Program	B.Pharmacy
Semester	First
CourseTitle /Subject Name	Basics of Python Programming for Pharmaceutical Sciences (Theory)
Course Code	BP101T
Module	Data Visualization with Matplotlib
Course Coordinator	Ms. Ramanjit Kaur
Mobile no	8968729307

Course Objectives:

The objectives of this course are to:

1. Introduce the fundamentals of python programming for pharmaceutical sciences.
2. Develop basic programming skills using control structures, functions ,and data structures.
3. Provide knowledge of data handling techniques for structured dataset management.
4. Familiarize students with data analysis tools such as NumPy and Pandas for healthcare datasets.
5. Enable students to visualize and interpret pharmaceutical data.

Course Outcomes (CO):

CO No.	Upon successful completion of this course, the students will be able to:
BP101.1	Explain the fundamentals of Python programming, including variables, data types, operators, and libraries.
BP101.2	Analyze program logic using control structures and functions.
BP101.3	Organize, manipulate, and retrieve data using data structures and file handling techniques.
BP101.4	Analyze pharmaceutical datasets using Python libraries.
BP101.5	Visualize and interpret pharmaceutical data using graphical tools.

Learning Outcomes:

After completing this unit, students will be able to:

LO	**Learning Outcomes**	CO
1	Understand the Matplotlib library	BP101.5
2	Create different types of plots	BP101.5
3	Customize graphs	BP101.5
4	Visualize pharmaceutical datasets	BP101.5
5	Compare oral and intravenous (IV) drug administration	BP101.5
6	Analyze ADR reporting data	BP101.5
7	Represent dissolution profiles graphically	BP101.5
8	Interpret scientific graphs accurately	BP101.5
9	Select appropriate visualization techniques	BP101.5
10	Develop practical skills in scientific data presentation	BP101.5

Module- 5
Data Visualization with Matplotlib

Matplotlib is one of the most popular plotting libraries in Python, widely used for creating static, interactive and animated visualizations from data. It provides flexible and customizable plotting functions that help in understanding data patterns, trends and relationships effectively. Whether you are a data scientist, engineer, or just someone who wants to visualize data, Matplotlib provides all the tools you need to create publication-quality plots. It serves as the foundational data stack component for plotting in data science, allowing you to build highly customized charts with minimal code. Popular high-level visualization tools like Seaborn and Pandas Data Frames use Matplotlib under the hood.

Creating line plots

A line chart or line plot is a graphical representation used to show the relationship between two continuous variables by connecting data points with a straight line. It is commonly used to visualize trends, patterns or changes over time. In a line chart, the x-axis typically represents the independent variable while the y-axis represents the dependent variable. In Matplotlib line charts are created using the pyplot sublibrary which provides simple and flexible functions for plotting data.

Basic Line Plot

The simplest approach relies on the pyplot module (plt). You define data points for the horizontal x-axis and vertical y-axis, map them with plt.plot(), and display the window using plt.show().

```
import matplotlib.pyplot as plt

1. Define data

x = [1, 2, 3, 4, 5]

y = [2, 4, 1, 5, 3]

2. Create the line plot

plt.plot(x, y)

3. Add information

plt.title("Simple Line Plot")

plt.xlabel("X Axis Label")

plt.ylabel("Y Axis Label")

4. Render plot
```

1. Histogram

Definition

A **histogram** is used to show the distribution of numerical data by dividing it into intervals (bins). It helps identify the frequency of values.

Example

```
</>python
import matplotlib.pyplot as plt
 # Sample data
marks = [45, 50, 55, 60, 65, 70, 72, 75, 80, 85, 90, 95]
# Create histogram
plt.hist(marks, bins=5)
# Add labels
plt.title("Histogram of Marks")
plt.xlabel("Marks")
plt.ylabel("Frequency")
# Display graph
plt.show()
```

Output

- X-axis: Marks
- Y-axis: Frequency (number of students)

2. Scatter Plot

Definition

A **scatter plot** displays the relationship between two numerical variables. Each point represents one observation. Example

```
</>python
import matplotlib.pyplot as plt
# Sample data
age = [20, 25, 30, 35, 40]
weight = [50, 55, 65, 70, 75]
# Create scatter plot
plt.scatter(age, weight)
# Add labels
plt.title("Age vs Weight")
plt.xlabel("Age")
plt.ylabel("Weight")
# Display graph
plt.show()
```

Output

- X-axis: Age
- Y-axis: Weight
- Each dot represents one person's age and weight.

