

# IC50\_Prediction\_with\_cells\_Submission

May 13, 2025

## 1 Simple feed forward NN to predict IC50 based on patient demographic and molecular drug information (INCLUDES CELL LINE FEATURE FOR TRAINING)

```
[2]: from CHEM277B_functions import *
```

```
[3]: valid_IC50s = pd.read_csv("data/valid_IC50s_within_range.csv")
merged_df = pd.read_csv("data/final_merged_imputed_race_CSV.csv")
lucas_df = pd.read_csv("data/Raw_Mapping_Imputed_Race.csv")
cell_lines_df = pd.read_csv("data/HarvardCellLines.csv")
```

```
/var/folders/s8/ghqk1l4n7n9_w17t7hx21g2m0000gn/T/ipykernel_12486/1684730604.py:2
: DtypeWarning: Columns (3,4,5,6,7,9,12,15,16,17,18,22,24,26,28,29,30,67) have
mixed types. Specify dtype option on import or set low_memory=False.
merged_df = pd.read_csv("final_merged_imputed_race_CSV.csv")
```

```
[4]: valid_IC50s.drop(columns = ['Unnamed: 0', 'N Points'], inplace = True)
```

```
[5]: columns = ["HMS LINCS Batch ID", "Name", "T Stage"]
cell_lines_df = cell_lines_df[columns]
```

## 2 USE LUCAS' DATASET STARTING HERE

```
[7]: merged_df['T_stage_by_size'] = merged_df.apply(lambda row: row['T Stage'] if pd.
↪notnull(row['T Stage']) else T_stage_by_size(row['Tumor Size']), axis=1)
```

```
[8]: columns = ['Age', 'Race', 'T_stage_by_size']
patients_df = merged_df[columns]
```

```
[9]: patients_df["cell_lines"] = lucas_df["Matched Cell Line ID"]
```

```
/var/folders/s8/ghqk1l4n7n9_w17t7hx21g2m0000gn/T/ipykernel_12486/3231217547.py:1
: 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](https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)  
patients\_df["cell\_lines"] = lucas\_df["Matched Cell Line ID"]

```
[11]: cell_lines_df_dict = cell_lines_df.set_index("HMS LINCS Batch ID").  
      ↪to_dict()["Name"]
```

```
[13]: def mapping(row, dictionary):  
      ↪return dictionary[row]
```

```
[14]: patients_df["Cell Name"] = patients_df["cell_lines"].apply(mapping, dictionary_  
      ↪= cell_lines_df_dict)
```

```
/var/folders/s8/ghqk1l4n7n9_w17t7hx21g2m0000gn/T/ipykernel_12486/1850949227.py:1  
: 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](https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)  
patients\_df["Cell Name"] = patients\_df["cell\_lines"].apply(mapping, dictionary\_  
= cell\_lines\_df\_dict)

```
[15]: patients_df.dropna(inplace=True)  
      ↪patients_df.isna().sum()
```

```
/var/folders/s8/ghqk1l4n7n9_w17t7hx21g2m0000gn/T/ipykernel_12486/2483854490.py:1  
: SettingWithCopyWarning:  
A value is trying to be set on a copy of a slice from a DataFrame
```

See the caveats in the documentation: [https://pandas.pydata.org/pandas-docs/stable/user\\_guide/indexing.html#returning-a-view-versus-a-copy](https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)  
patients\_df.dropna(inplace=True)

```
[15]: Age          0  
      Race          0  
      T_stage_by_size  0  
      cell_lines     0  
      Cell Name     0  
      dtype: int64
```

### 3 Add Small Molecule descriptors for each row.

```
[17]: drugs_df = pd.read_csv("Descriptors_Small_Molecules.csv")
drugs_df = drugs_df[['Name', 'Molecular Mass', 'LogP', 'NumHDonors',
↳ 'NumHAcceptors', 'TPSA']]
drugs_df.rename(columns={'Name': 'Small Molecule Name'}, inplace=True)

[18]: valid_IC50s = pd.merge(valid_IC50s, drugs_df, on='Small Molecule Name',
↳ how='left')

[19]: patient_drug_df = pd.merge(patients_df, valid_IC50s, on='Cell Name', how='left')

[20]: patient_drug_df.drop(columns = "cell_lines", inplace=True)

[21]: patient_drug_df.to_csv("patient_drug_information_aka_final_final_final.csv")

[22]: race_dict = {0:'N/A', 1:"white", 2:"black", 3:"asian", 4:"native", 5:
↳ "hispanic", 6:"multi", 7:"hawa", 8:"amer indian"}

[23]: patient_drug_df["Race"] = patient_drug_df["Race"].apply(mapping, dictionary =
↳ race_dict)
```

**3.0.1 Cell lines are proxy for patients, so drop the cell lines column.**

**3.0.2 Need to one-hot-encode categorical features**

```
[42]: categorical_cols = ['Race', 'T_stage_by_size', 'Small Molecule Name', 'Cell_
↳ Name']
patient_drug_df[categorical_cols] = patient_drug_df[categorical_cols].
↳ astype('category')

[44]: patient_drug_df_encoded = pd.get_dummies(patient_drug_df,
↳ columns=categorical_cols, drop_first=True)

[46]: bool_cols = patient_drug_df_encoded.select_dtypes(include='bool').columns
patient_drug_df_encoded[bool_cols] = patient_drug_df_encoded[bool_cols].
↳ astype(int)
```

**3.0.3 PRE-PROCESSING DONE. ONTO MODEL TRAINING.**

```
[49]: # Separate features (X) and target (y)
X = patient_drug_df_encoded.drop(columns=['EC50 (uM)']) # Drop EC50 and
↳ non-features
y = patient_drug_df_encoded['EC50 (uM)'] # EC50 is the target

# Standardize numerical features
scaler = StandardScaler()
```

```
X[['Age', 'Molecular Mass', 'LogP', 'NumHDonors', 'NumHAcceptors', 'TPSA']] = scaler.fit_transform(X[['Age', 'Molecular Mass', 'LogP', 'NumHDonors', 'NumHAcceptors', 'TPSA']])
```

```
[51]: # Train/Test Split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

```
[53]: # FEED FORWARD NEURAL NETWORK
class DrugEncoder(nn.Module):
    def __init__(self, input_dim=5): # 5 molecular descriptors
        super().__init__()
        self.encoder = nn.Sequential(
            nn.Linear(input_dim, 32),
            nn.ReLU(),
            nn.Linear(32, 32)
        )

    def forward(self, x):
        return self.encoder(x.float())

# SIMPLE FEED FORWARD NEURAL NETWORK
class PatientEncoder(nn.Module):
    def __init__(self, input_dim):
        super().__init__()
        self.encoder = nn.Sequential(
            nn.Linear(input_dim, 32),
            nn.ReLU(),
            nn.Linear(32, 32)
        )

    def forward(self, x):
        return self.encoder(x.float())

# REGRESSION PREDICTION WITH SIMPLE FEED FORWARD NEURAL NETWORK
class DrugResponsePredictor(nn.Module):
    def __init__(self, drug_input_dim, patient_input_dim):
        super().__init__()
        self.drug_encoder = DrugEncoder(drug_input_dim)
        self.patient_encoder = PatientEncoder(patient_input_dim)
        self.fc = nn.Sequential(
            nn.Linear(32 + 32, 32),
            nn.ReLU(),
            nn.Linear(32, 1) # IC50 prediction
        )
```

```

def forward(self, drug_feat, patient_feat):
    drug_vec = self.drug_encoder(drug_feat)
    patient_vec = self.patient_encoder(patient_feat)
    combined = torch.cat([drug_vec, patient_vec], dim=1)
    return self.fc(combined).squeeze(-1)

```

```

[55]: # Data
# Select drug descriptor columns
drug_feature_cols = ['Molecular Mass', 'LogP', 'NumHDonors', 'NumHAcceptors',
    ↪ 'TPSA']
drug_features = X_train[drug_feature_cols].to_numpy() # (n_samples, 5)

# Drop drug features to get patient features
patient_features = X_train.drop(columns=drug_feature_cols).to_numpy()

# Convert to tensors
drug_tensor = torch.tensor(drug_features).float()
patient_tensor = torch.tensor(patient_features).float()
ic50_tensor = torch.tensor(y_train.to_numpy()).float()

model = DrugResponsePredictor(drug_input_dim=5,
    ↪ patient_input_dim=patient_tensor.shape[1])
optimizer = torch.optim.Adam(model.parameters(), lr=1e-3)
loss_fn = nn.MSELoss()

# Training loop
model.train()
start_time = time.time()

my_epochs = []
my_losses = []

