier_jun16.csv")
print("- predicted_labels_probs_RandomForestClassifier_jun16.csv")
print("- predicted_labels_probs_ensemble_jun16.csv")
print("- model_performance_summary.csv")
print("- all_models_prediction_distributions.png")
print("- model_performance_comparison.png")
print("- cv_scores_boxplot.png")
print("- ensemble_prediction_barplot.png")
print("- probability_distributions.png")
print("- ensemble_probability_distribution.png")

print("\nAnalysis complete!")
```

```
Output directory created/verified: /Users/haley/Desktop/send_tooo/AAA_final/wtwt

Training models and making predictions…

Training LogisticRegression…
  - Predictions and probabilities saved to '/Users/haley/Desktop/send_tooo/AAA_f
inal/wtwt/predicted_labels_probs_LogisticRegression_jun16.csv'
  - CV Accuracy: 0.9009 (+/- 0.0182)
  - CV ROC-AUC: 0.9680 (+/- 0.0082)

Training LinearSVC…
  - Predictions and probabilities saved to '/Users/haley/Desktop/send_tooo/AAA_f
inal/wtwt/predicted_labels_probs_LinearSVC_jun16.csv'
  - CV Accuracy: 0.9012 (+/- 0.0178)
  - CV ROC-AUC: 0.9678 (+/- 0.0084)

Training XGBClassifier…
  - Predictions and probabilities saved to '/Users/haley/Desktop/send_tooo/AAA_f
inal/wtwt/predicted_labels_probs_XGBClassifier_jun16.csv'
  - CV Accuracy: 0.9045 (+/- 0.0088)
  - CV ROC-AUC: 0.9684 (+/- 0.0054)

Training RandomForestClassifier…
  - Predictions and probabilities saved to '/Users/haley/Desktop/send_tooo/AAA_f
```

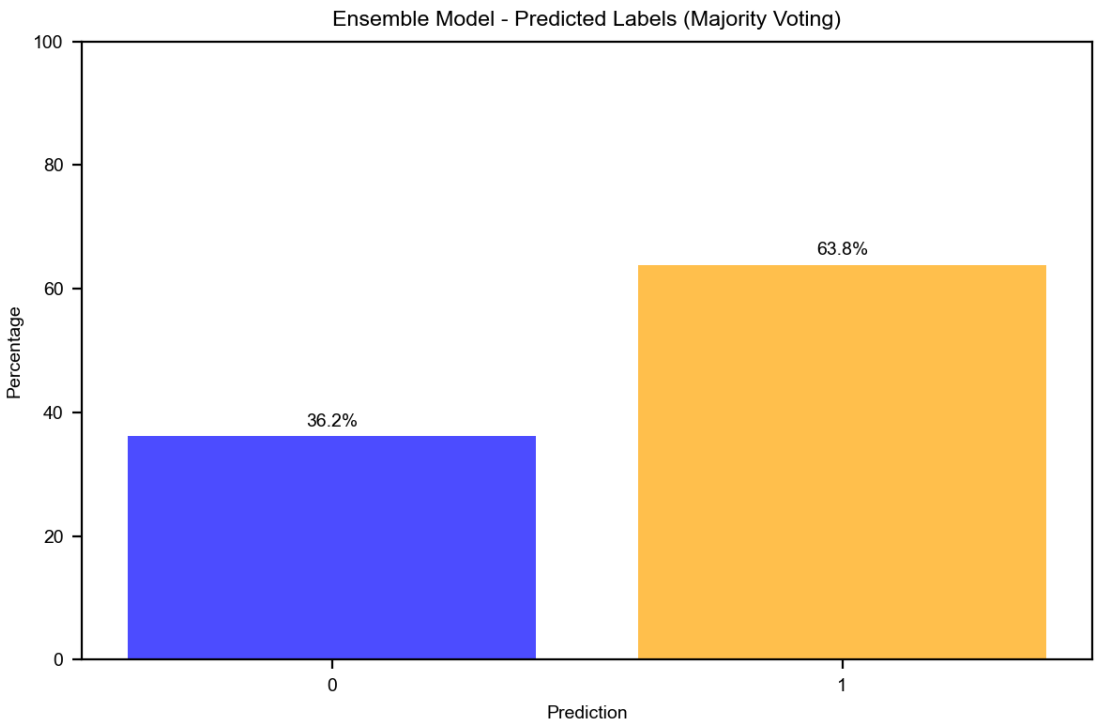
```
inal/wtwt/predicted_labels_probs_RandomForestClassifier_jun16.csv'
  - CV Accuracy: 0.9058 (+/- 0.0059)
  - CV ROC-AUC: 0.9693 (+/- 0.0068)