Box Plot

Definition

A box plot (or box-and-whisker plot) summarizes data using:

- Minimum value
- First Quartile (Q1)
- Median (Q2)
- Third Quartile (Q3)
- Maximum value
- Outliers

Example

```
</>python
import matplotlib.pyplot as plt
# Sample data
salary = [25000, 28000, 30000, 32000, 35000, 37000, 40000, 42000, 100000]
# Create box plot
plt.boxplot(salary)
# Add labels
plt.title("Box Plot of Salary")
plt.ylabel("Salary")
# Display graph
plt.show()
```

Output

- The box shows the middle 50% of the data.
- The line inside the box represents the median.
- Dots outside the whiskers represent outliers.

Labeling Axes, Titles, and Legends in Python (Matplotlib)

Introduction

When creating graphs in Python using the Matplotlib library, adding axis labels, titles, and legends makes the graph easier to understand and interpret.

Adding a Title

Definition

A **title** describes the graph and tells the viewer what the graph represents.

Syntax

```
plt.title("Graph Title")
```

Example

```
</>python
import matplotlib.pyplot as plt

x = [1, 2, 3, 4, 5]
y = [10, 20, 30, 40, 50]

plt.plot(x, y)
plt.title("Sales Growth")
plt.show()
```

Output:
The graph displays the title "Sales Growth" at the top.

Labeling the X-axis

Definition

The X-axis label describes the values displayed on the horizontal axis.

Syntax

```
plt.xlabel("X-axis Label")
```

Example

```
</>python
import matplotlib.pyplot as plt

months = [1, 2, 3, 4, 5]
sales = [100, 150, 180, 200, 250]

plt.plot(months, sales)
plt.xlabel("Months")
plt.ylabel("Sales")
plt.title("Monthly Sales")
plt.show()
```

Output:

- X-axis: Months
- Y-axis: Sales

Labeling the Y-axis

Definition

The Y-axis label describes the values displayed on the vertical axis.

Syntax

```
plt.ylabel("Y-axis Label")
```

Adding a Legend

Definition

A legend identifies different lines, bars, or data series in a graph.

Syntax

```
plt.legend()
```

Use the **label** parameter while plotting.

Example

```
</>python
import matplotlib.pyplot as plt

months = [1, 2, 3, 4, 5]
sales = [100, 150, 180, 200, 250]
profit = [20, 30, 40, 50, 60]

plt.plot(months, sales, label="Sales")
plt.plot(months, profit, label="Profit")

plt.title("Sales and Profit")
plt.xlabel("Months")
plt.ylabel("Amount")
plt.legend()

plt.show()
```

Output:

- Blue line → Sales
- Orange line → Profit
- Legend appears in the upper-right corner by default.

Creating Plots and Visualizing Pharmaceutical Datasets in Python

Data visualization helps researchers understand pharmaceutical data by presenting it graphically. Python provides powerful libraries such as **Matplotlib** and **Pandas** to create publication-quality graphs.

1. Concentration–Time Curve (Oral Administration)

A concentration-time curve shows how the drug concentration changes in blood after oral administration.

Example Data

Time (hr)	Concentration (mg/L)
0	0.0
1	2.5
2	5.8
3	7.2
4	6.0

Time (hr)	Concentration (mg/L)
6	4.0
8	2.3
12	0.8

Python Program

```
</>python
import matplotlib.pyplot as plt

time = [0, 1, 2, 3, 4, 6, 8, 12]
concentration = [0, 2.5, 5.8, 7.2, 6.0, 4.0, 2.3, 0.8]

plt.plot(time, concentration, marker='o')
plt.title("Oral Drug Concentration-Time Curve")
plt.xlabel("Time (Hours)")
plt.ylabel("Concentration (mg/L)")
plt.grid(True)
plt.show()
```

Output

- A line graph showing drug concentration increases, reaches a peak (Cmax), and then decreases due to elimination.