for epoch in range(500):
    optimizer.zero_grad()
    preds = model(drug_tensor, patient_tensor)
    loss = loss_fn(preds, ic50_tensor)
    loss.backward()
    optimizer.step()
    end_time = time.time()
    elapsed = end_time - start_time
    print(f"Epoch {epoch} | Loss: {loss.item():.4f}")
    print(f"Time elapsed: {elapsed:.2f} seconds")
    my_epochs.append(epoch)
    my_losses.append(loss.item())

```

Epoch 0 | Loss: 3.2312

Time elapsed: 0.06 seconds  
Epoch 1 | Loss: 3.1874  
Time elapsed: 0.10 seconds  
Epoch 2 | Loss: 3.1462  
Time elapsed: 0.13 seconds  
Epoch 3 | Loss: 3.1065  
Time elapsed: 0.16 seconds  
Epoch 4 | Loss: 3.0681  
Time elapsed: 0.20 seconds  
Epoch 5 | Loss: 3.0308  
Time elapsed: 0.23 seconds  
Epoch 6 | Loss: 2.9941  
Time elapsed: 0.26 seconds  
Epoch 7 | Loss: 2.9579  
Time elapsed: 0.30 seconds  
Epoch 8 | Loss: 2.9220  
Time elapsed: 0.33 seconds  
Epoch 9 | Loss: 2.8867  
Time elapsed: 0.36 seconds  
Epoch 10 | Loss: 2.8524  
Time elapsed: 0.40 seconds  
Epoch 11 | Loss: 2.8190  
Time elapsed: 0.43 seconds  
Epoch 12 | Loss: 2.7866  
Time elapsed: 0.46 seconds  
Epoch 13 | Loss: 2.7546  
Time elapsed: 0.50 seconds  
Epoch 14 | Loss: 2.7230  
Time elapsed: 0.53 seconds  
Epoch 15 | Loss: 2.6914  
Time elapsed: 0.56 seconds  
Epoch 16 | Loss: 2.6596  
Time elapsed: 0.59 seconds  
Epoch 17 | Loss: 2.6275  
Time elapsed: 0.63 seconds  
Epoch 18 | Loss: 2.5950  
Time elapsed: 0.66 seconds  
Epoch 19 | Loss: 2.5623  
Time elapsed: 0.69 seconds  
Epoch 20 | Loss: 2.5291  
Time elapsed: 0.73 seconds  
Epoch 21 | Loss: 2.4955  
Time elapsed: 0.76 seconds  
Epoch 22 | Loss: 2.4616  
Time elapsed: 0.79 seconds  
Epoch 23 | Loss: 2.4276  
Time elapsed: 0.82 seconds  
Epoch 24 | Loss: 2.3936

Time elapsed: 0.85 seconds  
Epoch 25 | Loss: 2.3598  
Time elapsed: 0.88 seconds  
Epoch 26 | Loss: 2.3263  
Time elapsed: 0.92 seconds  
Epoch 27 | Loss: 2.2932  
Time elapsed: 0.95 seconds  
Epoch 28 | Loss: 2.2607  
Time elapsed: 0.98 seconds  
Epoch 29 | Loss: 2.2290  
Time elapsed: 1.01 seconds  
Epoch 30 | Loss: 2.1983  
Time elapsed: 1.05 seconds  
Epoch 31 | Loss: 2.1688  
Time elapsed: 1.08 seconds  
Epoch 32 | Loss: 2.1408  
Time elapsed: 1.11 seconds  
Epoch 33 | Loss: 2.1145  
Time elapsed: 1.14 seconds  
Epoch 34 | Loss: 2.0903  
Time elapsed: 1.17 seconds  
Epoch 35 | Loss: 2.0683  
Time elapsed: 1.21 seconds  
Epoch 36 | Loss: 2.0486  
Time elapsed: 1.24 seconds  
Epoch 37 | Loss: 2.0316  
Time elapsed: 1.27 seconds  
Epoch 38 | Loss: 2.0171  
Time elapsed: 1.30 seconds  
Epoch 39 | Loss: 2.0051  
Time elapsed: 1.33 seconds  
Epoch 40 | Loss: 1.9954  
Time elapsed: 1.37 seconds  
Epoch 41 | Loss: 1.9876  
Time elapsed: 1.40 seconds  
Epoch 42 | Loss: 1.9811  
Time elapsed: 1.43 seconds  
Epoch 43 | Loss: 1.9755  
Time elapsed: 1.46 seconds  
Epoch 44 | Loss: 1.9700  
Time elapsed: 1.49 seconds  
Epoch 45 | Loss: 1.9643  
Time elapsed: 1.53 seconds  
Epoch 46 | Loss: 1.9581  
Time elapsed: 1.56 seconds  
Epoch 47 | Loss: 1.9510  
Time elapsed: 1.59 seconds  
Epoch 48 | Loss: 1.9431

Time elapsed: 1.62 seconds  
Epoch 49 | Loss: 1.9345  
Time elapsed: 1.65 seconds  
Epoch 50 | Loss: 1.9254  
Time elapsed: 1.69 seconds  
Epoch 51 | Loss: 1.9157  
Time elapsed: 1.72 seconds  
Epoch 52 | Loss: 1.9058  
Time elapsed: 1.75 seconds  
Epoch 53 | Loss: 1.8957  
Time elapsed: 1.78 seconds  
Epoch 54 | Loss: 1.8857  
Time elapsed: 1.82 seconds  
Epoch 55 | Loss: 1.8758  
Time elapsed: 1.85 seconds  
Epoch 56 | Loss: 1.8660  
Time elapsed: 1.88 seconds  
Epoch 57 | Loss: 1.8563  
Time elapsed: 1.91 seconds  
Epoch 58 | Loss: 1.8467  
Time elapsed: 1.94 seconds  
Epoch 59 | Loss: 1.8370  
Time elapsed: 1.98 seconds  
Epoch 60 | Loss: 1.8271  
Time elapsed: 2.01 seconds  
Epoch 61 | Loss: 1.8170  
Time elapsed: 2.04 seconds  
Epoch 62 | Loss: 1.8066  
Time elapsed: 2.07 seconds  
Epoch 63 | Loss: 1.7957  
Time elapsed: 2.11 seconds  
Epoch 64 | Loss: 1.7844  
Time elapsed: 2.14 seconds  
Epoch 65 | Loss: 1.7726  
Time elapsed: 2.17 seconds  
Epoch 66 | Loss: 1.7603  
Time elapsed: 2.20 seconds  
Epoch 67 | Loss: 1.7475  
Time elapsed: 2.24 seconds  
Epoch 68 | Loss: 1.7342  
Time elapsed: 2.27 seconds  
Epoch 69 | Loss: 1.7206  
Time elapsed: 2.30 seconds  
Epoch 70 | Loss: 1.7067  
Time elapsed: 2.33 seconds  
Epoch 71 | Loss: 1.6923  
Time elapsed: 2.37 seconds  
Epoch 72 | Loss: 1.6776



Time elapsed: 2.40 seconds  
Epoch 73 | Loss: 1.6626  
Time elapsed: 2.43 seconds  
Epoch 74 | Loss: 1.6471  
Time elapsed: 2.46 seconds  
Epoch 75 | Loss: 1.6312  
Time elapsed: 2.49 seconds  
Epoch 76 | Loss: 1.6146  
Time elapsed: 2.52 seconds  
Epoch 77 | Loss: 1.5974  
Time elapsed: 2.56 seconds  
Epoch 78 | Loss: 1.5796  
Time elapsed: 2.59 seconds  
Epoch 79 | Loss: 1.5610  
Time elapsed: 2.62 seconds  
Epoch 80 | Loss: 1.5416  
Time elapsed: 2.65 seconds  
Epoch 81 | Loss: 1.5213  
Time elapsed: 2.69 seconds  
Epoch 82 | Loss: 1.5004  
Time elapsed: 2.72 seconds  
Epoch 83 | Loss: 1.4792  
Time elapsed: 2.75 seconds  
Epoch 84 | Loss: 1.4575  
Time elapsed: 2.78 seconds  
Epoch 85 | Loss: 1.4352  
Time elapsed: 2.82 seconds  
Epoch 86 | Loss: 1.4121  
Time elapsed: 2.85 seconds  
Epoch 87 | Loss: 1.3883  
Time elapsed: 2.88 seconds  
Epoch 88 | Loss: 1.3637  
Time elapsed: 2.91 seconds  
Epoch 89 | Loss: 1.3387  
Time elapsed: 2.94 seconds  
Epoch 90 | Loss: 1.3135  
Time elapsed: 2.98 seconds  
Epoch 91 | Loss: 1.2879  
Time elapsed: 3.01 seconds  
Epoch 92 | Loss: 1.2620  
Time elapsed: 3.04 seconds  
Epoch 93 | Loss: 1.2357  
Time elapsed: 3.07 seconds  
Epoch 94 | Loss: 1.2092  
Time elapsed: 3.10 seconds  
Epoch 95 | Loss: 1.1826  
Time elapsed: 3.14 seconds  
Epoch 96 | Loss: 1.1559

Time elapsed: 3.17 seconds  
Epoch 97 | Loss: 1.1294  
Time elapsed: 3.20 seconds  
Epoch 98 | Loss: 1.1032  
Time elapsed: 3.23 seconds  
Epoch 99 | Loss: 1.0775  
Time elapsed: 3.26 seconds  
Epoch 100 | Loss: 1.0526  
Time elapsed: 3.30 seconds  
Epoch 101 | Loss: 1.0285  
Time elapsed: 3.33 seconds  
Epoch 102 | Loss: 1.0054  
Time elapsed: 3.36 seconds  
Epoch 103 | Loss: 0.9833  
Time elapsed: 3.39 seconds  
Epoch 104 | Loss: 0.9624  
Time elapsed: 3.42 seconds  
Epoch 105 | Loss: 0.9428  
Time elapsed: 3.45 seconds  
Epoch 106 | Loss: 0.9246  
Time elapsed: 3.49 seconds  
Epoch 107 | Loss: 0.9079  
Time elapsed: 3.52 seconds  
Epoch 108 | Loss: 0.8925  
Time elapsed: 3.55 seconds  
Epoch 109 | Loss: 0.8785  
Time elapsed: 3.58 seconds  
Epoch 110 | Loss: 0.8659  
Time elapsed: 3.61 seconds  
Epoch 111 | Loss: 0.8545  
Time elapsed: 3.64 seconds  
Epoch 112 | Loss: 0.8442  
Time elapsed: 3.68 seconds  
Epoch 113 | Loss: 0.8348  
Time elapsed: 3.71 seconds  
Epoch 114 | Loss: 0.8261  
Time elapsed: 3.74 seconds  
Epoch 115 | Loss: 0.8182  
Time elapsed: 3.77 seconds  
Epoch 116 | Loss: 0.8107  
Time elapsed: 3.80 seconds  
Epoch 117 | Loss: 0.8035  
Time elapsed: 3.83 seconds  
Epoch 118 | Loss: 0.7964  
Time elapsed: 3.87 seconds  
Epoch 119 | Loss: 0.7897  
Time elapsed: 3.90 seconds  
Epoch 120 | Loss: 0.7826

Time elapsed: 3.93 seconds  
Epoch 121 | Loss: 0.7758  
Time elapsed: 3.96 seconds  