Model Performance Summary (Cross-Validation):
--------------------------------------------------------------------------
                       Accuracy Precision  Recall F1-Score ROC-AUC
LogisticRegression       0.9009    0.8494  0.9173   0.8820  0.9680
LinearSVC                0.9012    0.8476  0.9210   0.8827  0.9678
XGBClassifier            0.9045    0.8475  0.9311   0.8873  0.9684
RandomForestClassifier   0.9058    0.8364  0.9534   0.8910  0.9693

Performance summary saved to
'/Users/haley/Desktop/send_tooo/AAA_final/wtwt/model_performance_summary.csv'
```

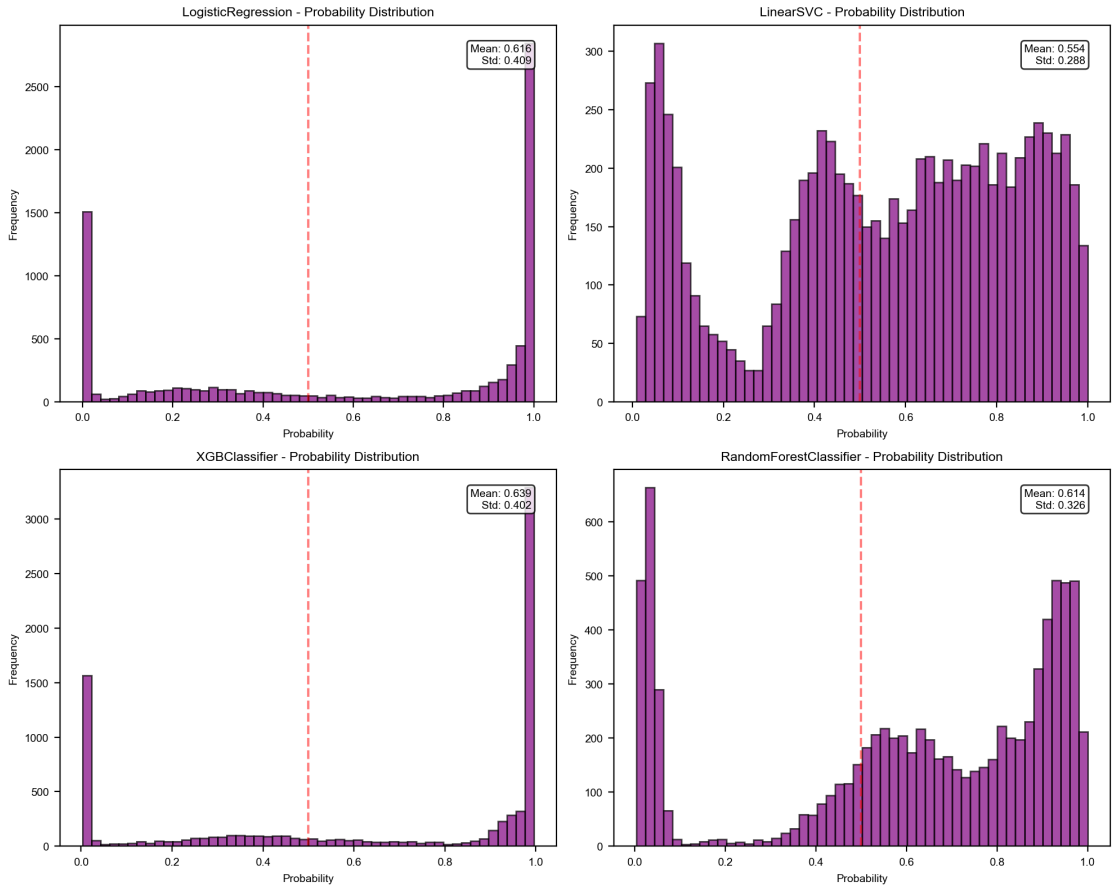


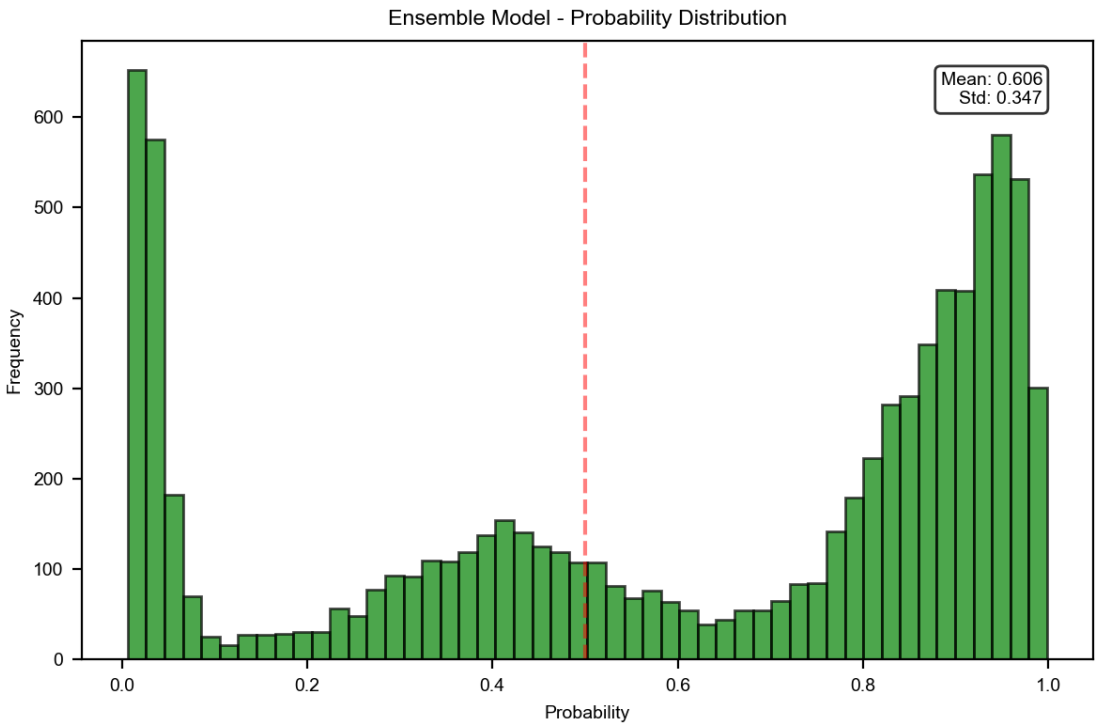