2. Concentration–Time Curve (IV Administration)

In intravenous (IV) administration, the drug concentration is highest initially and decreases over time.

Example Data

Time (hr)	Concentration (mg/L)
0	15
1	12
2	9
4	6
6	4
8	2.5
12	1

Python Program

```
</>python
import matplotlib.pyplot as plt
time = [0, 1, 2, 4, 6, 8, 12]
concentration = [15, 12, 9, 6, 4, 2.5, 1]
plt.plot(time, concentration, marker='o', color='red')
plt.title("IV Drug Concentration-Time Curve")
plt.xlabel("Time (Hours)")
plt.ylabel("Concentration (mg/L)")
plt.grid(True)
plt.show()
```

Output

- The graph starts with the highest concentration and continuously decreases.

3. ADR (Adverse Drug Reaction) Reporting Rates Across Drugs

A bar chart compares the number of adverse drug reactions reported for different drugs.

Example Data

Drug	ADR Reports
Drug A	25
Drug B	40
Drug C	18
Drug D	35
Drug E	12

Python Program

```
</>python
import matplotlib.pyplot as plt

drugs = ['Drug A', 'Drug B', 'Drug C', 'Drug D', 'Drug E']
adr = [25, 40, 18, 35, 12]

plt.bar(drugs, adr)
plt.title("ADR Reporting Rates Across Drugs")
plt.xlabel("Drug")
plt.ylabel("Number of ADR Reports")
plt.show()
```

Output

- A bar graph comparing ADR reports for different drugs.

4. Dissolution Profile

A dissolution profile shows the percentage of drug released over time.

Example Data

Time (min)	Drug Released (%)
0	0
10	20
20	42
30	60
45	78
60	92

Python Program

```
</>python
import matplotlib.pyplot as plt

time = [0, 10, 20, 30, 45, 60]
release = [0, 20, 42, 60, 78, 92]

plt.plot(time, release, marker='o')
plt.title("Drug Dissolution Profile")
plt.xlabel("Time (Minutes)")
plt.ylabel("Drug Released (%)")
plt.grid(True)
plt.show()
```

Output

- A line graph showing the percentage of drug dissolved over time.

Scientific Interpretation of Plots in Python (Matplotlib)

Definition

Scientific interpretation of plots is the process of analyzing graphs created in Python using **Matplotlib** to identify trends, patterns, relationships, and draw meaningful scientific conclusions from the data.

In pharmaceutical sciences, plots are used to interpret:

- Drug concentration over time
- Drug dissolution profiles
- Adverse Drug Reaction (ADR) reporting rates
- Dose-response relationships

Example 1: Concentration–Time Curve (Line Plot)

Python Program

```
</>python
import matplotlib.pyplot as plt

time = [0, 1, 2, 3, 4, 5, 6]
concentration = [0, 5, 12, 18, 14, 8, 3]

plt.plot(time, concentration, marker='o')
plt.xlabel("Time (Hours)")
plt.ylabel("Drug Concentration (mg/L)")
plt.title("Concentration-Time Curve")
plt.grid(True)
plt.show()
```

Interpretation

- Drug concentration increases after administration.
- Maximum concentration (**Cmax**) occurs at **3 hours (Tmax)**.
- After reaching the peak, concentration decreases because of drug metabolism and elimination.

Scientific Conclusion

The drug is absorbed into the bloodstream, reaches its peak concentration, and is gradually eliminated from the body.

Example 2: ADR Reporting Rates (Bar Chart)

Python Program

```
</>python
import matplotlib.pyplot as plt

drugs = ["Drug A", "Drug B", "Drug C", "Drug D"]
adr = [25, 40, 18, 32]

plt.bar(drugs, adr)
plt.xlabel("Drugs")
plt.ylabel("ADR Reports")
plt.title("ADR Reporting Rates")
plt.show()
```

Interpretation

- Drug B has the highest ADR reports.
- Drug C has the lowest ADR reports.
- Drug A and Drug D have moderate ADR reports.

Scientific Conclusion

Drug B requires closer pharmacovigilance monitoring due to its higher adverse reaction reporting rate.

