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```
Training: 100%|██████████████████████████████████████| 163/163 [00:26<00:00,  
6.10it/s, loss=0.189]
```

Evaluating:

100% | 1/1

[00:00<00:00, 2.52it/s]

Train Loss: 0.3100, Train Acc: 0.8760

Val Loss: 1.9708, Val Acc: 0.5000, Val AUC: 0.8594

Epoch 2/15

```
Training: 100%|██████████████████████████████████████| 163/163 [00:27<00:00,  
5.98it/s, loss=0.488]
```

Evaluating:

[illegible]

[00:00<00:00, 2.66it/s]

Train Loss: 0.2341, Train Acc: 0.9093

Val Loss: 1.8152, Val Acc: 0.5000, Val AUC: 0.8594

Epoch 3/15

```
Training: 100%|██████████████████████████████████████| 163/163 [00:26<00:00,  
6.06it/s, loss=0.139]
```

Evaluating:

100% | 1/1

[00:00<00:00, 2.66it/s]

Train Loss: 0.2279, Train Acc: 0.9089

Val Loss: 1.1969, Val Acc: 0.6250, Val AUC: 0.9062

Epoch 4/15

```
Training: 100%|██████████████████████████████████████| 163/163 [00:26<00:00,  
6.08it/s, loss=0.158]
```

Evaluating:

100% | 1/1

[00:00<00:00, 2.65it/s]

Train Loss: 0.2262, Train Acc: 0.9089

Val Loss: 1.6458, Val Acc: 0.5000, Val AUC: 0.9062

Epoch 5/15

[illegible]

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[00:26<00:00, 6.06it/s, loss=0.15]
```

Evaluating:

100% | 1/1

[00:00<00:00, 2.65it/s]

Train Loss: 0.2207, Train Acc: 0.9109
 Val Loss: 1.3981, Val Acc: 0.6250, Val AUC: 0.9375



Epoch 6/15

 Training: 100% 163/163 [00:27<00:00, 5.92it/s, loss=0.249]
 Evaluating:
 100% 1/1
 [00:00<00:00, 2.65it/s]
 Train Loss: 0.2073, Train Acc: 0.9166
 Val Loss: 2.0710, Val Acc: 0.5000, Val AUC: 0.8438

Epoch 7/15

 Training: 100% 163/163 [00:26<00:00, 6.09it/s, loss=0.321]
 Evaluating:
 100% 1/1
 [00:00<00:00, 2.66it/s]
 Train Loss: 0.1978, Train Acc: 0.9179
 Val Loss: 2.4053, Val Acc: 0.5000, Val AUC: 0.8438

Epoch 8/15

 Training: 100% 163/163 [00:26<00:00, 6.04it/s, loss=0.276]
 Evaluating:
 100% 1/1
 [00:00<00:00, 2.65it/s]
 Train Loss: 0.1960, Train Acc: 0.9218
 Val Loss: 1.8553, Val Acc: 0.5625, Val AUC: 0.8906
 Early stopping triggered at epoch 8

Best Validation AUC: 0.9375

Baseline model saved to models/resnet50_baseline.pth

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 STAGE 2: Progressive Unfreezing - Stage 1
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Unfrozen last 20 layers

Trainable parameters: 9,979,394

Training stage: stage_1

Epochs: 15, Learning rate: 0.0001

Epoch 1/15

Training: 100%  163/163 [00:27<00:00, 6.01it/s, loss=0.165]

Evaluating:

100%  1/1
[00:00<00:00, 2.53it/s]

Train Loss: 0.1752, Train Acc: 0.9317

Val Loss: 2.1222, Val Acc: 0.5625, Val AUC: 0.9062

Epoch 2/15

Training: 100%  163/163 [00:26<00:00, 6.14it/s, loss=0.179]

Evaluating:

100%  1/1
[00:00<00:00, 2.52it/s]

Train Loss: 0.1877, Train Acc: 0.9271

Val Loss: 1.8448, Val Acc: 0.5625, Val AUC: 0.8906

Epoch 3/15

Training: 100%  163/163 [00:26<00:00, 6.14it/s, loss=0.114]

Evaluating:

100%  1/1
[00:00<00:00, 2.53it/s]

Train Loss: 0.1607, Train Acc: 0.9377

Val Loss: 2.2626, Val Acc: 0.5625, Val AUC: 0.9219

Epoch 4/15



Training: 100%  163/163 [00:27<00:00, 5.94it/s, loss=0.164]