Ensemble predictions (majority voting) and probabilities saved to '/Users/haley/Desktop/send_tooo/AAA_final/wtwt/predicted_labels_probs_ensemble_jun16.csv'


Ensemble Model - Predicted Labels (Majority Voting)
Percentage
100
80
60
40
20
0
36.2%
63.8%
0
1
Prediction


LogisticRegression - Probability Distribution
Mean: 0.616
Std: 0.409
Frequency
Probability
LinearSVC - Probability Distribution
Mean: 0.554
Std: 0.288
Frequency
Probability
XGBClassifier - Probability Distribution
Mean: 0.639
Std: 0.402
Frequency
Probability
RandomForestClassifier - Probability Distribution
Mean: 0.614
Std: 0.326
Frequency
Probability



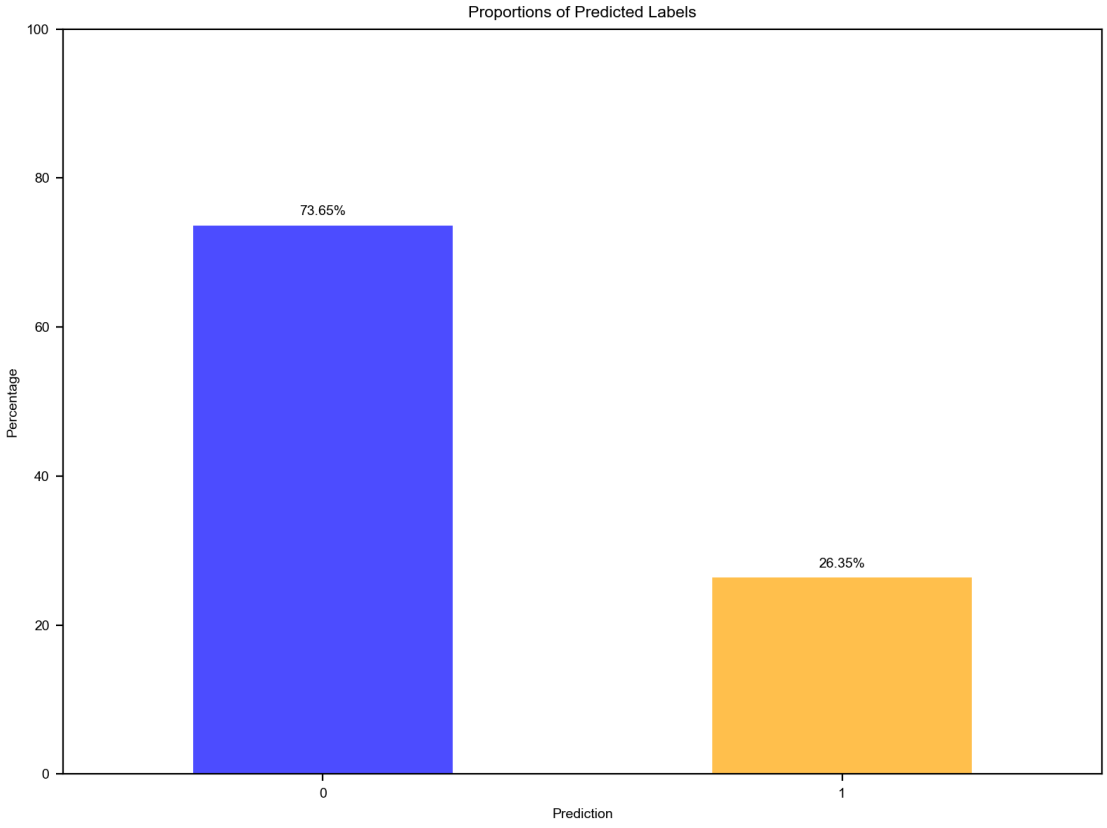