Example 3: Dissolution Profile (Line Plot)

Python Program

```
</>python
import matplotlib.pyplot as plt

time = [0, 10, 20, 30, 40, 50, 60]
release = [0, 20, 45, 65, 82, 93, 100]

plt.plot(time, release, marker='o')
plt.xlabel("Time (Minutes)")
plt.ylabel("% Drug Released")
plt.title("Dissolution Profile")
plt.grid(True)
plt.show()
```

Interpretation

- Drug release increases steadily with time.
- Nearly 100% of the drug is released after 60 minutes.
- The formulation shows good dissolution characteristics.

Scientific Conclusion

The tablet releases the drug efficiently and is suitable for therapeutic use.

Example 4: Dose–Response Relationship (Scatter Plot)

Python Program

```
</>python
import matplotlib.pyplot as plt

dose = [5, 10, 15, 20, 25]
response = [12, 22, 33, 42, 52]

plt.scatter(dose, response)
plt.xlabel("Dose (mg)")
plt.ylabel("Response (%)")
plt.title("Dose-Response Relationship")
plt.grid(True)
```

```
plt.show()
```

Interpretation

- Response increases as the drug dose increases.
- The data points show a positive correlation between dose and response.

Scientific Conclusion

Higher doses produce a greater therapeutic effect within the studied dose range.

Example 5: Box Plot (Drug Concentration)

Python Program

```
</>python
import matplotlib.pyplot as plt

concentration = [10, 12, 13, 15, 16, 18, 19, 22, 35]

plt.boxplot(concentration)
plt.title("Drug Concentration Distribution")
plt.ylabel("Concentration (mg/L)")
plt.show()
```

Interpretation

- The median represents the middle concentration.
- The box shows the spread of the middle 50% of the data (interquartile range).
- A value such as 35 mg/L may appear as an outlier, indicating an unusually high concentration.

Multiple Choice Questions (MCQs) Data Visualization with Matplotlib

1. Which Python library is commonly used for data visualization?

A) NumPy
B) Pandas
C) **Matplotlib**
D) SciPy

Answer: C

2. Which module of Matplotlib is mainly used for plotting?

A) matplotlib.image
B) matplotlib.data
C) **matplotlib.pyplot**
D) matplotlib.graph

Answer: C

3. Which statement imports Matplotlib correctly?

A) import matplotlib
B) **import matplotlib.pyplot as plt**
C) import plt
D) import graph

Answer: B

4. Which function displays a graph?

A) display()
B) graph()
C) plot()
D) **show()**

Answer: D

5. Which plot is best for showing changes over time?

A) Histogram
B) Scatter plot
C) Box plot
D) **Line plot**

Answer: D

6. Which function creates a line plot?

A) plt.bar()
B) **plt.plot()**
C) plt.scatter()
D) plt.hist()

Answer: B

7. Which plot shows frequency distribution?

A) Line plot
B) Scatter plot
C) **Histogram**
D) Pie chart

Answer: C

8. Which function creates a histogram?

A) plt.plot()
B) plt.scatter()
C) **plt.hist()**
D) plt.boxplot()

Answer: C

9. Scatter plots are mainly used to show:

A) Frequency
B) Distribution
C) **Relationship between two variables**
D) Categories

Answer: C

10. Which function creates a scatter plot?

A) plt.bar()
B) plt.hist()
C) **plt.scatter()**
D) plt.boxplot()

Answer: C

11. Which plot is useful for detecting outliers?

A) Histogram
B) Scatter plot
C) Line plot
D) **Box plot**

Answer: D

12. Which function creates a box plot?

A) plt.hist()
B) **plt.boxplot()**
C) plt.plot()
D) plt.scatter()

Answer: B

13. Which function labels the X-axis?

A) title()
B) ylabel()
C) **xlabel()**
D) legend()

Answer: C

14. Which function labels the Y-axis?

A) xlabel()
B) legend()
C) **ylabel()**
D) grid()

Answer: C

15. Which function adds a title to the graph?

A) xlabel()
B) ylabel()
C) **title()**
D) show()

Answer: C

16. Which function displays legends?

A) title()
B) xlabel()
C) **legend()**
D) show()

Answer: C

17. Which function adds grid lines?

A) xlabel()
B) ylabel()
C) **grid()**
D) show()