Epoch 122 | Loss: 0.7688  
Time elapsed: 3.99 seconds  
Epoch 123 | Loss: 0.7617  
Time elapsed: 4.02 seconds  
Epoch 124 | Loss: 0.7545  
Time elapsed: 4.06 seconds  
Epoch 125 | Loss: 0.7473  
Time elapsed: 4.09 seconds  
Epoch 126 | Loss: 0.7401  
Time elapsed: 4.12 seconds  
Epoch 127 | Loss: 0.7329  
Time elapsed: 4.15 seconds  
Epoch 128 | Loss: 0.7259  
Time elapsed: 4.18 seconds  
Epoch 129 | Loss: 0.7189  
Time elapsed: 4.21 seconds  
Epoch 130 | Loss: 0.7120  
Time elapsed: 4.25 seconds  
Epoch 131 | Loss: 0.7053  
Time elapsed: 4.28 seconds  
Epoch 132 | Loss: 0.6988  
Time elapsed: 4.31 seconds  
Epoch 133 | Loss: 0.6924  
Time elapsed: 4.34 seconds  
Epoch 134 | Loss: 0.6861  
Time elapsed: 4.37 seconds  
Epoch 135 | Loss: 0.6799  
Time elapsed: 4.41 seconds  
Epoch 136 | Loss: 0.6737  
Time elapsed: 4.44 seconds  
Epoch 137 | Loss: 0.6675  
Time elapsed: 4.47 seconds  
Epoch 138 | Loss: 0.6614  
Time elapsed: 4.50 seconds  
Epoch 139 | Loss: 0.6551  
Time elapsed: 4.53 seconds  
Epoch 140 | Loss: 0.6490  
Time elapsed: 4.56 seconds  
Epoch 141 | Loss: 0.6429  
Time elapsed: 4.59 seconds  
Epoch 142 | Loss: 0.6369  
Time elapsed: 4.63 seconds  
Epoch 143 | Loss: 0.6307  
Time elapsed: 4.66 seconds  
Epoch 144 | Loss: 0.6245

Time elapsed: 4.69 seconds  
Epoch 145 | Loss: 0.6183  
Time elapsed: 4.72 seconds  
Epoch 146 | Loss: 0.6120  
Time elapsed: 4.75 seconds  
Epoch 147 | Loss: 0.6057  
Time elapsed: 4.78 seconds  
Epoch 148 | Loss: 0.5994  
Time elapsed: 4.82 seconds  
Epoch 149 | Loss: 0.5930  
Time elapsed: 4.85 seconds  
Epoch 150 | Loss: 0.5867  
Time elapsed: 4.88 seconds  
Epoch 151 | Loss: 0.5803  
Time elapsed: 4.91 seconds  
Epoch 152 | Loss: 0.5740  
Time elapsed: 4.95 seconds  
Epoch 153 | Loss: 0.5676  
Time elapsed: 4.98 seconds  
Epoch 154 | Loss: 0.5612  
Time elapsed: 5.01 seconds  
Epoch 155 | Loss: 0.5548  
Time elapsed: 5.04 seconds  
Epoch 156 | Loss: 0.5483  
Time elapsed: 5.07 seconds  
Epoch 157 | Loss: 0.5419  
Time elapsed: 5.10 seconds  
Epoch 158 | Loss: 0.5356  
Time elapsed: 5.14 seconds  
Epoch 159 | Loss: 0.5292  
Time elapsed: 5.17 seconds  
Epoch 160 | Loss: 0.5229  
Time elapsed: 5.20 seconds  
Epoch 161 | Loss: 0.5167  
Time elapsed: 5.23 seconds  
Epoch 162 | Loss: 0.5104  
Time elapsed: 5.26 seconds  
Epoch 163 | Loss: 0.5042  
Time elapsed: 5.29 seconds  
Epoch 164 | Loss: 0.4980  
Time elapsed: 5.32 seconds  
Epoch 165 | Loss: 0.4918  
Time elapsed: 5.36 seconds  
Epoch 166 | Loss: 0.4856  
Time elapsed: 5.39 seconds  
Epoch 167 | Loss: 0.4794  
Time elapsed: 5.42 seconds  
Epoch 168 | Loss: 0.4732

Time elapsed: 5.45 seconds  
Epoch 169 | Loss: 0.4670  
Time elapsed: 5.49 seconds  
Epoch 170 | Loss: 0.4608  
Time elapsed: 5.52 seconds  
Epoch 171 | Loss: 0.4547  
Time elapsed: 5.55 seconds  
Epoch 172 | Loss: 0.4486  
Time elapsed: 5.58 seconds  
Epoch 173 | Loss: 0.4425  
Time elapsed: 5.61 seconds  
Epoch 174 | Loss: 0.4364  
Time elapsed: 5.64 seconds  
Epoch 175 | Loss: 0.4303  
Time elapsed: 5.68 seconds  
Epoch 176 | Loss: 0.4243  
Time elapsed: 5.71 seconds  
Epoch 177 | Loss: 0.4184  
Time elapsed: 5.74 seconds  
Epoch 178 | Loss: 0.4124  
Time elapsed: 5.77 seconds  
Epoch 179 | Loss: 0.4066  
Time elapsed: 5.80 seconds  
Epoch 180 | Loss: 0.4008  
Time elapsed: 5.84 seconds  
Epoch 181 | Loss: 0.3950  
Time elapsed: 5.87 seconds  
Epoch 182 | Loss: 0.3893  
Time elapsed: 5.90 seconds  
Epoch 183 | Loss: 0.3837  
Time elapsed: 5.93 seconds  
Epoch 184 | Loss: 0.3781  
Time elapsed: 5.96 seconds  
Epoch 185 | Loss: 0.3727  
Time elapsed: 6.00 seconds  
Epoch 186 | Loss: 0.3673  
Time elapsed: 6.03 seconds  
Epoch 187 | Loss: 0.3619  
Time elapsed: 6.06 seconds  
Epoch 188 | Loss: 0.3567  
Time elapsed: 6.09 seconds  
Epoch 189 | Loss: 0.3516  
Time elapsed: 6.13 seconds  
Epoch 190 | Loss: 0.3465  
Time elapsed: 6.16 seconds  
Epoch 191 | Loss: 0.3415  
Time elapsed: 6.19 seconds  
Epoch 192 | Loss: 0.3366

Time elapsed: 6.22 seconds  
Epoch 193 | Loss: 0.3319  
Time elapsed: 6.25 seconds  
Epoch 194 | Loss: 0.3271  
Time elapsed: 6.29 seconds  
Epoch 195 | Loss: 0.3225  
Time elapsed: 6.32 seconds  
Epoch 196 | Loss: 0.3179  
Time elapsed: 6.35 seconds  
Epoch 197 | Loss: 0.3133  
Time elapsed: 6.38 seconds  
Epoch 198 | Loss: 0.3089  
Time elapsed: 6.41 seconds  
Epoch 199 | Loss: 0.3044  
Time elapsed: 6.45 seconds  
Epoch 200 | Loss: 0.3000  
Time elapsed: 6.48 seconds  
Epoch 201 | Loss: 0.2957  
Time elapsed: 6.51 seconds  
Epoch 202 | Loss: 0.2915  
Time elapsed: 6.54 seconds  
Epoch 203 | Loss: 0.2873  
Time elapsed: 6.58 seconds  
Epoch 204 | Loss: 0.2833  
Time elapsed: 6.61 seconds  
Epoch 205 | Loss: 0.2794  
Time elapsed: 6.64 seconds  
Epoch 206 | Loss: 0.2756  
Time elapsed: 6.67 seconds  
Epoch 207 | Loss: 0.2719  
Time elapsed: 6.70 seconds  
Epoch 208 | Loss: 0.2682  
Time elapsed: 6.74 seconds  
Epoch 209 | Loss: 0.2647  
Time elapsed: 6.77 seconds  
Epoch 210 | Loss: 0.2611  
Time elapsed: 6.80 seconds  
Epoch 211 | Loss: 0.2577  
Time elapsed: 6.83 seconds  
Epoch 212 | Loss: 0.2543  
Time elapsed: 6.87 seconds  
Epoch 213 | Loss: 0.2510  
Time elapsed: 6.90 seconds  
Epoch 214 | Loss: 0.2478  
Time elapsed: 6.93 seconds  
Epoch 215 | Loss: 0.2446  
Time elapsed: 6.96 seconds  
Epoch 216 | Loss: 0.2415

Time elapsed: 6.99 seconds  
Epoch 217 | Loss: 0.2385  
Time elapsed: 7.03 seconds  
Epoch 218 | Loss: 0.2355  
Time elapsed: 7.06 seconds  
Epoch 219 | Loss: 0.2325  
Time elapsed: 7.09 seconds  
Epoch 220 | Loss: 0.2296  
Time elapsed: 7.12 seconds  
Epoch 221 | Loss: 0.2267  
Time elapsed: 7.16 seconds  
Epoch 222 | Loss: 0.2239  
Time elapsed: 7.19 seconds  
Epoch 223 | Loss: 0.2211  
Time elapsed: 7.22 seconds  
Epoch 224 | Loss: 0.2184  
Time elapsed: 7.25 seconds  
Epoch 225 | Loss: 0.2158  
Time elapsed: 7.29 seconds  
Epoch 226 | Loss: 0.2131  
Time elapsed: 7.32 seconds  
Epoch 227 | Loss: 0.2105  
Time elapsed: 7.35 seconds  
Epoch 228 | Loss: 0.2079  
Time elapsed: 7.38 seconds  
Epoch 229 | Loss: 0.2053  
Time elapsed: 7.41 seconds  
Epoch 230 | Loss: 0.2028  
Time elapsed: 7.45 seconds  
Epoch 231 | Loss: 0.2003  
Time elapsed: 7.48 seconds  
Epoch 232 | Loss: 0.1978  
Time elapsed: 7.51 seconds  
Epoch 233 | Loss: 0.1953  
Time elapsed: 7.54 seconds  
Epoch 234 | Loss: 0.1928  
Time elapsed: 7.57 seconds  
Epoch 235 | Loss: 0.1904  
Time elapsed: 7.61 seconds  
Epoch 236 | Loss: 0.1880  
Time elapsed: 7.64 seconds  
Epoch 237 | Loss: 0.1857  
Time elapsed: 7.67 seconds  
Epoch 238 | Loss: 0.1833  
Time elapsed: 7.70 seconds  
Epoch 239 | Loss: 0.1810  
Time elapsed: 7.74 seconds  
Epoch 240 | Loss: 0.1786

Time elapsed: 7.77 seconds  
Epoch 241 | Loss: 0.1763  
Time elapsed: 7.80 seconds  
Epoch 242 | Loss: 0.1740  
Time elapsed: 7.83 seconds  
Epoch 243 | Loss: 0.1716  
Time elapsed: 7.86 seconds  
Epoch 244 | Loss: 0.1694  
Time elapsed: 7.90 seconds  
Epoch 245 | Loss: 0.1671  
Time elapsed: 7.93 seconds  
Epoch 246 | Loss: 0.1649  
Time elapsed: 7.96 seconds  
Epoch 247 | Loss: 0.1628  
Time elapsed: 7.99 seconds  
Epoch 248 | Loss: 0.1607  
Time elapsed: 8.03 seconds  
Epoch 249 | Loss: 0.1586  