```
All files have been saved to: /Users/haley/Desktop/send_tooo/AAA_final/wtwt

Saved files:
- predicted_labels_probs_LogisticRegression_jun16.csv
- predicted_labels_probs_LinearSVC_jun16.csv
- predicted_labels_probs_XGBClassifier_jun16.csv
- predicted_labels_probs_RandomForestClassifier_jun16.csv
- predicted_labels_probs_ensemble_jun16.csv
- model_performance_summary.csv
- all_models_prediction_distributions.png
- model_performance_comparison.png
- cv_scores_boxplot.png
- ensemble_prediction_barplot.png
- probability_distributions.png
- ensemble_probability_distribution.png

Analysis complete!
```

[106]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
```

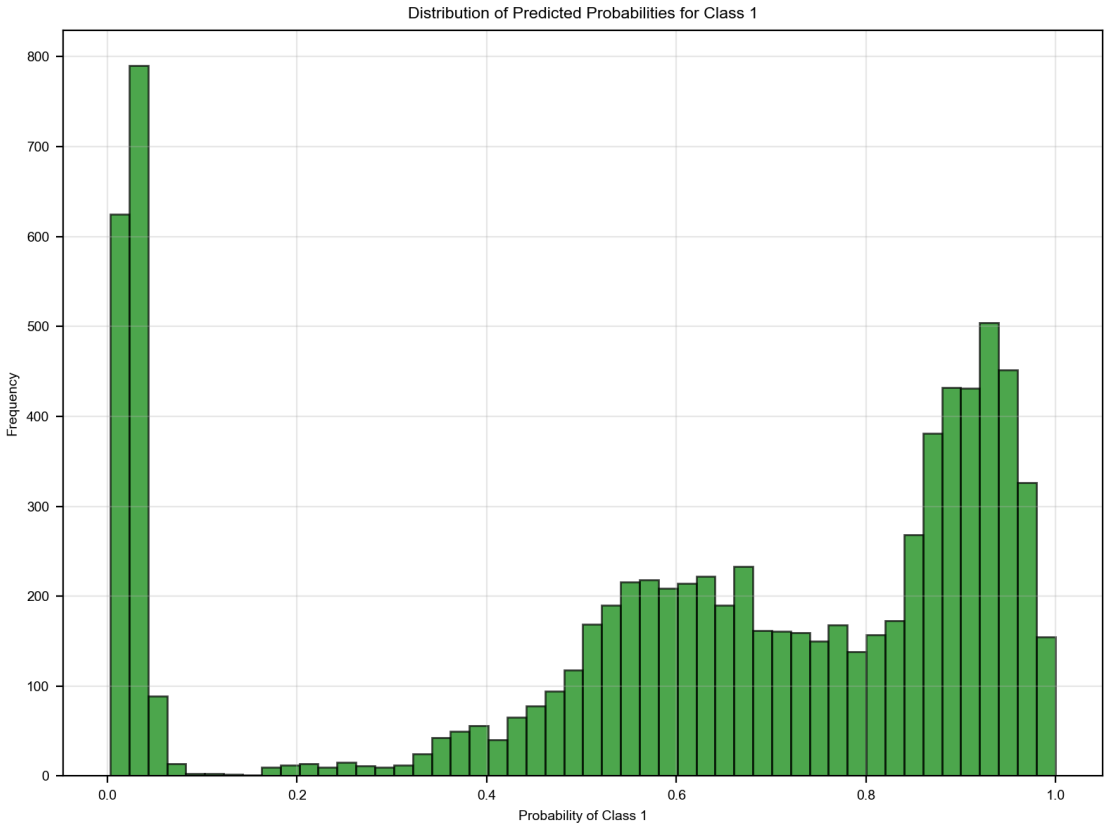
```
from sklearn.ensemble import RandomForestClassifier  # Added missing import
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, precision_recall_curve,␣
 ↪average_precision_score, roc_curve, auc
import matplotlib.pyplot as plt

plt.style.use("default")
# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'

# Define model
# model =  RandomForestClassifier(max_depth=10, random_state=41)
model = RandomForestClassifier(max_depth=10, random_state=41)
np.random.seed(42)  # For reproducibility

# Scale the training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Scale the test data
adata1_scaled = scaler.transform(extracted_columns_1)

# Fit the model on the training data
model.fit(full_X_train_scaled, full_Y_train)

# Predict probabilities for adata1
predicted_probabilities = model.predict_proba(adata1_scaled)

# Predict labels for adata1
predicted_labels = model.predict(adata1_scaled)

# Create output DataFrame with both probabilities and predictions
output_df = pd.DataFrame({
    "Probability_Class_0": predicted_probabilities[:, 0],  # Probability of␣
 ↪class 0
    "Probability_Class_1": predicted_probabilities[:, 1],  # Probability of␣
 ↪class 1
    "Predicted_Label": predicted_labels
})

# Save to CSV file
output_df.to_csv("predicted_probabilities_jun16.csv", index=False)
print("Predicted probabilities and labels saved to␣