Answer: C

18. The X-axis generally represents:

A) Dependent variable
B) **Independent variable**
C) Constant
D) Frequency

Answer: B

19. The Y-axis generally represents:

A) Independent variable
B) Constant
C) **Dependent variable**
D) Category

Answer: C

20. Which chart is commonly used for ADR reporting rates?

A) Histogram
B) Scatter plot
C) **Bar chart**
D) Pie chart

Answer: C

21. Which function creates a bar chart?

A) plt.hist()
B) plt.plot()
C) **plt.bar()**
D) plt.scatter()

Answer: C

22. Which plot is commonly used for concentration-time curves?

A) Histogram
B) **Line plot**
C) Box plot
D) Pie chart

Answer: B

23. Pharmacokinetic concentration-time curves represent:

A) Drug cost
B) Drug toxicity
C) **Drug concentration over time**
D) Patient age

Answer: C

24. IV administration generally starts with:
A) Zero concentration
B) Low concentration
C) **High concentration**
D) Constant concentration

Answer: C

25. Oral drug administration first shows:

A) Immediate peak
B) Constant level
C) **Absorption phase**
D) No concentration

Answer: C

26. Cmax represents:
A) Minimum concentration
B) **Maximum drug concentration**
C) Drug dose
D) Drug toxicity

Answer: B

27. Tmax represents:

A) Total dose
B) **Time to reach maximum concentration**
C) Half-life
D) Elimination rate

Answer: B

28. Dissolution profile mainly shows:

A) Drug metabolism
B) **Drug release over time**
C) Drug toxicity
D) Drug storage

Answer: B

29. The Y-axis of a dissolution profile usually represents:

A) Drug concentration
B) Temperature
C) **Percentage drug released**
D) Weight

Answer: C

30. Histograms are useful for:

A) Drug comparison
B) Correlation
C) **Frequency distribution**
D) Trend analysis

Answer: C

31. Scatter plots help determine:

A) Frequency
B) **Correlation**
C) Categories
D) Median

Answer: B

32. Which plot displays the median?

A) Histogram
B) Scatter plot
C) **Box plot**
D) Line plot

Answer: C

33. Outliers are best identified using:

A) Histogram
B) **Box plot**
C) Line plot
D) Pie chart

Answer: B

34. Scientific interpretation means:

A) Drawing graphs only
B) **Analyzing graphs to obtain conclusions**
C) Coloring graphs
D) Saving graphs

Answer: B

35. Which graph compares two variables?

A) Histogram
B) **Scatter plot**
C) Pie chart
D) Box plot

Answer: B

36. Matplotlib is mainly used for:

A) Database management
B) **Data visualization**
C) Web development
D) Networking

Answer: B

37. Which package is often used with Matplotlib?

A) Flask
B) Django
C) **NumPy**
D) Tkinter

Answer: C

38.Which package is commonly used with Matplotlib for datasets?

A) OpenCV
B) **Pandas**
C) TensorFlow
D) Pygame

Answer: B

39. Which plot is best for pharmaceutical dissolution studies?

A) Histogram
B) **Line plot**
C) Scatter plot
D) Pie chart

Answer: B

40. Which chart is useful for comparing ADR reports among drugs?

A) Scatter plot
B) Histogram
C) **Bar chart**
D) Box plot

Answer: C

41. The legend identifies:

A) X-axis
B) Y-axis
C) **Different data series**
D) Title

Answer: C

42. Which command displays multiple graph lines with labels?

A) xlabel()
B) ylabel()
C) **legend()**
D) grid()

Answer: C

43. Which graph best shows trends over time?

A) Box plot
B) Histogram

C) **Line plot**
D) Pie chart

Answer: C

44. Which graph summarizes data spread?

A) Line plot
B) Histogram
C) **Box plot**
D) Scatter plot

Answer: C

45. Which graph is useful for dose-response studies?

A) Histogram
B) **Scatter plot**
C) Pie chart
D) Box plot

Answer: B

46. Which graph helps compare different formulations?

A) **Line plot**
B) Histogram
C) Pie chart
D) Box plot

Answer: A

47. In Matplotlib, plots are created using:

A) SQL
B) HTML
C) Java
D) **Python**

Answer: D

48. Which of the following is NOT a Matplotlib plotting function?

A) plot()
B) scatter()
C) hist()
D) **compile()**

Answer: D

49. Which graph is most suitable for identifying trends in pharmacokinetic data?

A) Histogram
B) **Line plot**
C) Pie chart
D) Box plot

Answer: B

50. Scientific interpretation of pharmaceutical plots helps researchers to:

A) Decorate graphs
B) Print graphs
C) **Draw meaningful conclusions from experimental data**
D) Change graph colors

Answer: C

Short Questions with Answers

1. What is Matplotlib?

Answer:
Matplotlib is a Python library used to create graphs, charts, and other data visualizations. It helps represent data graphically for easy analysis and interpretation.