Time elapsed: 8.06 seconds  
Epoch 250 | Loss: 0.1566  
Time elapsed: 8.09 seconds  
Epoch 251 | Loss: 0.1546  
Time elapsed: 8.12 seconds  
Epoch 252 | Loss: 0.1526  
Time elapsed: 8.15 seconds  
Epoch 253 | Loss: 0.1507  
Time elapsed: 8.19 seconds  
Epoch 254 | Loss: 0.1488  
Time elapsed: 8.22 seconds  
Epoch 255 | Loss: 0.1470  
Time elapsed: 8.25 seconds  
Epoch 256 | Loss: 0.1451  
Time elapsed: 8.28 seconds  
Epoch 257 | Loss: 0.1433  
Time elapsed: 8.31 seconds  
Epoch 258 | Loss: 0.1416  
Time elapsed: 8.34 seconds  
Epoch 259 | Loss: 0.1398  
Time elapsed: 8.38 seconds  
Epoch 260 | Loss: 0.1381  
Time elapsed: 8.41 seconds  
Epoch 261 | Loss: 0.1364  
Time elapsed: 8.44 seconds  
Epoch 262 | Loss: 0.1347  
Time elapsed: 8.47 seconds  
Epoch 263 | Loss: 0.1331  
Time elapsed: 8.50 seconds  
Epoch 264 | Loss: 0.1315



Time elapsed: 8.53 seconds  
Epoch 265 | Loss: 0.1299  
Time elapsed: 8.57 seconds  
Epoch 266 | Loss: 0.1283  
Time elapsed: 8.60 seconds  
Epoch 267 | Loss: 0.1267  
Time elapsed: 8.63 seconds  
Epoch 268 | Loss: 0.1252  
Time elapsed: 8.66 seconds  
Epoch 269 | Loss: 0.1237  
Time elapsed: 8.69 seconds  
Epoch 270 | Loss: 0.1222  
Time elapsed: 8.73 seconds  
Epoch 271 | Loss: 0.1208  
Time elapsed: 8.76 seconds  
Epoch 272 | Loss: 0.1194  
Time elapsed: 8.79 seconds  
Epoch 273 | Loss: 0.1180  
Time elapsed: 8.82 seconds  
Epoch 274 | Loss: 0.1166  
Time elapsed: 8.86 seconds  
Epoch 275 | Loss: 0.1152  
Time elapsed: 8.89 seconds  
Epoch 276 | Loss: 0.1139  
Time elapsed: 8.92 seconds  
Epoch 277 | Loss: 0.1126  
Time elapsed: 8.95 seconds  
Epoch 278 | Loss: 0.1113  
Time elapsed: 8.98 seconds  
Epoch 279 | Loss: 0.1100  
Time elapsed: 9.02 seconds  
Epoch 280 | Loss: 0.1087  
Time elapsed: 9.05 seconds  
Epoch 281 | Loss: 0.1075  
Time elapsed: 9.08 seconds  
Epoch 282 | Loss: 0.1062  
Time elapsed: 9.11 seconds  
Epoch 283 | Loss: 0.1050  
Time elapsed: 9.15 seconds  
Epoch 284 | Loss: 0.1037  
Time elapsed: 9.21 seconds  
Epoch 285 | Loss: 0.1025  
Time elapsed: 9.24 seconds  
Epoch 286 | Loss: 0.1013  
Time elapsed: 9.28 seconds  
Epoch 287 | Loss: 0.1001  
Time elapsed: 9.31 seconds  
Epoch 288 | Loss: 0.0989

Time elapsed: 9.35 seconds  
Epoch 289 | Loss: 0.0978  
Time elapsed: 9.38 seconds  
Epoch 290 | Loss: 0.0966  
Time elapsed: 9.42 seconds  
Epoch 291 | Loss: 0.0955  
Time elapsed: 9.45 seconds  
Epoch 292 | Loss: 0.0944  
Time elapsed: 9.48 seconds  
Epoch 293 | Loss: 0.0933  
Time elapsed: 9.52 seconds  
Epoch 294 | Loss: 0.0922  
Time elapsed: 9.55 seconds  
Epoch 295 | Loss: 0.0911  
Time elapsed: 9.58 seconds  
Epoch 296 | Loss: 0.0901  
Time elapsed: 9.61 seconds  
Epoch 297 | Loss: 0.0890  
Time elapsed: 9.65 seconds  
Epoch 298 | Loss: 0.0880  
Time elapsed: 9.68 seconds  
Epoch 299 | Loss: 0.0869  
Time elapsed: 9.71 seconds  
Epoch 300 | Loss: 0.0859  
Time elapsed: 9.74 seconds  
Epoch 301 | Loss: 0.0849  
Time elapsed: 9.78 seconds  
Epoch 302 | Loss: 0.0839  
Time elapsed: 9.81 seconds  
Epoch 303 | Loss: 0.0829  
Time elapsed: 9.84 seconds  
Epoch 304 | Loss: 0.0819  
Time elapsed: 9.89 seconds  
Epoch 305 | Loss: 0.0810  
Time elapsed: 9.93 seconds  
Epoch 306 | Loss: 0.0800  
Time elapsed: 9.96 seconds  
Epoch 307 | Loss: 0.0791  
Time elapsed: 10.00 seconds  
Epoch 308 | Loss: 0.0781  
Time elapsed: 10.03 seconds  
Epoch 309 | Loss: 0.0772  
Time elapsed: 10.06 seconds  
Epoch 310 | Loss: 0.0763  
Time elapsed: 10.10 seconds  
Epoch 311 | Loss: 0.0754  
Time elapsed: 10.13 seconds  
Epoch 312 | Loss: 0.0745

Time elapsed: 10.16 seconds  
Epoch 313 | Loss: 0.0736  
Time elapsed: 10.20 seconds  
Epoch 314 | Loss: 0.0728  
Time elapsed: 10.23 seconds  
Epoch 315 | Loss: 0.0719  
Time elapsed: 10.26 seconds  
Epoch 316 | Loss: 0.0711  
Time elapsed: 10.30 seconds  
Epoch 317 | Loss: 0.0702  
Time elapsed: 10.33 seconds  
Epoch 318 | Loss: 0.0694  
Time elapsed: 10.37 seconds  
Epoch 319 | Loss: 0.0686  
Time elapsed: 10.40 seconds  
Epoch 320 | Loss: 0.0678  
Time elapsed: 10.44 seconds  
Epoch 321 | Loss: 0.0671  
Time elapsed: 10.47 seconds  
Epoch 322 | Loss: 0.0663  
Time elapsed: 10.53 seconds  
Epoch 323 | Loss: 0.0656  
Time elapsed: 10.56 seconds  
Epoch 324 | Loss: 0.0648  
Time elapsed: 10.60 seconds  
Epoch 325 | Loss: 0.0641  
Time elapsed: 10.63 seconds  
Epoch 326 | Loss: 0.0633  
Time elapsed: 10.67 seconds  
Epoch 327 | Loss: 0.0626  
Time elapsed: 10.70 seconds  
Epoch 328 | Loss: 0.0619  
Time elapsed: 10.74 seconds  
Epoch 329 | Loss: 0.0612  
Time elapsed: 10.77 seconds  
Epoch 330 | Loss: 0.0605  
Time elapsed: 10.80 seconds  
Epoch 331 | Loss: 0.0598  
Time elapsed: 10.83 seconds  
Epoch 332 | Loss: 0.0592  
Time elapsed: 10.87 seconds  
Epoch 333 | Loss: 0.0585  
Time elapsed: 10.90 seconds  
Epoch 334 | Loss: 0.0578  
Time elapsed: 10.93 seconds  
Epoch 335 | Loss: 0.0572  
Time elapsed: 10.97 seconds  
Epoch 336 | Loss: 0.0565

Time elapsed: 11.00 seconds  
Epoch 337 | Loss: 0.0559  
Time elapsed: 11.03 seconds  
Epoch 338 | Loss: 0.0553  
Time elapsed: 11.06 seconds  
Epoch 339 | Loss: 0.0546  
Time elapsed: 11.10 seconds  
Epoch 340 | Loss: 0.0540  
Time elapsed: 11.13 seconds  
Epoch 341 | Loss: 0.0534  
Time elapsed: 11.16 seconds  
Epoch 342 | Loss: 0.0528  
Time elapsed: 11.19 seconds  
Epoch 343 | Loss: 0.0522  
Time elapsed: 11.23 seconds  
Epoch 344 | Loss: 0.0516  
Time elapsed: 11.26 seconds  
Epoch 345 | Loss: 0.0510  
Time elapsed: 11.29 seconds  
Epoch 346 | Loss: 0.0505  
Time elapsed: 11.33 seconds  
Epoch 347 | Loss: 0.0499  
Time elapsed: 11.36 seconds  
Epoch 348 | Loss: 0.0494  
Time elapsed: 11.39 seconds  
Epoch 349 | Loss: 0.0488  
Time elapsed: 11.43 seconds  
Epoch 350 | Loss: 0.0483  
Time elapsed: 11.46 seconds  
Epoch 351 | Loss: 0.0477  
Time elapsed: 11.49 seconds  
Epoch 352 | Loss: 0.0472  
Time elapsed: 11.53 seconds  
Epoch 353 | Loss: 0.0467  
Time elapsed: 11.56 seconds  
Epoch 354 | Loss: 0.0462  
Time elapsed: 11.59 seconds  
Epoch 355 | Loss: 0.0456  
Time elapsed: 11.62 seconds  
Epoch 356 | Loss: 0.0451  
Time elapsed: 11.66 seconds  
Epoch 357 | Loss: 0.0446  
Time elapsed: 11.69 seconds  
Epoch 358 | Loss: 0.0442  
Time elapsed: 11.72 seconds  
Epoch 359 | Loss: 0.0437  
Time elapsed: 11.75 seconds  
Epoch 360 | Loss: 0.0432

Time elapsed: 11.79 seconds  
Epoch 361 | Loss: 0.0427  
Time elapsed: 11.82 seconds  
Epoch 362 | Loss: 0.0423  
Time elapsed: 11.85 seconds  
Epoch 363 | Loss: 0.0418  
Time elapsed: 11.89 seconds  
Epoch 364 | Loss: 0.0414  
Time elapsed: 11.92 seconds  
Epoch 365 | Loss: 0.0409  
Time elapsed: 11.95 seconds  
Epoch 366 | Loss: 0.0405  
Time elapsed: 11.98 seconds  
Epoch 367 | Loss: 0.0400  
Time elapsed: 12.01 seconds  
Epoch 368 | Loss: 0.0396  
Time elapsed: 12.05 seconds  
Epoch 369 | Loss: 0.0392  
Time elapsed: 12.08 seconds  
Epoch 370 | Loss: 0.0388  
Time elapsed: 12.11 seconds  
Epoch 371 | Loss: 0.0384  
Time elapsed: 12.14 seconds  
Epoch 372 | Loss: 0.0380  
Time elapsed: 12.18 seconds  
Epoch 373 | Loss: 0.0376  
Time elapsed: 12.21 seconds  
Epoch 374 | Loss: 0.0372  
Time elapsed: 12.24 seconds  
Epoch 375 | Loss: 0.0368  