 ↪'predicted_probabilities_jun16.csv'.")
```

```
# Display summary statistics
print("\nSummary Statistics:")
print(f"Mean probability for class 1: {predicted_probabilities[:, 1].mean():.
 ↪4f}")
print(f"Min probability for class 1: {predicted_probabilities[:, 1].min():.4f}")
print(f"Max probability for class 1: {predicted_probabilities[:, 1].max():.4f}")

# Calculate percentages for the bar plot
label_counts = pd.Series(predicted_labels).value_counts(normalize=True) * 100 ␣
 ↪# Convert to percentages

# Create a bar plot
plt.figure(figsize=(8, 6))
label_counts.plot(kind='bar', color=['blue', 'orange'], alpha=0.7)
plt.xlabel("Prediction")
plt.ylabel("Percentage")
plt.title("Proportions of Predicted Labels")
plt.xticks([0, 1], labels=['0', '1'], rotation=0)
plt.ylim(0, 100)  # Ensure the y-axis ranges from 0 to 100
plt.tight_layout()

# Add percentage labels on the bars
for i, v in enumerate(label_counts):
    plt.text(i, v + 1, f"{v:.2f}%", ha='center', va='bottom', fontsize=7)

# Save and show the plot
plt.savefig("prediction_percentage_barplot.png", dpi=300)
plt.show()

print("Bar plot of predicted label percentages saved to␣
 ↪'prediction_percentage_barplot.png'.")

# Optional: Create histogram of probabilities for class 1
plt.figure(figsize=(8, 6))
plt.hist(predicted_probabilities[:, 1], bins=50, alpha=0.7, color='green',␣
 ↪edgecolor='black')
plt.xlabel("Probability of Class 1")
plt.ylabel("Frequency")
plt.title("Distribution of Predicted Probabilities for Class 1")
plt.grid(True, alpha=0.3)
plt.tight_layout()
plt.savefig("probability_distribution_class1.png", dpi=300)
plt.show()

print("Probability distribution plot saved to 'probability_distribution_class1.
 ↪png'.")
```

```
Predicted probabilities and labels saved to 'predicted_probabilities_jun16.csv'.

Summary Statistics:
Mean probability for class 1: 0.6145
Min probability for class 1: 0.0031
Max probability for class 1: 0.9995
```




```
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot.png'.
```




```
Probability distribution plot saved to 'probability_distribution_class1.png'.
```

[89]:
```
# Predict labels for adata1
predicted_labels = model.predict(adata1_scaled)

# Save predictions to a CSV file
output_df = pd.DataFrame({"Prediction": predicted_labels})
output_df.to_csv("predicted_labels.csv", index=False)
print("Predicted labels saved to 'dec_3_predicted_labels.csv'.")
```

```
Predicted labels saved to 'dec_3_predicted_labels.csv'.
```

[ ]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, precision_recall_curve,␣
 ↪average_precision_score, roc_curve, auc
```

```
# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'


# LogisticRegression(max_iter=1000, random_state=551),
#         SVC(kernel='linear', probability=True, random_state=551),
#         XGBClassifier(
#             use_label_encoder=False,
#             eval_metric='logloss',
#             n_estimators=100,
#             learning_rate=0.05,
#             max_depth=10,
#             random_state=551
#         ),
#         RandomForestClassifier(max_depth=10, random_state=41)


# Define model
# model = XGBClassifier(
#     use_label_encoder=False,
#     eval_metric='logloss',
#     n_estimators=300,  # set large n_estimators but use early_stopping
#     learning_rate=0.01,
#     max_depth=6,
#     random_state=551
# )500        0.05        6
model =XGBClassifier(
use_label_encoder=False,
            eval_metric='logloss',
            random_state=551,
    n_estimators=500,  # set large n_estimators but use early_stopping
    learning_rate=0.05,
    max_depth=6

)
np.random.seed(42)  # For reproducibility

# Scale the training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Fit the model on the training data
model.fit(full_X_train_scaled, full_Y_train)

# Function to process each dataset
```

```python
def process_and_save(extracted_columns, name):
    # Scale the test data
    adata_scaled = scaler.transform(extracted_columns)

    # Predict labels
    predicted_labels = model.predict(adata_scaled)

    # Save predictions to a CSV file
    output_df = pd.DataFrame({"Prediction": predicted_labels})
    output_file = f"predicted_labels_{name}.csv"
    output_df.to_csv(output_file, index=False)
    print(f"Predicted labels saved to '{output_file}'.")

    # Calculate percentages for the bar plot
    label_counts = pd.Series(predicted_labels).value_counts(normalize=True) *␣
 ↪100  # Convert to percentages

    # Create a bar plot
    label_counts.plot(kind='bar', color=['blue', 'orange'], alpha=0.7)
    plt.xlabel("Prediction")
    plt.ylabel("Percentage")
    plt.title(f"Proportions of Predicted Labels - {name}")
    plt.xticks([0, 1], labels=['0', '1'], rotation=0)
    plt.ylim(0, 100)  # Ensure the y-axis ranges from 0 to 100
    plt.tight_layout()

    # Add percentage labels on the bars
    for i, v in enumerate(label_counts):
        plt.text(i, v + 1, f"{v:.2f}%", ha='center', va='bottom', fontsize=7)

    # Save and show the plot
    plot_file = f"prediction_percentage_barplot_{name}.png"
    plt.savefig(plot_file, dpi=300)
    plt.close()  # Close the plot to avoid overlap in subsequent iterations
    print(f"Bar plot of predicted label percentages saved to '{plot_file}'.")

