

## Supplementary Table

Table S1: Notation and Definitions of Mathematical Variables

Symbol	Description
$x_{rx\_rx}$	Input radiograph image
$x_{wx\_wx}$	Whole-slide image (WSI) represented as a bag of tiles
$x_{ox\_ox}$	Omics feature vector (RNA-seq ± mutation data)
$y_{yy}$	Ground-truth class label (cancer / normal)
$fr(\cdot)_r(\cdot)$	Radiography encoder network (ViT/Swin)
$fw(\cdot)_w(\cdot)$	WSI tile encoder network
$fo(\cdot)_o(\cdot)$	Omics encoder network (VAE/MLP)
$z_r, z_w, z_o, z_r, z_w, z_o, z_r, z_w, z_o$	Latent embeddings from radiograph, WSI, and omics streams
$y^r, y^w, y^o, \hat{y}_r, \hat{y}_w, \hat{y}_o, y^r, y^w, y^o$	Modality-specific predicted probabilities
$\theta_r, \theta_w, \theta_o, \theta_r, \theta_w, \theta_o$	Trainable parameters of radiograph, WSI, and omics models
$a_{i,i}$	Attention weight for the $i$ -th WSI tile
$\lambda_{ent}$	Weight of the entropy-based regularization term in MIL
$L_{CE}$	Cross-entropy classification loss
$L_{focal}$	Focal loss used to address class imbalance
$L_{MMD}$	Maximum Mean Discrepancy loss for distribution alignment
$L_{InfoNCE}$	Contrastive loss for instance-level latent alignment
$\tau$	Temperature parameter in the InfoNCE contrastive loss
$\alpha_m$	Reliability weight assigned to modality $m$ during late fusion
$H(\cdot)$	Predictive entropy used as an uncertainty measure
$T$	Temperature parameter for probability calibration
$\hat{p}$	Calibrated predicted probability
$\theta^*$	Optimal decision threshold selected via utility maximization
$U$	Expected clinical utility function
$\pi$	Estimated disease prevalence