Time elapsed: 12.27 seconds  
Epoch 376 | Loss: 0.0364  
Time elapsed: 12.31 seconds  
Epoch 377 | Loss: 0.0360  
Time elapsed: 12.34 seconds  
Epoch 378 | Loss: 0.0356  
Time elapsed: 12.37 seconds  
Epoch 379 | Loss: 0.0352  
Time elapsed: 12.40 seconds  
Epoch 380 | Loss: 0.0348  
Time elapsed: 12.43 seconds  
Epoch 381 | Loss: 0.0344  
Time elapsed: 12.47 seconds  
Epoch 382 | Loss: 0.0341  
Time elapsed: 12.50 seconds  
Epoch 383 | Loss: 0.0337  
Time elapsed: 12.53 seconds  
Epoch 384 | Loss: 0.0333

Time elapsed: 12.57 seconds  
Epoch 385 | Loss: 0.0330  
Time elapsed: 12.60 seconds  
Epoch 386 | Loss: 0.0326  
Time elapsed: 12.63 seconds  
Epoch 387 | Loss: 0.0322  
Time elapsed: 12.67 seconds  
Epoch 388 | Loss: 0.0319  
Time elapsed: 12.70 seconds  
Epoch 389 | Loss: 0.0315  
Time elapsed: 12.73 seconds  
Epoch 390 | Loss: 0.0312  
Time elapsed: 12.76 seconds  
Epoch 391 | Loss: 0.0308  
Time elapsed: 12.79 seconds  
Epoch 392 | Loss: 0.0305  
Time elapsed: 12.83 seconds  
Epoch 393 | Loss: 0.0302  
Time elapsed: 12.86 seconds  
Epoch 394 | Loss: 0.0299  
Time elapsed: 12.89 seconds  
Epoch 395 | Loss: 0.0295  
Time elapsed: 12.92 seconds  
Epoch 396 | Loss: 0.0292  
Time elapsed: 12.96 seconds  
Epoch 397 | Loss: 0.0289  
Time elapsed: 12.99 seconds  
Epoch 398 | Loss: 0.0286  
Time elapsed: 13.02 seconds  
Epoch 399 | Loss: 0.0283  
Time elapsed: 13.05 seconds  
Epoch 400 | Loss: 0.0280  
Time elapsed: 13.09 seconds  
Epoch 401 | Loss: 0.0277  
Time elapsed: 13.12 seconds  
Epoch 402 | Loss: 0.0274  
Time elapsed: 13.15 seconds  
Epoch 403 | Loss: 0.0271  
Time elapsed: 13.18 seconds  
Epoch 404 | Loss: 0.0268  
Time elapsed: 13.21 seconds  
Epoch 405 | Loss: 0.0266  
Time elapsed: 13.24 seconds  
Epoch 406 | Loss: 0.0263  
Time elapsed: 13.28 seconds  
Epoch 407 | Loss: 0.0260  
Time elapsed: 13.31 seconds  
Epoch 408 | Loss: 0.0257

Time elapsed: 13.34 seconds  
Epoch 409 | Loss: 0.0254  
Time elapsed: 13.37 seconds  
Epoch 410 | Loss: 0.0251  
Time elapsed: 13.41 seconds  
Epoch 411 | Loss: 0.0248  
Time elapsed: 13.44 seconds  
Epoch 412 | Loss: 0.0246  
Time elapsed: 13.47 seconds  
Epoch 413 | Loss: 0.0243  
Time elapsed: 13.50 seconds  
Epoch 414 | Loss: 0.0240  
Time elapsed: 13.53 seconds  
Epoch 415 | Loss: 0.0238  
Time elapsed: 13.56 seconds  
Epoch 416 | Loss: 0.0235  
Time elapsed: 13.60 seconds  
Epoch 417 | Loss: 0.0232  
Time elapsed: 13.63 seconds  
Epoch 418 | Loss: 0.0230  
Time elapsed: 13.66 seconds  
Epoch 419 | Loss: 0.0227  
Time elapsed: 13.69 seconds  
Epoch 420 | Loss: 0.0224  
Time elapsed: 13.72 seconds  
Epoch 421 | Loss: 0.0222  
Time elapsed: 13.76 seconds  
Epoch 422 | Loss: 0.0219  
Time elapsed: 13.79 seconds  
Epoch 423 | Loss: 0.0217  
Time elapsed: 13.82 seconds  
Epoch 424 | Loss: 0.0214  
Time elapsed: 13.85 seconds  
Epoch 425 | Loss: 0.0212  
Time elapsed: 13.88 seconds  
Epoch 426 | Loss: 0.0209  
Time elapsed: 13.92 seconds  
Epoch 427 | Loss: 0.0207  
Time elapsed: 13.95 seconds  
Epoch 428 | Loss: 0.0205  
Time elapsed: 13.98 seconds  
Epoch 429 | Loss: 0.0203  
Time elapsed: 14.01 seconds  
Epoch 430 | Loss: 0.0201  
Time elapsed: 14.04 seconds  
Epoch 431 | Loss: 0.0198  
Time elapsed: 14.07 seconds  
Epoch 432 | Loss: 0.0195

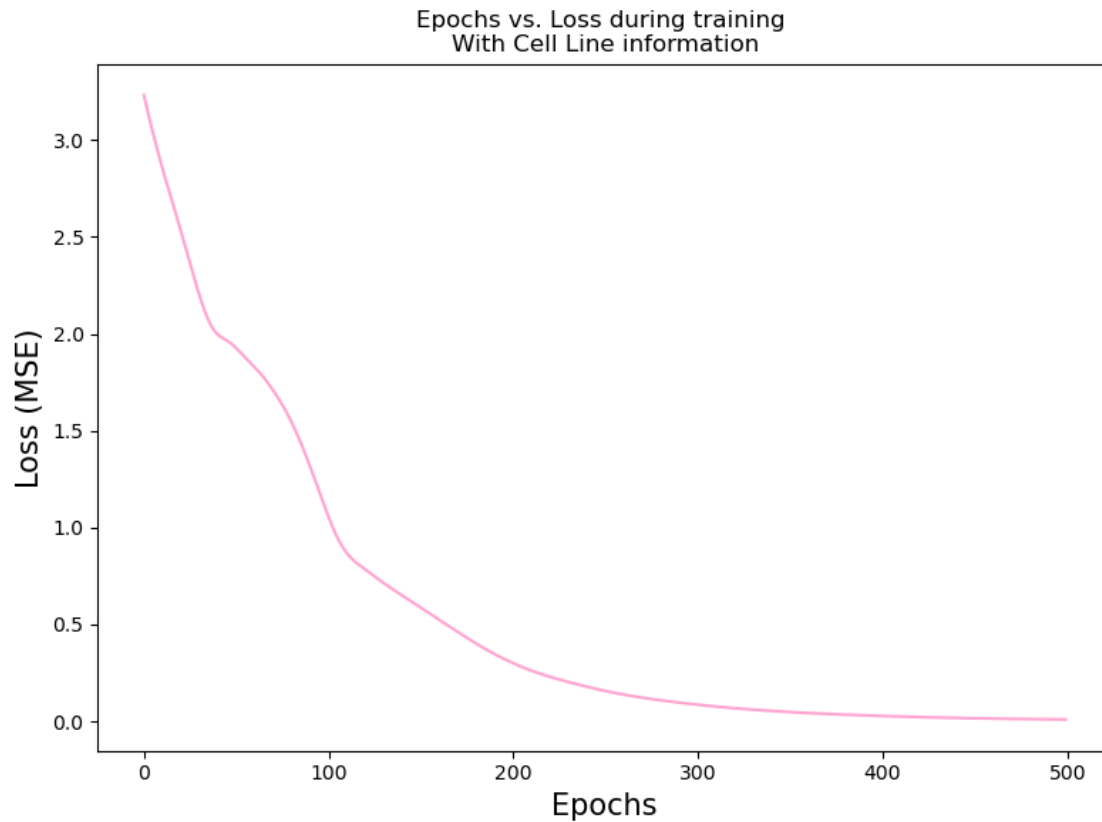
Time elapsed: 14.11 seconds  
Epoch 433 | Loss: 0.0193  
Time elapsed: 14.15 seconds  
Epoch 434 | Loss: 0.0191  
Time elapsed: 14.19 seconds  
Epoch 435 | Loss: 0.0189  
Time elapsed: 14.22 seconds  
Epoch 436 | Loss: 0.0187  
Time elapsed: 14.25 seconds  
Epoch 437 | Loss: 0.0185  
Time elapsed: 14.29 seconds  
Epoch 438 | Loss: 0.0183  
Time elapsed: 14.32 seconds  
Epoch 439 | Loss: 0.0181  
Time elapsed: 14.35 seconds  
Epoch 440 | Loss: 0.0179  
Time elapsed: 14.39 seconds  
Epoch 441 | Loss: 0.0177  
Time elapsed: 14.42 seconds  
Epoch 442 | Loss: 0.0175  
Time elapsed: 14.45 seconds  
Epoch 443 | Loss: 0.0173  
Time elapsed: 14.48 seconds  
Epoch 444 | Loss: 0.0171  
Time elapsed: 14.51 seconds  
Epoch 445 | Loss: 0.0169  
Time elapsed: 14.55 seconds  
Epoch 446 | Loss: 0.0168  
Time elapsed: 14.58 seconds  
Epoch 447 | Loss: 0.0166  
Time elapsed: 14.61 seconds  
Epoch 448 | Loss: 0.0164  
Time elapsed: 14.64 seconds  
Epoch 449 | Loss: 0.0162  
Time elapsed: 14.68 seconds  
Epoch 450 | Loss: 0.0161  
Time elapsed: 14.71 seconds  
Epoch 451 | Loss: 0.0159  
Time elapsed: 14.74 seconds  
Epoch 452 | Loss: 0.0157  
Time elapsed: 14.77 seconds  
Epoch 453 | Loss: 0.0156  
Time elapsed: 14.80 seconds  
Epoch 454 | Loss: 0.0154  
Time elapsed: 14.84 seconds  
Epoch 455 | Loss: 0.0153  
Time elapsed: 14.87 seconds  
Epoch 456 | Loss: 0.0151



Time elapsed: 14.90 seconds  
Epoch 457 | Loss: 0.0149  
Time elapsed: 14.93 seconds  
Epoch 458 | Loss: 0.0148  
Time elapsed: 14.96 seconds  
Epoch 459 | Loss: 0.0147  
Time elapsed: 14.99 seconds  
Epoch 460 | Loss: 0.0145  
Time elapsed: 15.03 seconds  
Epoch 461 | Loss: 0.0144  
Time elapsed: 15.06 seconds  
Epoch 462 | Loss: 0.0142  
Time elapsed: 15.09 seconds  
Epoch 463 | Loss: 0.0141  
Time elapsed: 15.12 seconds  
Epoch 464 | Loss: 0.0139  
Time elapsed: 15.16 seconds  
Epoch 465 | Loss: 0.0138  
Time elapsed: 15.19 seconds  
Epoch 466 | Loss: 0.0137  
Time elapsed: 15.22 seconds  
Epoch 467 | Loss: 0.0135  
Time elapsed: 15.25 seconds  
Epoch 468 | Loss: 0.0134  
Time elapsed: 15.29 seconds  
Epoch 469 | Loss: 0.0133  
Time elapsed: 15.32 seconds  
Epoch 470 | Loss: 0.0131  
Time elapsed: 15.35 seconds  
Epoch 471 | Loss: 0.0130  
Time elapsed: 15.38 seconds  
Epoch 472 | Loss: 0.0129  
Time elapsed: 15.41 seconds  
Epoch 473 | Loss: 0.0128  
Time elapsed: 15.45 seconds  
Epoch 474 | Loss: 0.0127  
Time elapsed: 15.48 seconds  
Epoch 475 | Loss: 0.0125  
Time elapsed: 15.51 seconds  
Epoch 476 | Loss: 0.0125  
Time elapsed: 15.54 seconds  
Epoch 477 | Loss: 0.0124  
Time elapsed: 15.57 seconds  
Epoch 478 | Loss: 0.0123  
Time elapsed: 15.61 seconds  
Epoch 479 | Loss: 0.0121  
Time elapsed: 15.64 seconds  
Epoch 480 | Loss: 0.0120

Time elapsed: 15.67 seconds  
Epoch 481 | Loss: 0.0119  
Time elapsed: 15.70 seconds  
Epoch 482 | Loss: 0.0117  
Time elapsed: 15.74 seconds  
Epoch 483 | Loss: 0.0116  
Time elapsed: 15.77 seconds  
Epoch 484 | Loss: 0.0115  
Time elapsed: 15.80 seconds  
Epoch 485 | Loss: 0.0114  
Time elapsed: 15.83 seconds  
Epoch 486 | Loss: 0.0113  
Time elapsed: 15.86 seconds  
Epoch 487 | Loss: 0.0112  
Time elapsed: 15.90 seconds  
Epoch 488 | Loss: 0.0111  
Time elapsed: 15.93 seconds  
Epoch 489 | Loss: 0.0110  
Time elapsed: 15.96 seconds  
Epoch 490 | Loss: 0.0109  
Time elapsed: 16.00 seconds  
Epoch 491 | Loss: 0.0108  
Time elapsed: 16.03 seconds  
Epoch 492 | Loss: 0.0107  
Time elapsed: 16.06 seconds  
Epoch 493 | Loss: 0.0106  
Time elapsed: 16.09 seconds  
Epoch 494 | Loss: 0.0105  
Time elapsed: 16.13 seconds  
Epoch 495 | Loss: 0.0104  
Time elapsed: 16.16 seconds  
Epoch 496 | Loss: 0.0104  
Time elapsed: 16.19 seconds  
Epoch 497 | Loss: 0.0103  
Time elapsed: 16.22 seconds  
Epoch 498 | Loss: 0.0102  
Time elapsed: 16.26 seconds  
Epoch 499 | Loss: 0.0101  
Time elapsed: 16.29 seconds