Evaluating:

100%  1/1
[00:00<00:00, 2.52it/s]

Train Loss: 0.1554, Train Acc: 0.9404
 Val Loss: 2.1609, Val Acc: 0.5000, Val AUC: 0.9219



Epoch 5/15

 Training: 100% 163/163 [00:26<00:00,
 6.08it/s, loss=0.0551]
 Evaluating:
 100% | 1/1
 [00:00<00:00, 2.52it/s]
 Train Loss: 0.1521, Train Acc: 0.9450
 Val Loss: 1.8661, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 6/15

 Training: 100% 163/163 [00:27<00:00,
 6.03it/s, loss=0.343]
 Evaluating:
 100% | 1/1
 [00:00<00:00, 2.54it/s]
 Train Loss: 0.1484, Train Acc: 0.9417
 Val Loss: 2.3928, Val Acc: 0.5000, Val AUC: 0.9375

Epoch 7/15

 Training: 100% 163/163 [00:27<00:00,
 6.02it/s, loss=0.0423]
 Evaluating:
 100% | 1/1
 [00:00<00:00, 2.52it/s]
 Train Loss: 0.1404, Train Acc: 0.9450
 Val Loss: 2.4182, Val Acc: 0.5000, Val AUC: 0.9062
 Early stopping triggered at epoch 7

Best Validation AUC: 0.9531

Stage 1 model saved to models/resnet50_stage1.pth

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 STAGE 3: Progressive Unfreezing - Stage 2
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Unfrozen last 50 layers

Trainable parameters: 18,251,266

Training stage: stage_2

Epochs: 15, Learning rate: 1e-05

Epoch 1/15

Training: 100%  163/163 [00:26<00:00, 6.06it/s, loss=0.117]

Evaluating:

100%  1/1
[00:00<00:00, 2.60it/s]

Train Loss: 0.1252, Train Acc: 0.9486

Val Loss: 2.6821, Val Acc: 0.5000, Val AUC: 0.9219

Epoch 2/15

Training: 100%  163/163 [00:26<00:00, 6.16it/s, loss=0.145]

Evaluating:

100%  1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1293, Train Acc: 0.9509

Val Loss: 2.4331, Val Acc: 0.5000, Val AUC: 0.9062

Epoch 3/15

Training: 100%  163/163 [00:26<00:00, 6.14it/s, loss=0.223]

Evaluating:

100%  1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1375, Train Acc: 0.9507

Val Loss: 2.4886, Val Acc: 0.5000, Val AUC: 0.9219

Epoch 4/15

Training: 100%  163/163 [00:26<00:00, 6.12it/s, loss=0.349]

Evaluating:

100%  1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1282, Train Acc: 0.9475
Val Loss: 2.6990, Val Acc: 0.5000, Val AUC: 0.9219

Epoch 5/15

```
Training: 100%|████████████████████████████████████████| 163/163 [00:26<00:00,
6.04it/s, loss=0.0757]
```

Evaluating:

100% | 1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1224, Train Acc: 0.9521

Val Loss: 2.8557, Val Acc: 0.5000, Val AUC: 0.9219

Epoch 6/15

```
Training: 100%|██████████████████████████████████████| 163/163 [00:27<00:00,  
6.01it/s, loss=0.264]
```

Evaluating:

100% | 1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1255, Train Acc: 0.9490

Val Loss: 2.8795, Val Acc: 0.5000, Val AUC: 0.9219

Epoch 7/15

```
Training: 100%|██████████████████████████████████████| 163/163 [00:26<00:00,  
6.05it/s, loss=0.129]
```

Evaluating:

100% | 1/1
[00:00<00:00, 2.59it/s]

Train Loss: 0.1219, Train Acc: 0.9538

Val Loss: 2.6783, Val Acc: 0.5000, Val AUC: 0.9062

Early stopping triggered at epoch 7

Best Validation AUC: 0.9219

Final model saved to models/resnet50_final.pth

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FINAL EVALUATION ON TEST SET
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Evaluating: 100%
20/20 [00:03<00:00, 5.95it/s]

Test Metrics:

loss: 1.1768

accuracy: 0.6715

auc: 0.9230

f1_score: 0.7915

precision: 0.6560

recall: 0.9974

sensitivity: 0.9974

specificity: 0.1282

Results saved to results/resnet50_test_results.txt

Training completed successfully!