# Process each dataset
process_and_save(extracted_columns_1, "dataset_1")
process_and_save(extracted_columns_2, "dataset_2")
process_and_save(extracted_columns_3, "dataset_3")
process_and_save(extracted_columns_4, "dataset_4")
```

```
Predicted labels saved to 'predicted_labels_dataset_1.csv'.
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_1.png'.
Predicted labels saved to 'predicted_labels_dataset_2.csv'.
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_2.png'.
```

```
Predicted labels saved to 'predicted_labels_dataset_3.csv'.
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_3.png'.
Predicted labels saved to 'predicted_labels_dataset_4.csv'.
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_4.png'.
```

[211]:
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import rcParams
from xgboost import XGBClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score, precision_recall_curve,␣
 ↪average_precision_score, roc_curve, auc

# Set global font properties
rcParams['font.family'] = 'Arial'
rcParams['font.size'] = 7
rcParams['font.weight'] = 'normal'

# Define model
model = XGBClassifier(
    use_label_encoder=False,
    eval_metric='logloss',
    random_state=551,
    n_estimators=500,
    learning_rate=0.15,
    max_depth=6
)

np.random.seed(42)  # For reproducibility

# Scale the training data
scaler = StandardScaler()
full_X_train_scaled = scaler.fit_transform(full_X_train)

# Fit the model on the training data
model.fit(full_X_train_scaled, full_Y_train)

# Function to process each dataset and print male percentage
def process_and_save(extracted_columns, name):
    # Scale the test data
    adata_scaled = scaler.transform(extracted_columns)

    # Predict labels
    predicted_labels = model.predict(adata_scaled)
```

```
    # Save predictions to a CSV file
    output_df = pd.DataFrame({"Prediction": predicted_labels})
    output_file = f"predicted_labels_{name}.csv"
    output_df.to_csv(output_file, index=False)
    print(f"Predicted labels saved to '{output_file}'.")

    # Calculate percentages for male (label 0)
    label_counts = pd.Series(predicted_labels).value_counts(normalize=True) *␣
↪100  # Convert to percentages
    male_percentage = label_counts.get(0, 0)  # Get male percentage (0),␣
↪default to 0 if missing
    female_percentage = label_counts.get(1, 0)  # Get female percentage (1),␣
↪default to 0 if missing

    print(f"{name} - Male Percentage: {male_percentage:.2f}%, Female Percentage:
↪ {female_percentage:.2f}%")

    # Create a bar plot
    label_counts.plot(kind='bar', color=['blue', 'orange'], alpha=0.7)
    plt.xlabel("Prediction")
    plt.ylabel("Percentage")
    plt.title(f"Proportions of Predicted Labels - {name}")
    plt.xticks([0, 1], labels=['Male', 'Female'], rotation=0)
    plt.ylim(0, 100)  # Ensure the y-axis ranges from 0 to 100
    plt.tight_layout()

    # Add percentage labels on the bars
    for i, v in enumerate(label_counts):
        plt.text(i, v + 1, f"{v:.2f}%", ha='center', va='bottom', fontsize=7)

    # Save and close the plot
    plot_file = f"prediction_percentage_barplot_{name}.png"
    plt.savefig(plot_file, dpi=300)
    plt.close()  # Close the plot to avoid overlap in subsequent iterations
    print(f"Bar plot of predicted label percentages saved to '{plot_file}'.")

# Process each dataset and print male percentages
process_and_save(extracted_columns_1, "dataset_1")
process_and_save(extracted_columns_2, "dataset_2")
process_and_save(extracted_columns_3, "dataset_3")
process_and_save(extracted_columns_4, "dataset_4")
```

```
Predicted labels saved to 'predicted_labels_dataset_1.csv'.
dataset_1 - Male Percentage: 34.41%, Female Percentage: 65.59%
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_1.png'.
```

```
Predicted labels saved to 'predicted_labels_dataset_2.csv'.
dataset_2 - Male Percentage: 43.95%, Female Percentage: 56.05%
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_2.png'.
Predicted labels saved to 'predicted_labels_dataset_3.csv'.
dataset_3 - Male Percentage: 28.82%, Female Percentage: 71.18%
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_3.png'.
Predicted labels saved to 'predicted_labels_dataset_4.csv'.
dataset_4 - Male Percentage: 32.60%, Female Percentage: 67.40%
Bar plot of predicted label percentages saved to
'prediction_percentage_barplot_dataset_4.png'.
```