```
[57]: epochs_vs_loss_with_cells(my_epochs,my_losses)
```



```
[59]: model = DrugResponsePredictor(drug_input_dim=5,
    ↪ patient_input_dim=patient_tensor.shape[1])
optimizer = torch.optim.Adam(model.parameters(), lr=1e-3)
loss_fn = nn.MSELoss()

# Training loop
model.train()
start_time = time.time()

my_epochs = []
my_losses = []

for epoch in range(300):
    optimizer.zero_grad()
    preds = model(drug_tensor, patient_tensor)
    loss = loss_fn(preds, ic50_tensor)
    loss.backward()
    optimizer.step()
    end_time = time.time()
    elapsed = end_time - start_time
```

```
print(f"Epoch {epoch} | Loss: {loss.item():.4f}")
print(f"Time elapsed: {elapsed:.2f} seconds")
my_epochs.append(epoch)
my_losses.append(loss.item())
```

```
Epoch 0 | Loss: 3.0935
Time elapsed: 0.06 seconds
Epoch 1 | Loss: 3.0416
Time elapsed: 0.10 seconds
Epoch 2 | Loss: 2.9909
Time elapsed: 0.14 seconds
Epoch 3 | Loss: 2.9418
Time elapsed: 0.17 seconds
Epoch 4 | Loss: 2.8942
Time elapsed: 0.21 seconds
Epoch 5 | Loss: 2.8478
Time elapsed: 0.24 seconds
Epoch 6 | Loss: 2.8023
Time elapsed: 0.27 seconds
Epoch 7 | Loss: 2.7578
Time elapsed: 0.31 seconds
Epoch 8 | Loss: 2.7144
Time elapsed: 0.34 seconds
Epoch 9 | Loss: 2.6727
Time elapsed: 0.37 seconds
Epoch 10 | Loss: 2.6321
Time elapsed: 0.41 seconds
Epoch 11 | Loss: 2.5922
Time elapsed: 0.44 seconds
Epoch 12 | Loss: 2.5527
Time elapsed: 0.47 seconds
Epoch 13 | Loss: 2.5135
Time elapsed: 0.50 seconds
Epoch 14 | Loss: 2.4743
Time elapsed: 0.54 seconds
Epoch 15 | Loss: 2.4354
Time elapsed: 0.57 seconds
Epoch 16 | Loss: 2.3968
Time elapsed: 0.60 seconds
Epoch 17 | Loss: 2.3586
Time elapsed: 0.63 seconds
Epoch 18 | Loss: 2.3212
Time elapsed: 0.66 seconds
Epoch 19 | Loss: 2.2852
Time elapsed: 0.70 seconds
Epoch 20 | Loss: 2.2507
Time elapsed: 0.73 seconds
```

Epoch 21 | Loss: 2.2181  
Time elapsed: 0.76 seconds  
Epoch 22 | Loss: 2.1877  
Time elapsed: 0.79 seconds  
Epoch 23 | Loss: 2.1599  
Time elapsed: 0.83 seconds  
Epoch 24 | Loss: 2.1347  
Time elapsed: 0.86 seconds  
Epoch 25 | Loss: 2.1125  
Time elapsed: 0.89 seconds  
Epoch 26 | Loss: 2.0933  
Time elapsed: 0.92 seconds  
Epoch 27 | Loss: 2.0772  
Time elapsed: 0.95 seconds  
Epoch 28 | Loss: 2.0638  
Time elapsed: 0.99 seconds  
Epoch 29 | Loss: 2.0530  
Time elapsed: 1.02 seconds  
Epoch 30 | Loss: 2.0441  
Time elapsed: 1.05 seconds  
Epoch 31 | Loss: 2.0365  
Time elapsed: 1.08 seconds  
Epoch 32 | Loss: 2.0296  
Time elapsed: 1.11 seconds  
Epoch 33 | Loss: 2.0230  
Time elapsed: 1.15 seconds  
Epoch 34 | Loss: 2.0158  
Time elapsed: 1.18 seconds  
Epoch 35 | Loss: 2.0081  
Time elapsed: 1.21 seconds  
Epoch 36 | Loss: 1.9995  
Time elapsed: 1.24 seconds  
Epoch 37 | Loss: 1.9901  
Time elapsed: 1.27 seconds  
Epoch 38 | Loss: 1.9801  
Time elapsed: 1.31 seconds  
Epoch 39 | Loss: 1.9697  
Time elapsed: 1.34 seconds  
Epoch 40 | Loss: 1.9593  
Time elapsed: 1.37 seconds  
Epoch 41 | Loss: 1.9490  
Time elapsed: 1.40 seconds  
Epoch 42 | Loss: 1.9391  
Time elapsed: 1.43 seconds  
Epoch 43 | Loss: 1.9296  
Time elapsed: 1.47 seconds  
Epoch 44 | Loss: 1.9204  
Time elapsed: 1.50 seconds

Epoch 45 | Loss: 1.9115  
Time elapsed: 1.53 seconds  
Epoch 46 | Loss: 1.9026  
Time elapsed: 1.56 seconds  
Epoch 47 | Loss: 1.8937  
Time elapsed: 1.59 seconds  
Epoch 48 | Loss: 1.8845  
Time elapsed: 1.63 seconds  
Epoch 49 | Loss: 1.8750  
Time elapsed: 1.66 seconds  
Epoch 50 | Loss: 1.8650  
Time elapsed: 1.69 seconds  
Epoch 51 | Loss: 1.8544  
Time elapsed: 1.72 seconds  
Epoch 52 | Loss: 1.8433  
Time elapsed: 1.75 seconds  
Epoch 53 | Loss: 1.8315  
Time elapsed: 1.79 seconds  
Epoch 54 | Loss: 1.8192  
Time elapsed: 1.82 seconds  
Epoch 55 | Loss: 1.8063  
Time elapsed: 1.85 seconds  
Epoch 56 | Loss: 1.7930  
Time elapsed: 1.88 seconds  
Epoch 57 | Loss: 1.7791  
Time elapsed: 1.91 seconds  
Epoch 58 | Loss: 1.7648  
Time elapsed: 1.94 seconds  
Epoch 59 | Loss: 1.7500  
Time elapsed: 1.98 seconds  
Epoch 60 | Loss: 1.7348  
Time elapsed: 2.01 seconds  
Epoch 61 | Loss: 1.7190  
Time elapsed: 2.04 seconds  
Epoch 62 | Loss: 1.7026  
Time elapsed: 2.07 seconds  
Epoch 63 | Loss: 1.6854  
Time elapsed: 2.10 seconds  
Epoch 64 | Loss: 1.6674  
Time elapsed: 2.13 seconds  
Epoch 65 | Loss: 1.6486  
Time elapsed: 2.17 seconds  
Epoch 66 | Loss: 1.6288  
Time elapsed: 2.20 seconds  
Epoch 67 | Loss: 1.6081  
Time elapsed: 2.23 seconds  
Epoch 68 | Loss: 1.5863  
Time elapsed: 2.26 seconds

Epoch 69 | Loss: 1.5635  
Time elapsed: 2.29 seconds  
Epoch 70 | Loss: 1.5396  
Time elapsed: 2.33 seconds  
Epoch 71 | Loss: 1.5146  
Time elapsed: 2.36 seconds  
Epoch 72 | Loss: 1.4887  
Time elapsed: 2.39 seconds  
Epoch 73 | Loss: 1.4618  
Time elapsed: 2.42 seconds  
Epoch 74 | Loss: 1.4339  
Time elapsed: 2.45 seconds  
Epoch 75 | Loss: 1.4051  
Time elapsed: 2.49 seconds  
Epoch 76 | Loss: 1.3754  
Time elapsed: 2.52 seconds  
Epoch 77 | Loss: 1.3448  
Time elapsed: 2.55 seconds  
Epoch 78 | Loss: 1.3135  
Time elapsed: 2.58 seconds  
Epoch 79 | Loss: 1.2815  
Time elapsed: 2.61 seconds  
Epoch 80 | Loss: 1.2488  
Time elapsed: 2.65 seconds  
Epoch 81 | Loss: 1.2157  
Time elapsed: 2.68 seconds  
Epoch 82 | Loss: 1.1822  
Time elapsed: 2.71 seconds  
Epoch 83 | Loss: 1.1487  
Time elapsed: 2.74 seconds  
Epoch 84 | Loss: 1.1153  
Time elapsed: 2.77 seconds  
Epoch 85 | Loss: 1.0824  
Time elapsed: 2.80 seconds  
Epoch 86 | Loss: 1.0502  
Time elapsed: 2.84 seconds  
Epoch 87 | Loss: 1.0192  
Time elapsed: 2.87 seconds  
Epoch 88 | Loss: 0.9898  
Time elapsed: 2.90 seconds  
Epoch 89 | Loss: 0.9621  
Time elapsed: 2.93 seconds  
Epoch 90 | Loss: 0.9363  
Time elapsed: 2.96 seconds  
Epoch 91 | Loss: 0.9126  
Time elapsed: 3.00 seconds  
Epoch 92 | Loss: 0.8911  
Time elapsed: 3.03 seconds

Epoch 93 | Loss: 0.8717  
Time elapsed: 3.06 seconds  
Epoch 94 | Loss: 0.8542  
Time elapsed: 3.09 seconds  
Epoch 95 | Loss: 0.8386  
Time elapsed: 3.12 seconds  
Epoch 96 | Loss: 0.8246  
Time elapsed: 3.16 seconds  
Epoch 97 | Loss: 0.8120  
Time elapsed: 3.19 seconds  
Epoch 98 | Loss: 0.8008  
Time elapsed: 3.22 seconds  
Epoch 99 | Loss: 0.7905  
Time elapsed: 3.25 seconds  
Epoch 100 | Loss: 0.7810  
Time elapsed: 3.28 seconds  
Epoch 101 | Loss: 0.7720  
Time elapsed: 3.32 seconds  
Epoch 102 | Loss: 0.7633  
Time elapsed: 3.35 seconds  
Epoch 103 | Loss: 0.7547  
Time elapsed: 3.38 seconds  
Epoch 104 | Loss: 0.7462  
Time elapsed: 3.41 seconds  
Epoch 105 | Loss: 0.7376  
Time elapsed: 3.44 seconds  
Epoch 106 | Loss: 0.7290  
Time elapsed: 3.47 seconds  
Epoch 107 | Loss: 0.7204  
Time elapsed: 3.51 seconds  
Epoch 108 | Loss: 0.7118  
Time elapsed: 3.54 seconds  
Epoch 109 | Loss: 0.7035  
Time elapsed: 3.57 seconds  
Epoch 110 | Loss: 0.6952  
Time elapsed: 3.60 seconds  
Epoch 111 | Loss: 0.6871  
Time elapsed: 3.63 seconds  
Epoch 112 | Loss: 0.6792  
Time elapsed: 3.67 seconds  
Epoch 113 | Loss: 0.6715  
Time elapsed: 3.70 seconds  
Epoch 114 | Loss: 0.6640  
Time elapsed: 3.73 seconds  
Epoch 115 | Loss: 0.6568  
Time elapsed: 3.76 seconds  
Epoch 116 | Loss: 0.6498  
Time elapsed: 3.80 seconds



Epoch 117 | Loss: 0.6431  
Time elapsed: 3.83 seconds  
Epoch 118 | Loss: 0.6365  
Time elapsed: 3.86 seconds  
Epoch 119 | Loss: 0.6300  
Time elapsed: 3.89 seconds  
Epoch 120 | Loss: 0.6236  
Time elapsed: 3.92 seconds  
Epoch 121 | Loss: 0.6172  
Time elapsed: 3.96 seconds  
Epoch 122 | Loss: 0.6108  
Time elapsed: 3.99 seconds  
Epoch 123 | Loss: 0.6044  
Time elapsed: 4.02 seconds  
Epoch 124 | Loss: 0.5981  
Time elapsed: 4.05 seconds  
Epoch 125 | Loss: 0.5917  
Time elapsed: 4.08 seconds  
Epoch 126 | Loss: 0.5852  
Time elapsed: 4.12 seconds  
Epoch 127 | Loss: 0.5788  
Time elapsed: 4.15 seconds  
Epoch 128 | Loss: 0.5724  
Time elapsed: 4.18 seconds  
Epoch 129 | Loss: 0.5659  
Time elapsed: 4.21 seconds  
Epoch 130 | Loss: 0.5595  
Time elapsed: 4.24 seconds  
Epoch 131 | Loss: 0.5532  
Time elapsed: 4.28 seconds  
Epoch 132 | Loss: 0.5468  
Time elapsed: 4.31 seconds  
Epoch 133 | Loss: 0.5405  
Time elapsed: 4.34 seconds  
Epoch 134 | Loss: 0.5343  
Time elapsed: 4.37 seconds  
Epoch 135 | Loss: 0.5280  
Time elapsed: 4.41 seconds  
Epoch 136 | Loss: 0.5218  
Time elapsed: 4.44 seconds  
Epoch 137 | Loss: 0.5155  
Time elapsed: 4.47 seconds  
Epoch 138 | Loss: 0.5094  
Time elapsed: 4.50 seconds  
Epoch 139 | Loss: 0.5032  
Time elapsed: 4.53 seconds  
Epoch 140 | Loss: 0.4970  
Time elapsed: 4.57 seconds

Epoch 141 | Loss: 0.4909  
Time elapsed: 4.60 seconds  
Epoch 142 | Loss: 0.4847  
Time elapsed: 4.63 seconds  
Epoch 143 | Loss: 0.4785  
Time elapsed: 4.66 seconds  
Epoch 144 | Loss: 0.4724  
Time elapsed: 4.69 seconds  
Epoch 145 | Loss: 0.4662  
Time elapsed: 4.73 seconds  