2. Why is Matplotlib used?

Answer:
Matplotlib is used to visualize data, identify trends and patterns, compare datasets, and present scientific results clearly.

3. Which module of Matplotlib is used for plotting?

Answer:
The `matplotlib.pyplot` module is used for creating plots and is commonly imported as:

```
import matplotlib.pyplot as plt
```

4. What is a line plot?

Answer:
A line plot is a graph in which data points are connected by straight lines. It is used to show changes or trends over time.

5. What is a histogram?

Answer:
A histogram is a graph that shows the frequency distribution of numerical data by dividing it into intervals called bins.

6. What is a scatter plot?

Answer:
A scatter plot displays individual data points to show the relationship or correlation between two numerical variables.

7. What is a box plot?

Answer:
A box plot is a graph that summarizes the distribution of data using the minimum, first quartile, median, third quartile, and maximum values.

8. What is the purpose of `plt.xlabel()`?

Answer:
`plt.xlabel()` is used to add a label to the X-axis of a graph.

9. What is the purpose of plt.ylabel()?

Answer:

`plt.ylabel()` is used to add a label to the Y-axis of a graph.

10. What is the purpose of plt.title()?

Answer:

`plt.title()` is used to display the title of a graph.

11. What is the purpose of plt.legend()?

Answer:

`plt.legend()` displays the legend, which identifies different data series in a graph.

12. What is the purpose of plt.grid()?

Answer:

`plt.grid()` adds grid lines to a graph, making it easier to read and interpret data values.

13. What is a concentration–time curve?

Answer:

A concentration–time curve is a line graph that shows how the concentration of a drug in the body changes with time after administration.

14. How does an oral concentration–time curve differ from an IV concentration–time curve?

Answer:

In oral administration, drug concentration increases gradually due to absorption before reaching a peak. In IV administration, the drug concentration is highest immediately after administration and then decreases over time.

15. What is an ADR reporting rate?

Answer:

An ADR (Adverse Drug Reaction) reporting rate indicates the number of adverse drug reactions reported for a particular drug.

16. What is a dissolution profile?

Answer:

A dissolution profile is a graph showing the percentage of drug released from a dosage form over time.

17. Which plot is commonly used to compare ADR reporting rates across drugs?

Answer:

A **bar chart** is commonly used to compare ADR reporting rates among different drugs.

18. What is scientific interpretation of plots?

Answer:
Scientific interpretation of plots is the process of analyzing graphs to identify trends, relationships, and patterns and to draw meaningful scientific conclusions from the data.

19. Which plot is best for detecting outliers?

Answer:
A **box plot** is the best graph for detecting outliers and studying data variability.

20. What are the applications of Matplotlib in pharmaceutical sciences?

Answer:
Matplotlib is used for:

- Plotting concentration–time curves
- Visualizing dissolution profiles
- Comparing ADR reporting rates
- Clinical trial data analysis
- Pharmacokinetic and pharmacodynamic studies
- Drug development and quality control

Long Questions:

1. **Explain Matplotlib. Discuss its features, advantages, and applications in pharmaceutical sciences.**
2. **Explain the different types of plots in Matplotlib. Describe line plots, histograms, scatter plots, and box plots with suitable examples.**
3. **Explain how to create and customize graphs in Matplotlib. Discuss labeling of axes, titles, legends, and grid lines with examples.**
4. **Describe the steps involved in creating line plots, histograms, scatter plots, and box plots using Matplotlib.**
5. **Explain the visualization of pharmaceutical datasets using Matplotlib with suitable examples.**
6. **Discuss the concentration–time curves for oral and intravenous (IV) drug administration. Explain their significance in pharmacokinetic studies.**
7. **Explain how Matplotlib is used to visualize ADR (Adverse Drug Reaction) reporting rates across different drugs.**
8. **Discuss dissolution profiles and explain how Matplotlib is used to visualize drug dissolution data.**
9. **Explain the scientific interpretation of plots. Discuss how graphs help in analyzing pharmaceutical research data.**
10. **Write a detailed note on data visualization in pharmaceutical sciences using Matplotlib. Explain its importance with suitable applications.**

Case-Based Learning (CBL)

Data Visualization with Matplotlib

Case Study: Visualization of Concentration–Time Curves for Oral and IV Administration

Case

A pharmaceutical researcher conducted a pharmacokinetic study to compare drug concentrations after Oral and Intravenous (IV) administration.

Time (hr)	Oral (mg/L)	IV (mg/L)
0	0	20
1	5	18
2	12	15
4	18	10
6	10	6
8	4	3

The researcher wants to create a graph using Matplotlib and scientifically interpret the results.

Python Program

```
</>python
import matplotlib.pyplot as plt
time = [0, 1, 2, 4, 6, 8]
oral = [0, 5, 12, 18, 10, 4]
iv = [20, 18, 15, 10, 6, 3]
plt.plot(time, oral, label="Oral Administration")
plt.plot(time, iv, label="IV Administration")
plt.xlabel("Time (Hours)")
plt.ylabel("Drug Concentration (mg/L)")
plt.title("Concentration-Time Curve")
plt.legend()
plt.show()
```

Short Questions and Answers

Q1. What is Matplotlib?
Answer: A Python library used for creating graphs and data visualizations.
Q2. Which function is used to create a line plot?
Answer: plt.plot()
Q3. Which function adds a title to the graph?
Answer: plt.title()
Q4. Which function labels the X-axis?
Answer: plt.xlabel()
Q5. Which function labels the Y-axis?
Answer: plt.ylabel()
Q6. Which function displays the legend?
Answer: plt.legend()
Q7. Which type of plot is used for concentration-time curves?
Answer: Line plot.
Q8. Which plot is used to show frequency distribution?
Answer: Histogram.
Q9. Which plot is used to study the relationship between two variables?
Answer: Scatter plot.
Q10. Which plot is useful for identifying outliers?
Answer: Box plot.

Problem-Based Learning (PBL)

Data Visualization with Matplotlib

Problem Scenario

A pharmaceutical researcher wants to compare the **ADR (Adverse Drug Reaction) reporting rates** of three drugs.

Drug	ADR Reports
Drug A	25
Drug B	40
Drug C	15

The researcher needs to visualize the data using Matplotlib and identify which drug has the highest ADR reporting rate.

Problem

How can the researcher create a graph and interpret the results?

Solution

```
</>python
import matplotlib.pyplot as plt

drugs = ["Drug A", "Drug B", "Drug C"]
reports = [25, 40, 15]

plt.bar(drugs, reports)

plt.xlabel("Drugs")
plt.ylabel("Number of ADR Reports")
plt.title("ADR Reporting Rates Across Drugs")

plt.show()
```

Scientific Interpretation

- Drug B has the highest ADR reporting rate.
- Drug C has the lowest ADR reporting rate.
- Higher ADR reports may indicate the need for further safety monitoring and investigation.

Short Questions and Answers

Q1. What is Matplotlib?
Ans. A Python library used for data visualization.
Q2. Which function creates a bar graph?
Ans. `plt.bar()`
Q3. Which function adds a title to the graph?
Ans. `plt.title()`
Q4. Which function labels the X-axis?
Ans. `plt.xlabel()`
Q5. Which function labels the Y-axis?
Ans. `plt.ylabel()`
Q6. What does the bar graph represent in this problem?
Ans. ADR reporting rates for different drugs.
Q7. Which drug shows the highest ADR reports?
Ans. Drug B.
Q8. Why is data visualization important in pharmacovigilance?
Ans. It helps identify drug safety trends and risks.
Q9. Which Matplotlib plot is best for comparing categories?
Ans. Bar plot.
Q10. What conclusion can be drawn from this graph?
Ans. Drug B requires closer safety monitoring due to its higher ADR reporting rate.