Epoch 146 | Loss: 0.4601  
Time elapsed: 4.76 seconds  
Epoch 147 | Loss: 0.4540  
Time elapsed: 4.79 seconds  
Epoch 148 | Loss: 0.4480  
Time elapsed: 4.82 seconds  
Epoch 149 | Loss: 0.4420  
Time elapsed: 4.86 seconds  
Epoch 150 | Loss: 0.4360  
Time elapsed: 4.89 seconds  
Epoch 151 | Loss: 0.4301  
Time elapsed: 4.92 seconds  
Epoch 152 | Loss: 0.4244  
Time elapsed: 4.95 seconds  
Epoch 153 | Loss: 0.4186  
Time elapsed: 4.98 seconds  
Epoch 154 | Loss: 0.4130  
Time elapsed: 5.02 seconds  
Epoch 155 | Loss: 0.4074  
Time elapsed: 5.05 seconds  
Epoch 156 | Loss: 0.4019  
Time elapsed: 5.08 seconds  
Epoch 157 | Loss: 0.3964  
Time elapsed: 5.11 seconds  
Epoch 158 | Loss: 0.3910  
Time elapsed: 5.15 seconds  
Epoch 159 | Loss: 0.3857  
Time elapsed: 5.18 seconds  
Epoch 160 | Loss: 0.3805  
Time elapsed: 5.21 seconds  
Epoch 161 | Loss: 0.3753  
Time elapsed: 5.24 seconds  
Epoch 162 | Loss: 0.3703  
Time elapsed: 5.27 seconds  
Epoch 163 | Loss: 0.3653  
Time elapsed: 5.31 seconds  
Epoch 164 | Loss: 0.3603  
Time elapsed: 5.34 seconds

Epoch 165 | Loss: 0.3555  
Time elapsed: 5.37 seconds  
Epoch 166 | Loss: 0.3507  
Time elapsed: 5.40 seconds  
Epoch 167 | Loss: 0.3461  
Time elapsed: 5.44 seconds  
Epoch 168 | Loss: 0.3415  
Time elapsed: 5.47 seconds  
Epoch 169 | Loss: 0.3369  
Time elapsed: 5.50 seconds  
Epoch 170 | Loss: 0.3325  
Time elapsed: 5.53 seconds  
Epoch 171 | Loss: 0.3282  
Time elapsed: 5.56 seconds  
Epoch 172 | Loss: 0.3240  
Time elapsed: 5.60 seconds  
Epoch 173 | Loss: 0.3198  
Time elapsed: 5.63 seconds  
Epoch 174 | Loss: 0.3157  
Time elapsed: 5.66 seconds  
Epoch 175 | Loss: 0.3116  
Time elapsed: 5.69 seconds  
Epoch 176 | Loss: 0.3075  
Time elapsed: 5.72 seconds  
Epoch 177 | Loss: 0.3035  
Time elapsed: 5.76 seconds  
Epoch 178 | Loss: 0.2996  
Time elapsed: 5.79 seconds  
Epoch 179 | Loss: 0.2958  
Time elapsed: 5.82 seconds  
Epoch 180 | Loss: 0.2920  
Time elapsed: 5.85 seconds  
Epoch 181 | Loss: 0.2882  
Time elapsed: 5.89 seconds  
Epoch 182 | Loss: 0.2845  
Time elapsed: 5.92 seconds  
Epoch 183 | Loss: 0.2809  
Time elapsed: 5.95 seconds  
Epoch 184 | Loss: 0.2773  
Time elapsed: 5.98 seconds  
Epoch 185 | Loss: 0.2738  
Time elapsed: 6.01 seconds  
Epoch 186 | Loss: 0.2703  
Time elapsed: 6.05 seconds  
Epoch 187 | Loss: 0.2668  
Time elapsed: 6.08 seconds  
Epoch 188 | Loss: 0.2634  
Time elapsed: 6.11 seconds

Epoch 189 | Loss: 0.2601  
Time elapsed: 6.14 seconds  
Epoch 190 | Loss: 0.2568  
Time elapsed: 6.18 seconds  
Epoch 191 | Loss: 0.2535  
Time elapsed: 6.21 seconds  
Epoch 192 | Loss: 0.2503  
Time elapsed: 6.24 seconds  
Epoch 193 | Loss: 0.2471  
Time elapsed: 6.27 seconds  
Epoch 194 | Loss: 0.2439  
Time elapsed: 6.30 seconds  
Epoch 195 | Loss: 0.2408  
Time elapsed: 6.34 seconds  
Epoch 196 | Loss: 0.2377  
Time elapsed: 6.37 seconds  
Epoch 197 | Loss: 0.2346  
Time elapsed: 6.40 seconds  
Epoch 198 | Loss: 0.2317  
Time elapsed: 6.43 seconds  
Epoch 199 | Loss: 0.2287  
Time elapsed: 6.46 seconds  
Epoch 200 | Loss: 0.2259  
Time elapsed: 6.50 seconds  
Epoch 201 | Loss: 0.2231  
Time elapsed: 6.53 seconds  
Epoch 202 | Loss: 0.2203  
Time elapsed: 6.56 seconds  
Epoch 203 | Loss: 0.2176  
Time elapsed: 6.59 seconds  
Epoch 204 | Loss: 0.2149  
Time elapsed: 6.63 seconds  
Epoch 205 | Loss: 0.2122  
Time elapsed: 6.66 seconds  
Epoch 206 | Loss: 0.2096  
Time elapsed: 6.69 seconds  
Epoch 207 | Loss: 0.2071  
Time elapsed: 6.72 seconds  
Epoch 208 | Loss: 0.2045  
Time elapsed: 6.75 seconds  
Epoch 209 | Loss: 0.2020  
Time elapsed: 6.78 seconds  
Epoch 210 | Loss: 0.1995  
Time elapsed: 6.82 seconds  
Epoch 211 | Loss: 0.1971  
Time elapsed: 6.85 seconds  
Epoch 212 | Loss: 0.1947  
Time elapsed: 6.88 seconds

Epoch 213 | Loss: 0.1924  
Time elapsed: 6.91 seconds  
Epoch 214 | Loss: 0.1900  
Time elapsed: 6.95 seconds  
Epoch 215 | Loss: 0.1877  
Time elapsed: 6.98 seconds  
Epoch 216 | Loss: 0.1854  
Time elapsed: 7.01 seconds  
Epoch 217 | Loss: 0.1831  
Time elapsed: 7.04 seconds  
Epoch 218 | Loss: 0.1809  
Time elapsed: 7.07 seconds  
Epoch 219 | Loss: 0.1787  
Time elapsed: 7.11 seconds  
Epoch 220 | Loss: 0.1765  
Time elapsed: 7.14 seconds  
Epoch 221 | Loss: 0.1743  
Time elapsed: 7.17 seconds  
Epoch 222 | Loss: 0.1722  
Time elapsed: 7.20 seconds  
Epoch 223 | Loss: 0.1700  
Time elapsed: 7.23 seconds  
Epoch 224 | Loss: 0.1680  
Time elapsed: 7.27 seconds  
Epoch 225 | Loss: 0.1659  
Time elapsed: 7.30 seconds  
Epoch 226 | Loss: 0.1639  
Time elapsed: 7.33 seconds  
Epoch 227 | Loss: 0.1619  
Time elapsed: 7.36 seconds  
Epoch 228 | Loss: 0.1599  
Time elapsed: 7.39 seconds  
Epoch 229 | Loss: 0.1579  
Time elapsed: 7.43 seconds  
Epoch 230 | Loss: 0.1560  
Time elapsed: 7.46 seconds  
Epoch 231 | Loss: 0.1541  
Time elapsed: 7.49 seconds  
Epoch 232 | Loss: 0.1522  
Time elapsed: 7.52 seconds  
Epoch 233 | Loss: 0.1503  
Time elapsed: 7.55 seconds  
Epoch 234 | Loss: 0.1485  
Time elapsed: 7.59 seconds  
Epoch 235 | Loss: 0.1467  
Time elapsed: 7.62 seconds  
Epoch 236 | Loss: 0.1449  
Time elapsed: 7.65 seconds

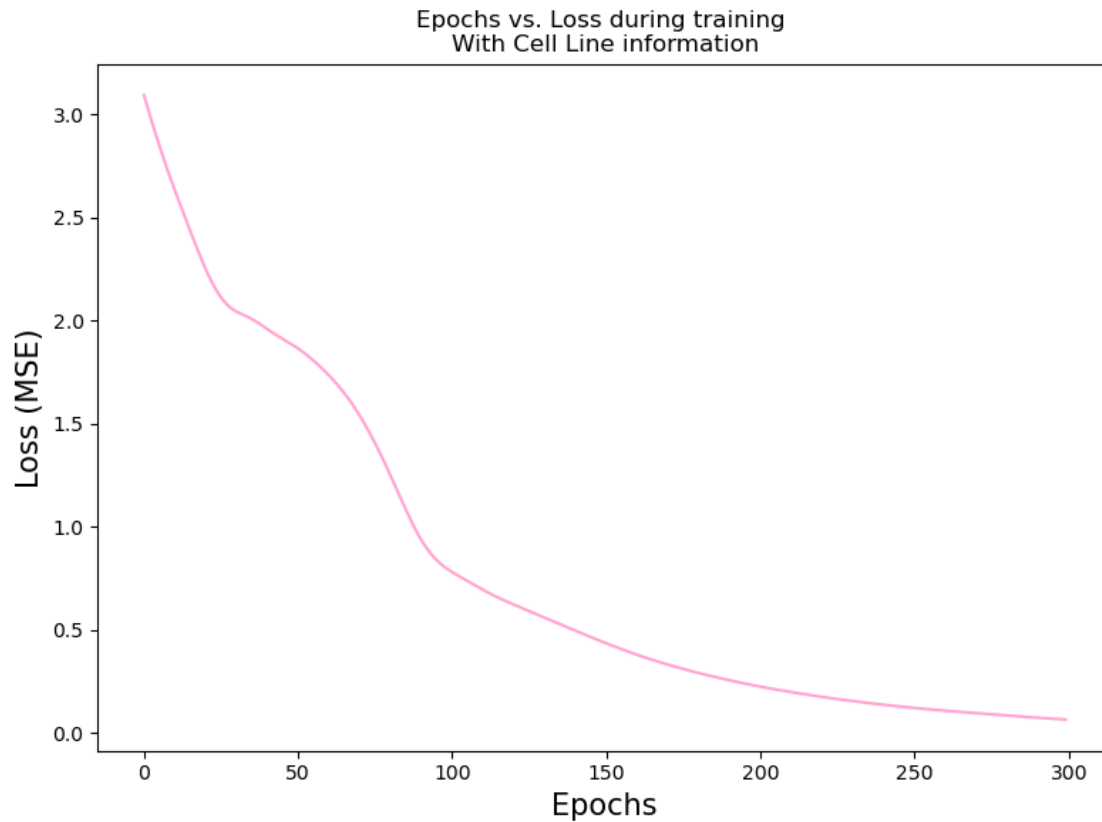
Epoch 237 | Loss: 0.1431  
Time elapsed: 7.68 seconds  
Epoch 238 | Loss: 0.1414  
Time elapsed: 7.71 seconds  
Epoch 239 | Loss: 0.1397  
Time elapsed: 7.75 seconds  
Epoch 240 | Loss: 0.1380  
Time elapsed: 7.78 seconds  
Epoch 241 | Loss: 0.1364  
Time elapsed: 7.81 seconds  
Epoch 242 | Loss: 0.1347  
Time elapsed: 7.84 seconds  
Epoch 243 | Loss: 0.1331  
Time elapsed: 7.87 seconds  
Epoch 244 | Loss: 0.1315  
Time elapsed: 7.91 seconds  
Epoch 245 | Loss: 0.1300  
Time elapsed: 7.94 seconds  
Epoch 246 | Loss: 0.1284  
Time elapsed: 7.97 seconds  
Epoch 247 | Loss: 0.1269  
Time elapsed: 8.00 seconds  
Epoch 248 | Loss: 0.1255  
Time elapsed: 8.03 seconds  
Epoch 249 | Loss: 0.1240  
Time elapsed: 8.06 seconds  
Epoch 250 | Loss: 0.1226  
Time elapsed: 8.10 seconds  
Epoch 251 | Loss: 0.1211  
Time elapsed: 8.13 seconds  
Epoch 252 | Loss: 0.1198  
Time elapsed: 8.16 seconds  
Epoch 253 | Loss: 0.1184  
Time elapsed: 8.19 seconds  
Epoch 254 | Loss: 0.1170  
Time elapsed: 8.23 seconds  
Epoch 255 | Loss: 0.1156  
Time elapsed: 8.26 seconds  
Epoch 256 | Loss: 0.1143  
Time elapsed: 8.29 seconds  
Epoch 257 | Loss: 0.1130  
Time elapsed: 8.32 seconds  
Epoch 258 | Loss: 0.1118  
Time elapsed: 8.35 seconds  
Epoch 259 | Loss: 0.1105  
Time elapsed: 8.39 seconds  
Epoch 260 | Loss: 0.1093  
Time elapsed: 8.42 seconds

Epoch 261 | Loss: 0.1081  
Time elapsed: 8.45 seconds  
Epoch 262 | Loss: 0.1069  
Time elapsed: 8.48 seconds  
Epoch 263 | Loss: 0.1057  
Time elapsed: 8.51 seconds  
Epoch 264 | Loss: 0.1046  
Time elapsed: 8.55 seconds  
Epoch 265 | Loss: 0.1034  
Time elapsed: 8.58 seconds  
Epoch 266 | Loss: 0.1023  
Time elapsed: 8.61 seconds  
Epoch 267 | Loss: 0.1012  
Time elapsed: 8.64 seconds  
Epoch 268 | Loss: 0.1000  
Time elapsed: 8.68 seconds  
Epoch 269 | Loss: 0.0989  
Time elapsed: 8.71 seconds  
Epoch 270 | Loss: 0.0978  
Time elapsed: 8.74 seconds  
Epoch 271 | Loss: 0.0967  
Time elapsed: 8.77 seconds  
Epoch 272 | Loss: 0.0956  
Time elapsed: 8.80 seconds  
Epoch 273 | Loss: 0.0944  
Time elapsed: 8.84 seconds  
Epoch 274 | Loss: 0.0932  
Time elapsed: 8.87 seconds  
Epoch 275 | Loss: 0.0920  
Time elapsed: 8.90 seconds  
Epoch 276 | Loss: 0.0908  
Time elapsed: 8.93 seconds  
Epoch 277 | Loss: 0.0896  
Time elapsed: 8.97 seconds  
Epoch 278 | Loss: 0.0885  
Time elapsed: 9.00 seconds  
Epoch 279 | Loss: 0.0873  
Time elapsed: 9.03 seconds  
Epoch 280 | Loss: 0.0862  
Time elapsed: 9.06 seconds  
Epoch 281 | Loss: 0.0850  
Time elapsed: 9.09 seconds  
Epoch 282 | Loss: 0.0839  
Time elapsed: 9.12 seconds  
Epoch 283 | Loss: 0.0827  
Time elapsed: 9.16 seconds  
Epoch 284 | Loss: 0.0816  
Time elapsed: 9.19 seconds

Epoch 285 | Loss: 0.0805  
Time elapsed: 9.22 seconds  
Epoch 286 | Loss: 0.0795  
Time elapsed: 9.25 seconds  
Epoch 287 | Loss: 0.0784  
Time elapsed: 9.28 seconds  
Epoch 288 | Loss: 0.0773  
Time elapsed: 9.31 seconds  
Epoch 289 | Loss: 0.0763  
Time elapsed: 9.35 seconds  
Epoch 290 | Loss: 0.0752  
Time elapsed: 9.38 seconds  
Epoch 291 | Loss: 0.0743  
Time elapsed: 9.41 seconds  
Epoch 292 | Loss: 0.0733  
Time elapsed: 9.44 seconds  
Epoch 293 | Loss: 0.0723  
Time elapsed: 9.47 seconds  
Epoch 294 | Loss: 0.0714  
Time elapsed: 9.51 seconds  
Epoch 295 | Loss: 0.0705  
Time elapsed: 9.54 seconds  
Epoch 296 | Loss: 0.0696  
Time elapsed: 9.57 seconds  
Epoch 297 | Loss: 0.0687  
Time elapsed: 9.60 seconds  
Epoch 298 | Loss: 0.0678  
Time elapsed: 9.63 seconds  
Epoch 299 | Loss: 0.0669  
Time elapsed: 9.67 seconds

[61]: `epochs_vs_loss_with_cells(my_epochs,my_losses)`





```
[63]: drug_features_test = X_test[['Molecular Mass', 'LogP', 'NumHDonors',
    ↳ 'NumHAcceptors', 'TPSA']]
patient_features_test = X_test.drop(columns=drug_features_test.columns)

metrics = evaluate_model(model, drug_features_test, patient_features_test,
    ↳ y_test)

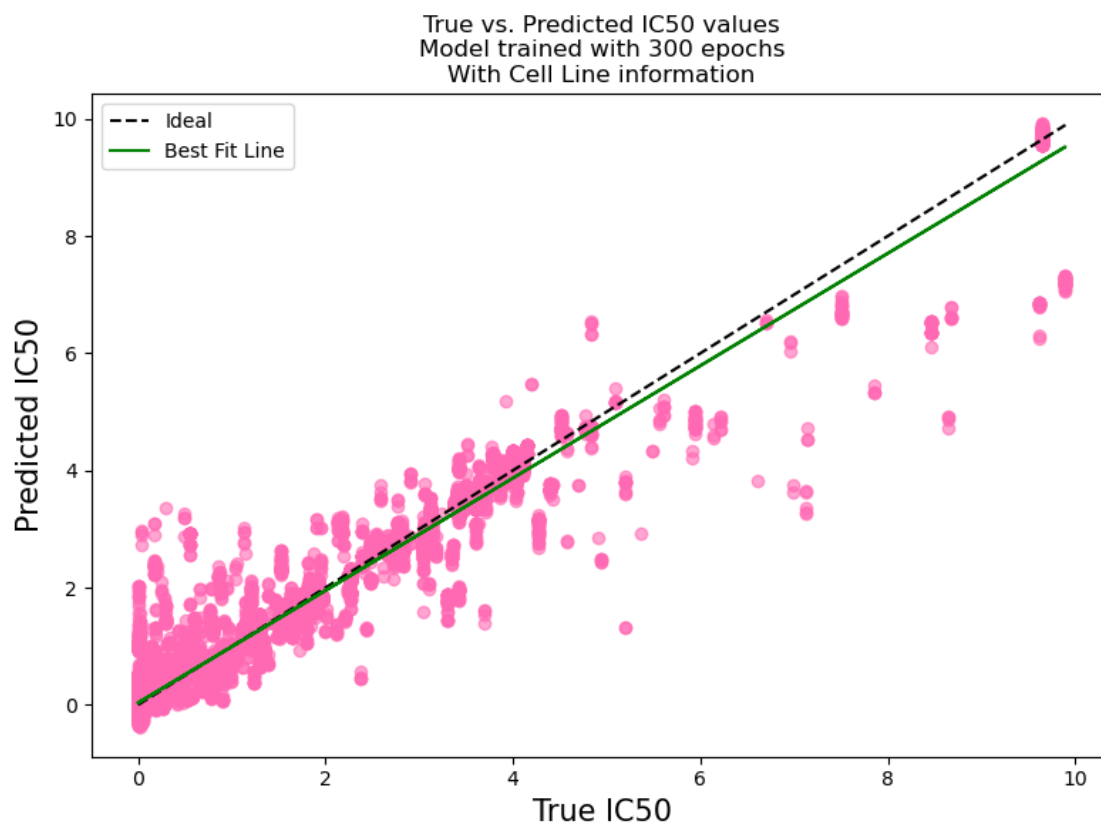
print(f"MSE: {metrics[0]:.4f}")
print(f"MAE: {metrics[1]:.4f}")
print(f"R2: {metrics[2]:.4f}")
```

```
MSE: 0.0650
MAE: 0.1026
R2: 0.9706
```

```
[65]: with torch.no_grad():
    preds = model(torch.tensor(drug_features_test.values).float(),
        torch.tensor(patient_features_test.values).float()).cpu().
    ↳ numpy()
plot_pred_vs_true_with_cells(y_test.to_numpy(), preds)
```

```
/Users/joyceyu/Documents/CHEM277B - ML Algorithms/Final  
project/Data_277_-Cancer/CHEM277B_functions.py:108: UserWarning: color is  
redundantly defined by the 'color' keyword argument and the fmt string "r--" (->  
color='r'). The keyword argument will take precedence.
```

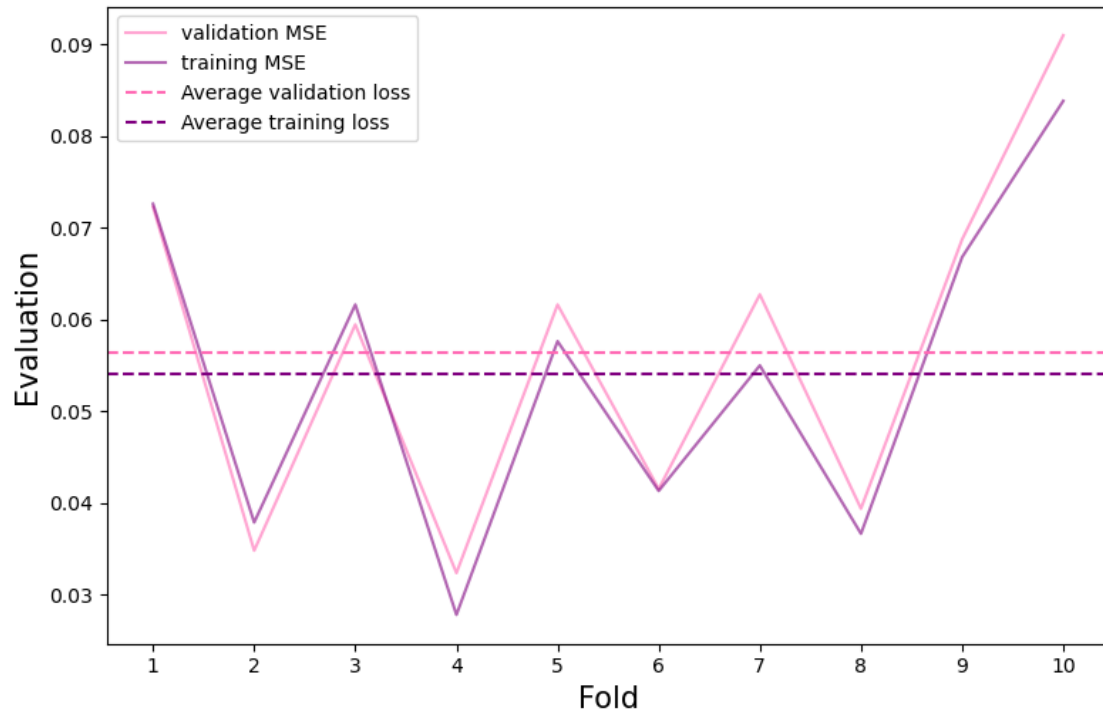
```
plt.plot([true.min(), true.max()], [true.min(), true.max()], 'r--',  
label='Ideal', color = "Black")
```



```
[69]: k_fold_cv = compute_CV_error(X_train, y_train)
```

```
[71]: Kfold_CV_plot_with_cells(k_fold_cv)
```

K Fold cross-validation (k=10)  
Proof of well generalized model  
(i.e. MODEL NOT OVER-FITTED)  
With Cell Line information



[ ]: