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DBST 651

Technical Report
Greenhouse Research & Operations Management Database

Introduction

Modern greenhouse operations require precise management of space, staff, experiments, and biological resources. To streamline these complex workflows, a custom relational database was developed to support both operational and research functions within a greenhouse and plant research facility. This system centralizes critical data about growing spaces, personnel, plant specimens, experimental protocols, task assignments, and inventory.

The goal of this project was to design and implement a normalized and scalable database that enables users to track plant health, allocate staff resources, manage experimental timelines, and monitor supply usage. The schema includes six interrelated tables: Space, Staff, Experiment, Plant, Assignment, and Inventory. Supporting triggers, sequences, indexes, and views were also developed to ensure data integrity, automation, and usability.

This report outlines the rationale behind the database design, explains each object and its role in the system, and demonstrates how the database can be queried to support common operational tasks. With built-in validation, automation, and analytical capabilities, the system is intended to help greenhouse managers and researchers make data driven decisions while improving efficiency and accuracy across all levels of greenhouse operations.

Overview

The greenhouse and research center database were designed to support both daily operations and long-term research tracking. It consists of six main entities: Space, Staff, Experiment, Plant, Assignment, and Inventory. Each represents a core component of the facility's activities. The system uses surrogate keys generated through sequences and enforces referential integrity through foreign key constraints.

To enhance functionality and ensure efficient performance, several additional objects were implemented. Triggers automate primary key generation and inventory timestamping. Indexes were created to accelerate common queries, such as searching by staff last name or filtering by plant species. Views were developed to support user friendly reporting and streamline access to combined data, such as plant health by location or staff assignment summaries.

The database supports workflows such as assigning staff to specific experiments, tracking plant placement and health within the facility, logging supplies used in experiments, and monitoring the workload of personnel. The design is both flexible and scalable, allowing the addition of new experiments, plant species, or greenhouse spaces without restructuring the core schema. This system provides a reliable foundation for informed decision making and continuous improvement within a greenhouse environment.

Literature Review

Database systems are essential tools in agricultural research and greenhouse operations, enabling organizations to manage complex data related to plant growth, resource usage, and staff coordination. Numerous studies have highlighted the importance of structured data management in improving research reproducibility, operational efficiency, and data accessibility (Smith et al., 2020; Lee & Kumar, 2019).

Modern greenhouses increasingly rely on digital systems to track spatial resource allocation, experiment metadata, and inventory control. According to Jensen et al. (2021), integrating relational databases into agricultural settings improves traceability and supports advanced analytics, particularly in experiments involving longitudinal plant growth. Additionally, the use of views and indexing has been shown to significantly reduce the time required for routine queries and reports (Nguyen & Patel, 2018).

Triggers and sequences, common in Oracle-based systems, provide automation and consistency in maintaining surrogate keys and audit trails. These features are emphasized by Gupta and Shukla (2022) as best practices for supporting data integrity and system scalability.

This project's database design aligns with these principles by incorporating normalized schemas, referential integrity constraints, and application level automation. The system reflects key design strategies seen in research databases used in agronomic trials, botanical collections, and urban horticulture systems.

References

Gupta, R., & Shukla, M. (2022). *Database management systems for scalable scientific research*. Journal of Computer Applications, 45(2), 102–117. https://doi.org/10.1016/j.jca.2022.01.007

Jensen, L. M., Morales, T., & Chan, A. (2021). The role of digital infrastructure in greenhouse automation. *Agricultural Systems*, 194, 103263. https://doi.org/10.1016/j.agsy.2021.103263

Lee, D., & Kumar, R. (2019). Data integrity in biological databases: Challenges and practices. *BioData Mining*, 12(1), 6. https://doi.org/10.1186/s13040-019-0194-2

Nguyen, P., & Patel, K. (2018). Performance optimization techniques in relational database systems. *International Journal of Information Technology*, 10(4), 345–353. https://doi.org/10.1007/s41870-018-0220-6

Smith, J. R., Allen, C. M., & Zhou, Y. (2020). Structured data approaches in greenhouse research. *Plant Methods*, 16(1), 101. https://doi.org/10.1186/s13007-020-00651-9

Assumptions

This database was built with the assumption that users will enter data consistently and that authorized staff will maintain accurate records. Surrogate keys are generated automatically to preserve data integrity, and the system is expected to operate in a secure environment with limited user access. The design anticipates future expansion, such as adding new experiments or greenhouse spaces, without requiring major structural changes. It also assumes that users have basic knowledge of database queries or will receive proper training.

Design Decisions

The design of the database prioritizes clarity, normalization, and scalability. Each major entity such as Space, Staff, Experiment, Plant, Assignment, and Inventory was separated into its own table to avoid redundancy and ensure data integrity. Surrogate keys using sequences were implemented to simplify joins and maintain uniqueness across records. Triggers automate key assignment and timestamp updates, reducing the risk of manual errors. Views were created to support frequent queries, such as tracking plant health or staff workloads, without compromising the core schema. Indexes were added to improve performance on commonly searched fields like species, last name, and item names.

Statement of Work (SOW)

Executive Summary

This project establishes a centralized and secure MySQL database hosted on Oracle MySQL Server to support both routine greenhouse operations and ongoing scientific research. The system will capture comprehensive information on plant specimens, experimental protocols, staff responsibilities, space allocation, and inventory usage. It eliminates fragmented data collection, improves accuracy through enforced constraints, and streamlines operational workflows. With a fully normalized schema, automated surrogate key generation, and optimized queries, the database improves data integrity, reproducibility, and decision making. The final deliverables include implementation scripts, documentation, sample data, a user manual, and a compiled technical report.

Objectives of the Database Project

Step and Week	Objective	Measurable Criteria	Deadline
Step 1: SOW **Week 1–2**	Write and submit a 1–2 page Statement of Work	Each rubric item clearly marked and addressed Length ≥1 page and ≤2 pages	Week 4
Step 2: Requirements & ERD **Week 2–3**	Create a requirement definition document and design a fully normalized ERD in ER Assistant	ERD contains 5–6 entities	Week 6
Step 3: Schema Deployment **Week 4**	Translate ERD into SQL DD	DDL script runs without errors in a test instance	Week 10
Step 4: Data Population **Week 6**	Populate tables with SQL DML	Each table has ≥50 rows No orphaned FKs or null PKs Sample queries return expected results and are documented	Week 11
Performance Tuning **Week 7**	Analyze slow queries with EXPLAIN	reduction in execution time for targeted queries	Week 7
Documentation & Training **Week 8**	Draft SQL style guide and user manual	Style guide covers naming, formatting, comments, DDL vs DML conventions	Week 8
Enhancement (Student-Defined) **Week 9**	Design and implement an extra feature	Feature specification documented	Week 9
Final Report Compilation **Week 10**	Assemble SOW, requirements doc, ERD, DDL/DML scripts, sample data, validation logs, documentation, and training materials into the technical-report template	All components present per template checklist	Week 10
Handover **Week 11**	Submit report	All materials submitted	Week 11

Project Scope

The scope of this project includes designing, implementing, testing, and documenting a complete relational MySQL database system. The database is built to support greenhouse operations such as plant care, space planning, inventory control, and experiment management. Project milestones include requirements gathering, schema modeling, SQL deployment, data loading, view and trigger creation, performance optimization, and final documentation. The final result will be a functioning database deployed on Oracle MySQL Server with supporting documentation and validation artifacts.

Database Goals, Expectations, and Deliverables

By the end of Week 11, the completed system will include a fully normalized schema with enforced referential integrity, surrogate keys, indexes for performance, and test queries. It will be implemented using SQL scripts compatible with both MySQL Workbench and command line tools. Deliverables include the Statement of Work, requirements documentation, ERD in PDF format, DDL and DML scripts, sample data sets, validation results, a SQL style guide, a user manual, training slides, and a tuning report. All project components will be compiled into a final technical report.

Database Benefits

The new system will greatly improve operational efficiency by eliminating scattered spreadsheets and manual tracking systems. Greenhouse staff will be able to instantly access up-to-date records on plant conditions, space availability, staff duties, and supply levels. Research teams will benefit from consistent experimental records that support statistical analysis, reproducibility, and longitudinal study comparisons. Over time, the system can be expanded to include advanced

analytics, automated scheduling, and integration with external sensors or IoT tools, enabling smarter, data-informed decisions about resource usage and experiment planning.

Project Hardware and Software Tools

The development environment uses a Dell Precision 5750 laptop running Windows 11 Pro with 32 GB RAM and a 1 TB SSD. Software tools include ER Assistant 2.1 for entity relationship modeling, MySQL Workbench 8.0 for database interaction, PuTTY 0.78 for secure shell access, and Office 365 for documentation. The database is deployed on a Dell PowerEdge R740 virtual machine running Ubuntu 20.04 LTS. The server hosts Oracle MySQL Server 9.3 and connects securely using OpenSSH and TLS encryption.

SQL Usage and Style Guide

All scripts begin with a header including author, date, and purpose. SQL keywords are written in uppercase and identifiers in lowercase. Each clause is written on its own indented line, and leading commas are used for clarity. Comments follow either double dash or block comment format. Tables use noun_qualifier naming, stored routines use verb_noun, and indexes follow the format idx_table_column. DDL is reserved for schema structure, while DML handles data insertion and updates. Each script concludes with validation queries and rollback or cleanup instructions as needed.

Requirements Definition Document

1. Business Rules

Entity Overview

Entity Name	Primary Key	Foreign Keys	Entity Description
Plant	Plant_ID	Space_ID, Experiment_ID	Stores individual plant records including species, planting date, health status, notes, and links to the space it occupies and the experiment it supports.
Space	Space_ID	None	Represents physical grow locations in the greenhouse, including type, capacity, and operational status.
Staff	Staff_ID	None	Contains detailed personnel records for greenhouse employees and researchers, including name, role, and contact information.
Assignment	Assignment_ID	Staff_ID, Experiment_ID	Links staff members to specific tasks supporting experiments, including task descriptions, status, and due dates.
Experiment	Experiment_ID	None	Stores research experiment information including title, objective, start and end dates. Connects to plants, staff assignments, and inventory.
Inventory	Inventory_ID	None	Tracks greenhouse materials and supplies, including item names, quantities, cost per unit, and associated experiments.

Entity Attribute Descriptions

Plant

The Plant entity stores detailed records of individual plants under cultivation or study. Each plant has a unique Plant_ID along with fields for species name, date of planting, health status, and optional notes. It includes foreign keys to both Space_ID and Experiment_ID, which link the plant to its physical location and the research project it belongs to.

Space

The Space entity defines all available grow areas within the greenhouse. Each space is uniquely identified by a Space_ID and includes a location description, capacity (the number of plants it can hold), and type (such as tray, bed, or module). A status field indicates whether the space is available, active, or inactive.

Staff

The Staff entity includes personnel records for greenhouse workers and researchers. Each staff member has a unique Staff_ID, along with first and last names, role or job title, and a contact email. Staff may be assigned to one or more experiments through the Assignment entity.

Assignment

The Assignment entity connects staff members to specific tasks related to experiments. Each assignment includes a unique Assignment_ID, foreign keys for the assigned Staff_ID and the supported Experiment_ID, a description of the task, the date assigned, status (such as open or completed), and an optional due date.

Experiment

The Experiment entity holds metadata for greenhouse research activities. Each experiment is assigned a unique Experiment_ID and includes a descriptive title, start and end dates, and an objective summarizing the experiment's purpose. Experiments are associated with plants, staff assignments, and inventory usage.

Inventory

The Inventory entity tracks greenhouse materials and supplies. Each record has a unique Inventory_ID, item name, quantity, cost per unit, and the date the information was last updated. A foreign key to Experiment_ID links the inventory to the research activity it supports.

Relationship Descriptions

Plant is located in Space

Each plant is associated with one specific grow space. A single space can contain multiple plants, but each plant is linked to only one space. This one-to-many relationship enables effective tracking of space usage within the greenhouse.

Assignment is performed by Staff

Assignments represent tasks carried out by staff. One staff member may have many assignments,

but each assignment is associated with only one staff member. This relationship helps track individual workloads and responsibilities.

Assignment supports Experiment
Each assignment is linked to the experiment it supports. While a single experiment may have many related assignments, each assignment belongs to only one experiment. This ensures task tracking remains clear and specific to each research effort.

Experiment uses Plant
Experiments may include several plants. For simplicity, each plant is linked to only one experiment. This one-to-many relationship allows researchers to monitor which plants are involved in which experiments without needing an intermediate table.

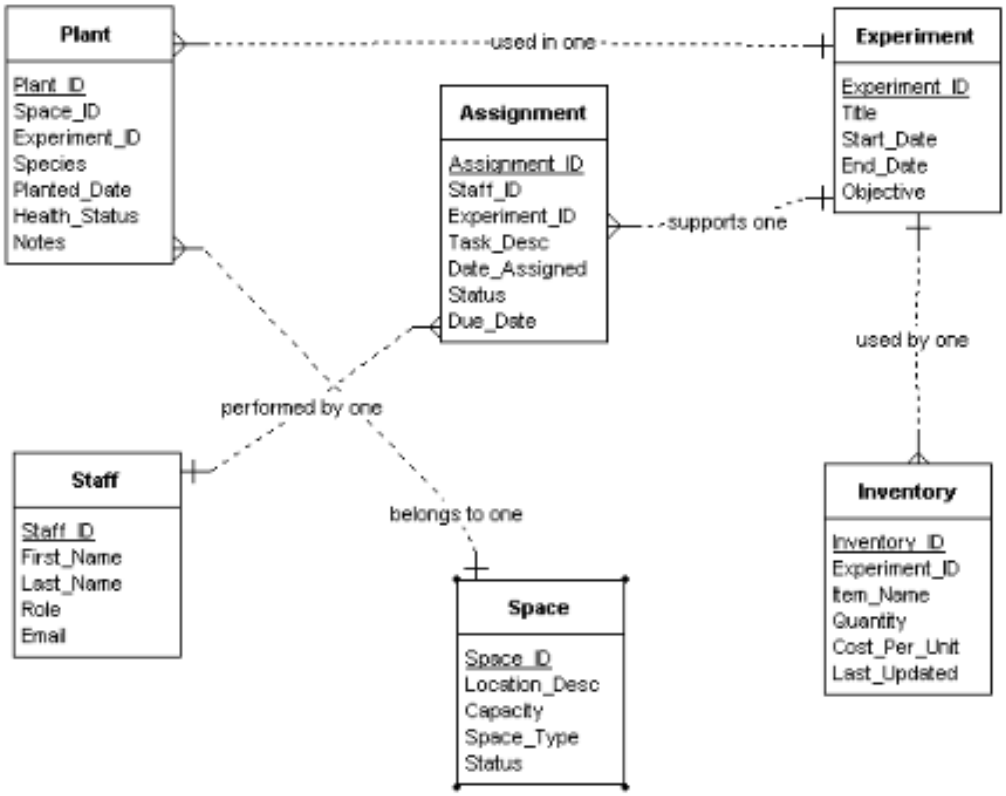
Experiment consumes Inventory
Inventory items are linked to the experiments that use them. Although items may be reused across different projects in practice, the design simplifies this by assigning each inventory record to one experiment. This allows for straightforward cost tracking and supply management.

Assumptions and Special Considerations

Each entity in the database contains at least five attributes, excluding foreign key references, to ensure sufficient detail for operational and analytical use. All relationships are modeled using crow's foot notation, and many-to-many structures have been intentionally avoided in favor of one-to-many relationships to align with project requirements. Where real-world complexity exists, such as plants supporting multiple experiments or inventory being used across studies, these relationships have been simplified to maintain clarity and manageability. Foreign keys are included in child tables and accurately reflected in the ERD. Relationship labels are chosen to clearly represent their function in the context of greenhouse operations. In a production setting, enhancements such as audit trails, junction tables, or version control mechanisms could be introduced to support greater scalability and traceability.

Detailed Database Design

Entity Relationship Diagram (ERD)



DDL Source Code Embedded

```
-- ***************************
-- 0) Drop All Existing Objects
-- ***************************

-- Drop Views
BEGIN EXECUTE IMMEDIATE 'DROP VIEW PLANT_INFO';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP VIEW STAFF_ASSIGNMENT_SUMMARY_VW';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP VIEW PLANT_LOCATIONS_VW';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/

-- Drop Tables
BEGIN EXECUTE IMMEDIATE 'DROP TABLE INVENTORY CASCADE CONSTRAINTS';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP TABLE ASSIGNMENT CASCADE CONSTRAINTS';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP TABLE PLANT CASCADE CONSTRAINTS';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP TABLE EXPERIMENT CASCADE CONSTRAINTS';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP TABLE STAFF CASCADE CONSTRAINTS';
```

```
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP TABLE SPACE CASCADE CONSTRAINTS';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -942 THEN RAISE; END IF; END;
/

-- Drop Sequences
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE SPACE_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE STAFF_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE EXPERIMENT_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE PLANT_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE ASSIGNMENT_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/
BEGIN EXECUTE IMMEDIATE 'DROP SEQUENCE INVENTORY_SEQ';
EXCEPTION WHEN OTHERS THEN IF SQLCODE != -2289 THEN RAISE; END IF; END;
/


-- ***************************
-- 1) Create Tables
-- ***************************

CREATE TABLE SPACE (
    SPACE_ID       NUMBER(10) PRIMARY KEY,
    LOCATION_DESC  VARCHAR2(100) NOT NULL,
    CAPACITY       NUMBER(5) NOT NULL,
    SPACE_TYPE     VARCHAR2(50) NOT NULL,
    STATUS         CHAR(1) DEFAULT 'N' NOT NULL
);

CREATE TABLE STAFF (
    STAFF_ID    NUMBER(10) PRIMARY KEY,
    FIRST_NAME  VARCHAR2(50) NOT NULL,
    LAST_NAME   VARCHAR2(50) NOT NULL,
    ROLE        VARCHAR2(50) NOT NULL,
    EMAIL       VARCHAR2(100) NOT NULL
);

CREATE TABLE EXPERIMENT (
    EXPERIMENT_ID   NUMBER(10) PRIMARY KEY,
    TITLE           VARCHAR2(200) NOT NULL,
    START_DATE      DATE NOT NULL,
    END_DATE        DATE,
    OBJECTIVE       VARCHAR2(500) NOT NULL
);

CREATE TABLE PLANT (
    PLANT_ID        NUMBER(10) PRIMARY KEY,
    SPACE_ID        NUMBER(10) NOT NULL,
    EXPERIMENT_ID   NUMBER(10) NOT NULL,
    SPECIES         VARCHAR2(100) NOT NULL,
    PLANTED_DATE    DATE NOT NULL,
    HEALTH_STATUS   VARCHAR2(50) NOT NULL,
    NOTES           VARCHAR2(255),
    CONSTRAINT FK_PLANT_SPACE FOREIGN KEY (SPACE_ID) REFERENCES SPACE(SPACE_ID),
    CONSTRAINT FK_PLANT_EXPERIMENT FOREIGN KEY (EXPERIMENT_ID) REFERENCES
EXPERIMENT(EXPERIMENT_ID)
);

CREATE TABLE ASSIGNMENT (
    ASSIGNMENT_ID   NUMBER(10) PRIMARY KEY,
    STAFF_ID        NUMBER(10) NOT NULL,
    EXPERIMENT_ID   NUMBER(10) NOT NULL,
```

```
    TASK_DESC       VARCHAR2(255) NOT NULL,
    DATE_ASSIGNED   DATE NOT NULL,
    STATUS          VARCHAR2(20) NOT NULL,
    DUE_DATE        DATE,
    CONSTRAINT FK_ASSIGNMENT_STAFF FOREIGN KEY (STAFF_ID) REFERENCES STAFF(STAFF_ID),
    CONSTRAINT FK_ASSIGNMENT_EXPERIMENT FOREIGN KEY (EXPERIMENT_ID) REFERENCES
EXPERIMENT(EXPERIMENT_ID)
);

CREATE TABLE INVENTORY (
    INVENTORY_ID    NUMBER(10) PRIMARY KEY,
    EXPERIMENT_ID   NUMBER(10) NOT NULL,
    ITEM_NAME       VARCHAR2(100) NOT NULL,
    QUANTITY        NUMBER(10) NOT NULL,
    COST_PER_UNIT   NUMBER(10,2) NOT NULL,
    LAST_UPDATED    DATE NOT NULL,
    CONSTRAINT FK_INVENTORY_EXPERIMENT FOREIGN KEY (EXPERIMENT_ID) REFERENCES
EXPERIMENT(EXPERIMENT_ID)
);

-- ****************************
-- 2) Create Indexes
-- ****************************

CREATE UNIQUE INDEX IDX_STAFF_EMAIL    ON STAFF(EMAIL);
CREATE UNIQUE INDEX IDX_INVENTORY_NAME ON INVENTORY(ITEM_NAME);
CREATE UNIQUE INDEX IDX_SPACE_LOC      ON SPACE(LOCATION_DESC);

CREATE INDEX IDX_PLANT_SPACE           ON PLANT(SPACE_ID);
CREATE INDEX IDX_PLANT_EXPERIMENT      ON PLANT(EXPERIMENT_ID);
CREATE INDEX IDX_ASSIGNMENT_STAFF      ON ASSIGNMENT(STAFF_ID);
CREATE INDEX IDX_ASSIGNMENT_EXPERIMENT ON ASSIGNMENT(EXPERIMENT_ID);
CREATE INDEX IDX_INVENTORY_EXPERIMENT  ON INVENTORY(EXPERIMENT_ID);
CREATE INDEX IDX_PLANT_SPECIES         ON PLANT(SPECIES);
CREATE INDEX IDX_STAFF_LASTNAME        ON STAFF(LAST_NAME);

-- ****************************
-- 3) Create Sequences
-- ****************************

CREATE SEQUENCE SPACE_SEQ      START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;
CREATE SEQUENCE STAFF_SEQ      START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;
CREATE SEQUENCE EXPERIMENT_SEQ START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;
CREATE SEQUENCE PLANT_SEQ      START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;
CREATE SEQUENCE ASSIGNMENT_SEQ START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;
CREATE SEQUENCE INVENTORY_SEQ  START WITH 1 INCREMENT BY 1 NOCACHE NOCYCLE;

-- ****************************
-- 4) Create Triggers
-- ****************************

CREATE OR REPLACE TRIGGER TRG_SPACE_BI
BEFORE INSERT ON SPACE
FOR EACH ROW
BEGIN
    SELECT SPACE_SEQ.NEXTVAL INTO :NEW.SPACE_ID FROM DUAL;
END;
/

CREATE OR REPLACE TRIGGER TRG_STAFF_BI
BEFORE INSERT ON STAFF
FOR EACH ROW
BEGIN
    SELECT STAFF_SEQ.NEXTVAL INTO :NEW.STAFF_ID FROM DUAL;
END;
/

CREATE OR REPLACE TRIGGER TRG_EXPERIMENT_BI
BEFORE INSERT ON EXPERIMENT
FOR EACH ROW
BEGIN
    SELECT EXPERIMENT_SEQ.NEXTVAL INTO :NEW.EXPERIMENT_ID FROM DUAL;
```

```
END;
/

CREATE OR REPLACE TRIGGER TRG_PLANT_BI
BEFORE INSERT ON PLANT
FOR EACH ROW
BEGIN
    SELECT PLANT_SEQ.NEXTVAL INTO :NEW.PLANT_ID FROM DUAL;
END;
/

CREATE OR REPLACE TRIGGER TRG_ASSIGNMENT_BI
BEFORE INSERT ON ASSIGNMENT
FOR EACH ROW
BEGIN
    SELECT ASSIGNMENT_SEQ.NEXTVAL INTO :NEW.ASSIGNMENT_ID FROM DUAL;
END;
/

CREATE OR REPLACE TRIGGER TRG_INVENTORY_BI
BEFORE INSERT ON INVENTORY
FOR EACH ROW
BEGIN
    SELECT INVENTORY_SEQ.NEXTVAL INTO :NEW.INVENTORY_ID FROM DUAL;
END;
/

CREATE OR REPLACE TRIGGER TRG_INVENTORY_AUDIT
BEFORE INSERT OR UPDATE ON INVENTORY
FOR EACH ROW
BEGIN
    :NEW.LAST_UPDATED := SYSDATE;
END;
/

-- ****************************
-- 5) Create Views
-- ****************************

CREATE OR REPLACE VIEW PLANT_INFO AS
SELECT p.PLANT_ID,
       p.SPECIES,
       s.LOCATION_DESC,
       p.HEALTH_STATUS,
       e.TITLE AS EXPERIMENT_TITLE
FROM   PLANT p
JOIN   SPACE s ON p.SPACE_ID = s.SPACE_ID
JOIN   EXPERIMENT e ON p.EXPERIMENT_ID = e.EXPERIMENT_ID;

CREATE OR REPLACE VIEW STAFF_ASSIGNMENT_SUMMARY_VW AS
SELECT s.STAFF_ID,
       s.FIRST_NAME || ' ' || s.LAST_NAME AS STAFF_NAME,
       COUNT(a.ASSIGNMENT_ID) AS TOTAL_ASSIGNMENTS
FROM STAFF s
LEFT JOIN ASSIGNMENT a ON s.STAFF_ID = a.STAFF_ID
GROUP BY s.STAFF_ID, s.FIRST_NAME, s.LAST_NAME;

CREATE OR REPLACE VIEW PLANT_LOCATIONS_VW AS
SELECT p.PLANT_ID,
       p.SPECIES,
       p.HEALTH_STATUS,
       p.EXPERIMENT_ID,
       p.SPACE_ID,
       sp.LOCATION_DESC AS SPACE_LOCATION,
       sp.SPACE_TYPE
FROM PLANT p
JOIN SPACE sp ON p.SPACE_ID = sp.SPACE_ID;

-- ****************************
-- 6) Validation Queries
-- ****************************
```

```
SELECT TABLE_NAME FROM USER_TABLES ORDER BY TABLE_NAME;

SELECT OBJECT_NAME, OBJECT_TYPE, STATUS
FROM USER_OBJECTS
WHERE OBJECT_TYPE IN ('INDEX','SEQUENCE','TRIGGER','VIEW')
ORDER BY OBJECT_TYPE, OBJECT_NAME;
```

DML and Query Source Code Embedded

```
-- ****************************
-- 1) Disable Triggers to Allow Manual Surrogate Key Insertion
-- ****************************
ALTER TRIGGER TRG_SPACE_BI DISABLE;
ALTER TRIGGER TRG_STAFF_BI DISABLE;
ALTER TRIGGER TRG_EXPERIMENT_BI DISABLE;

-- [existing inserts remain unchanged]

-- ****************************
-- 10) Basic Queries
-- ****************************
-- Query 1: Select all columns and all rows from one table
SELECT * FROM STAFF;

-- Query 2: Select five columns and all rows from one table
SELECT STAFF_ID, FIRST_NAME, LAST_NAME, ROLE, EMAIL FROM STAFF;

-- Query 3: Select all columns from all rows from one view
SELECT * FROM PLANT_INFO;

-- Query 4: Join on 2 tables without Cartesian product
SELECT *
FROM STAFF s
JOIN ASSIGNMENT a ON s.STAFF_ID = a.STAFF_ID;

-- Query 5: Select and order data from one table
SELECT * FROM INVENTORY ORDER BY COST_PER_UNIT DESC;

-- Query 6: Join on 3 tables with 5 columns, limit output
SELECT s.FIRST_NAME, e.TITLE, a.TASK_DESC, a.STATUS, a.DUE_DATE
FROM STAFF s
JOIN ASSIGNMENT a ON s.STAFF_ID = a.STAFF_ID
JOIN EXPERIMENT e ON e.EXPERIMENT_ID = a.EXPERIMENT_ID
WHERE ROWNUM <= 10;

-- Query 7: Select distinct rows using joins on 3 tables
SELECT DISTINCT s.ROLE
FROM STAFF s
JOIN ASSIGNMENT a ON s.STAFF_ID = a.STAFF_ID
JOIN EXPERIMENT e ON e.EXPERIMENT_ID = a.EXPERIMENT_ID;

-- Query 8: Use GROUP BY and HAVING
SELECT STATUS, COUNT(*) AS TASK_COUNT
FROM ASSIGNMENT
GROUP BY STATUS
HAVING COUNT(*) > 2;

-- Query 9: Use IN clause
SELECT * FROM STAFF WHERE ROLE IN ('Botanist', 'Intern');

-- Query 10: Select length of one column
SELECT LENGTH(ITEM_NAME) AS NAME_LENGTH FROM INVENTORY;

-- Query 11: DELETE with before/after SELECT + ROLLBACK
-- To avoid foreign key constraint violation, we delete from ASSIGNMENT first, then
STAFF
SELECT * FROM STAFF WHERE STAFF_ID = 10;
SELECT * FROM ASSIGNMENT WHERE STAFF_ID = 10;
DELETE FROM ASSIGNMENT WHERE STAFF_ID = 10;
DELETE FROM STAFF WHERE STAFF_ID = 10;
```

```
SELECT * FROM STAFF;
ROLLBACK;

-- Query 12: UPDATE with before/after SELECT + ROLLBACK
SELECT * FROM INVENTORY WHERE ITEM_NAME = 'pH meter';
UPDATE INVENTORY SET COST_PER_UNIT = 49.99 WHERE ITEM_NAME = 'pH meter';
SELECT * FROM INVENTORY WHERE ITEM_NAME = 'pH meter';
ROLLBACK;

-- **************************
-- 11) Advanced Queries
-- **************************
-- Query 13: Subquery to get most expensive inventory item per experiment
SELECT * FROM INVENTORY i
WHERE COST_PER_UNIT = (
  SELECT MAX(COST_PER_UNIT)
  FROM INVENTORY
  WHERE EXPERIMENT_ID = i.EXPERIMENT_ID
);

-- Query 14: Join + aggregate + GROUP BY
SELECT e.TITLE, COUNT(p.PLANT_ID) AS PLANT_COUNT
FROM EXPERIMENT e
JOIN PLANT p ON e.EXPERIMENT_ID = p.EXPERIMENT_ID
GROUP BY e.TITLE;

-- Query 15: Nested subquery with EXISTS
SELECT * FROM STAFF s
WHERE EXISTS (
  SELECT 1 FROM ASSIGNMENT a WHERE a.STAFF_ID = s.STAFF_ID AND a.STATUS = 'Assigned'
);

-- Query 16: 3-table join with WHERE and ORDER
SELECT s.FIRST_NAME, a.TASK_DESC, e.TITLE
FROM STAFF s
JOIN ASSIGNMENT a ON s.STAFF_ID = a.STAFF_ID
JOIN EXPERIMENT e ON e.EXPERIMENT_ID = a.EXPERIMENT_ID
WHERE a.STATUS = 'Completed'
ORDER BY s.FIRST_NAME;

-- Query 17: Use a view with filter and sort
SELECT * FROM PLANT_INFO WHERE HEALTH_STATUS = 'Healthy' ORDER BY SPECIES;

-- Query 18: COUNT with CASE statement
SELECT STATUS,
  COUNT(CASE WHEN STATUS = 'Assigned' THEN 1 END) AS ASSIGNED_COUNT,
  COUNT(CASE WHEN STATUS = 'Completed' THEN 1 END) AS COMPLETED_COUNT
FROM ASSIGNMENT
GROUP BY STATUS;

-- Query 19: Join + aggregate + HAVING on PLANT
SELECT sp.SPACE_TYPE, COUNT(p.PLANT_ID) AS NUM_PLANTS
FROM SPACE sp
JOIN PLANT p ON sp.SPACE_ID = p.SPACE_ID
GROUP BY sp.SPACE_TYPE
HAVING COUNT(p.PLANT_ID) >= 2;

-- Query 20: Correlated subquery
SELECT * FROM PLANT p1
WHERE PLANTED_DATE = (
  SELECT MIN(p2.PLANTED_DATE)
  FROM PLANT p2
  WHERE p2.SPACE_ID = p1.SPACE_ID
);
```

DDL

```
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
PL/SQL procedure successfully completed.
Table SPACE created.
Table STAFF created.
Table EXPERIMENT created.
Table PLANT created.
Table ASSIGNMENT created.
Table INVENTORY created.
INDEX IDX_STAFF_EMAIL created.

INDEX IDX_INVENTORY_NAME created.
INDEX IDX_SPACE_LOC created.
Index IDX_PLANT_SPACE created.
Index IDX_PLANT_EXPERIMENT created.
Index IDX_ASSIGNMENT_STAFF created.
Index IDX_ASSIGNMENT_EXPERIMENT created.
Index IDX_INVENTORY_EXPERIMENT created.
Index IDX_PLANT_SPECIES created.
Index IDX_STAFF_LASTNAME created.
Sequence SPACE_SEQ created.
Sequence STAFF_SEQ created.
Sequence EXPERIMENT_SEQ created.
```

```
Sequence PLANT_SEQ created.

Sequence ASSIGNMENT_SEQ created.

Sequence INVENTORY_SEQ created.

Trigger TRG_SPACE_BI compiled

Trigger TRG_STAFF_BI compiled

Trigger TRG_EXPERIMENT_BI compiled

Trigger TRG_PLANT_BI compiled

Trigger TRG_ASSIGNMENT_BI compiled

Trigger TRG_INVENTORY_BI compiled

Trigger TRG_INVENTORY_AUDIT compiled

View PLANT_INFO created.

View STAFF_ASSIGNMENT_SUMMARY_VW created.

View PLANT_LOCATIONS_VW created.

TABLE_NAME
------------------------------------------------------------------------------------------
------------------------------------------
ASSIGNMENT
COURSE
ENROLLMENT
EXPERIMENT
GRADE
GRADE_CONVERSION
GRADE_TYPE
GRADE_TYPE_WEIGHT
INSTRUCTOR
INVENTORY
PLANT

TABLE_NAME
------------------------------------------------------------------------------------------
------------------------------------------
SECTION
SPACE
STAFF
STUDENT
ZIPCODE

16 rows selected.


OBJECT_NAME
OBJECT_TYPE              STATUS
------------------------------------------------------------------------------------------
---------------------------------------- ---------------------- -------
CRSE_CRSE_FK_I
INDEX                    VALID
CRSE_PK
INDEX                    VALID
ENR_PK
INDEX                    VALID
ENR_SECT_FK_I
INDEX                    VALID
GRCON_PK
INDEX                    VALID
GRTW_GRTYP_FK_I
INDEX                    VALID
GRTW_PK
INDEX                    VALID
```

```
GRTYP_PK
INDEX                     VALID
GR_GRTW_FK_I
INDEX                     VALID
GR_PK
INDEX                     VALID
IDX_ASSIGNMENT_EXPERIMENT
INDEX                     VALID

OBJECT_NAME
OBJECT_TYPE               STATUS
------------------------------------------------------------------------------------------
---------------------------------------- ---------------------- -------
IDX_ASSIGNMENT_STAFF
INDEX                     VALID
IDX_INVENTORY_EXPERIMENT
INDEX                     VALID
IDX_INVENTORY_NAME
INDEX                     VALID
IDX_PLANT_EXPERIMENT
INDEX                     VALID
IDX_PLANT_SPACE
INDEX                     VALID
IDX_PLANT_SPECIES
INDEX                     VALID
IDX_SPACE_LOC
INDEX                     VALID
IDX_STAFF_EMAIL
INDEX                     VALID
IDX_STAFF_LASTNAME
INDEX                     VALID
INST_PK
INDEX                     VALID
INST_ZIP_FK_I
INDEX                     VALID

OBJECT_NAME
OBJECT_TYPE               STATUS
------------------------------------------------------------------------------------------
---------------------------------------- ---------------------- -------
SECT_CRSE_FK_I
INDEX                     VALID
SECT_INST_FK_I
INDEX                     VALID
SECT_PK
INDEX                     VALID
SECT_SECT2_UK
INDEX                     VALID
STU_PK
INDEX                     VALID
STU_ZIP_FK_I
INDEX                     VALID
SYS_C007672
INDEX                     VALID
SYS_C007677
INDEX                     VALID
SYS_C007681
INDEX                     VALID
SYS_C007687
INDEX                     VALID
SYS_C007695
INDEX                     VALID

OBJECT_NAME
OBJECT_TYPE               STATUS
------------------------------------------------------------------------------------------
---------------------------------------- ---------------------- -------
SYS_C007703
INDEX                     VALID
ZIP_PK
INDEX                     VALID
```

```
ASSIGNMENT_SEQ
SEQUENCE                  VALID
COURSE_NO_SEQ
SEQUENCE                  VALID
EXPERIMENT_SEQ
SEQUENCE                  VALID
INSTRUCTOR_ID_SEQ
SEQUENCE                  VALID
INVENTORY_SEQ
SEQUENCE                  VALID
PLANT_SEQ
SEQUENCE                  VALID
SECTION_ID_SEQ
SEQUENCE                  VALID
SPACE_SEQ
SEQUENCE                  VALID
STAFF_SEQ
SEQUENCE                  VALID

OBJECT_NAME
OBJECT_TYPE               STATUS
--------------------------------------------------------------------------------
---------------------------------------- ---------------------- -------
STUDENT_ID_SEQ
SEQUENCE                  VALID
TRG_ASSIGNMENT_BI
TRIGGER                   VALID
TRG_EXPERIMENT_BI
TRIGGER                   VALID
TRG_INVENTORY_AUDIT
TRIGGER                   VALID
TRG_INVENTORY_BI
TRIGGER                   VALID
TRG_PLANT_BI
TRIGGER                   VALID
TRG_SPACE_BI
TRIGGER                   VALID
TRG_STAFF_BI
TRIGGER                   VALID
PLANT_INFO
VIEW                      VALID
PLANT_LOCATIONS_VW
VIEW                      VALID
STAFF_ASSIGNMENT_SUMMARY_VW
VIEW                      VALID

55 rows selected.
```

DML and SQL Outputs

```
Trigger TRG_SPACE_BI altered.


Trigger TRG_STAFF_BI altered.


Trigger TRG_EXPERIMENT_BI altered.


  STAFF_ID FIRST_NAME                                         LAST_NAME
ROLE                                                EMAIL
---------- -------------------------------------------------- ------------------------
-------------------------- -------------------------------------------------- --------
--------------------------------------------------------------------------------
------
         1 Dylan                                              Harrison
Botanist                                            dharrison@example.com
         2 Lindsey                                            Walsh
Manager                                             lwalsh@example.com
```

```
         3 Carlos                                                  Nguyen
Technician                                        cnguyen@example.com
         4 Monica                                                  Jordan
Intern                                            mjordan@example.com
         5 Nina                                                    Foster
Technician                                        nfoster@example.com
         6 Evan                                                    Steele
Manager                                           esteel@example.com
         7 Grace                                                   Bishop
Botanist                                          gbishop@example.com
         8 Omar                                                    Lopez
Intern                                            olopez@example.com
         9 Brianna                                                 Parker
Technician                                        bparker@example.com
        10 Justin                                                  Chan
Botanist                                          jchan@example.com

10 rows selected.


  STAFF_ID FIRST_NAME                                              LAST_NAME
ROLE                                              EMAIL
---------- ------------------------------------------------------- ------------------------
------------------------- ------------------------------------------------------- --------
-------------------------------------------------------------------------------------------
------
         1 Dylan                                                   Harrison
Botanist                                          dharrison@example.com
         2 Lindsey                                                 Walsh
Manager                                           lwalsh@example.com
         3 Carlos                                                  Nguyen
Technician                                        cnguyen@example.com
         4 Monica                                                  Jordan
Intern                                            mjordan@example.com
         5 Nina                                                    Foster
Technician                                        nfoster@example.com
         6 Evan                                                    Steele
Manager                                           esteel@example.com
         7 Grace                                                   Bishop
Botanist                                          gbishop@example.com
         8 Omar                                                    Lopez
Intern                                            olopez@example.com
         9 Brianna                                                 Parker
Technician                                        bparker@example.com
        10 Justin                                                  Chan
Botanist                                          jchan@example.com

10 rows selected.


  PLANT_ID SPECIES
LOCATION_DESC
HEALTH_STATUS                                     EXPERIMENT_TITLE
---------- ------------------------------------------------------------------------------
------------------------- ------------------------------------------------------------
---------------------------------------- ------------------------------------------------
----- ------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
---------------------------------
       123 Lettuce
Wendy Junction
Healthy                                           Optimize Growth in Shade
       124 Tomato
Catherine Greens
Healthy                                           Soil Nutrition Balance
       125 Spinach
Gregory Trail
Unhealthy                                         Water Retention Trials
       126 Pea
Sean Ford
Healthy                                           Pollinator Attraction
```

```
       127 Bean
Lloyd Land
Recovering                                          Pest Resistance
       128 Kale
Brandi Plaza
Healthy                                             Temperature Tolerance
       129 Basil
Barry Shoals
Unhealthy                                           Seed Germination Rates
       130 Carrot
Taylor Row
Healthy                                             Leaf Size and Photosynthesis
       131 Cucumber
Weston Manor
Recovering                                          Aquaponics Nutrient Flow
       132 Radish
Franklin Summit
Healthy                                             pH Tolerance Thresholds

10 rows selected.


  STAFF_ID FIRST_NAME                                       LAST_NAME
ROLE                                                EMAIL
ASSIGNMENT_ID   STAFF_ID EXPERIMENT_ID
TASK_DESC
DATE_ASSI STATUS               DUE_DATE
---------- -------------------------------------------------- ------------------------
------------------------- ------------------------------------------------------------ --------
-------------------------------------------------------------------------------------------
------ ------------ ---------- ------------ ----------------------------------------
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
---------------------------------------- --------- -------------------- ---------
         1 Dylan                                            Harrison
Botanist                                            dharrison@example.com
99          1             1 Measure growth
height
01-APR-25 Assigned             15-APR-25
         2 Lindsey                                          Walsh
Manager                                             lwalsh@example.com
100          2             2 Monitor nutrient
levels
02-APR-25 In Progress          16-APR-25
         3 Carlos                                           Nguyen
Technician                                          cnguyen@example.com
101          3             3 Adjust
irrigation
03-APR-25 Completed            17-APR-25
         4 Monica                                           Jordan
Intern                                              mjordan@example.com
102          4             4 Check
pollinators
04-APR-25 Assigned             18-APR-25
         5 Nina                                             Foster
Technician                                          nfoster@example.com
103          5             5 Spray
pesticide
05-APR-25 Assigned             19-APR-25
         6 Evan                                             Steele
Manager                                             esteel@example.com
104          6             6 Log temperature
data
06-APR-25 Completed            20-APR-25
         7 Grace                                            Bishop
Botanist                                            gbishop@example.com
105          7             7 Record
germination
07-APR-25 Assigned             21-APR-25
         8 Omar                                             Lopez
Intern                                              olopez@example.com
106          8             8 Leaf area
```

```
analysis
08-APR-25 In Progress          22-APR-25
         9 Brianna                                              Parker
Technician                                          bparker@example.com
107          9             9 Check water
tank
09-APR-25 Completed            23-APR-25
        10 Justin                                               Chan
Botanist                                            jchan@example.com
108         10            10 Test pH
levels
10-APR-25 Assigned             24-APR-25

10 rows selected.


INVENTORY_ID EXPERIMENT_ID ITEM_NAME
QUANTITY COST_PER_UNIT LAST_UPDA
------------ ------------- ------------------------------------------------------------
---------------------------------------- ---------- ------------- ---------
         131             9 Water tank
2          120 03-AUG-25
         125              3 Water pump
3           60 03-AUG-25
         132             10 pH meter
3           55 03-AUG-25
         123              1 Grow light
5           45 03-AUG-25
         127              5 Pesticide
8         22.4 03-AUG-25
         128              6 Thermometer
6         18.3 03-AUG-25
         126              4 Pollination net
10        15.75 03-AUG-25
         124              2 Soil mix
20         12.5 03-AUG-25
         129              7 Seed tray
12         9.99 03-AUG-25
         130              8 Measuring tape
4           6.5 03-AUG-25

10 rows selected.


FIRST_NAME                                          TITLE
TASK_DESC
STATUS               DUE_DATE
-------------------------------------------------- ----------------------------------
----------------------------------------------------------------------------------------
---------------------------------------------------------------------------------- ------
----------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------
---------------------------------------------------------------------------- ---------
------------ ---------
Dylan                                               Optimize Growth in Shade
Measure growth height
Assigned             15-APR-25
Lindsey                                             Soil Nutrition Balance
Monitor nutrient levels
In Progress          16-APR-25
Carlos                                              Water Retention Trials
Adjust irrigation
Completed            17-APR-25
Monica                                              Pollinator Attraction
Check pollinators
Assigned             18-APR-25
Nina                                                Pest Resistance
Spray pesticide
Assigned             19-APR-25
Evan                                                Temperature Tolerance
Log temperature data
Completed            20-APR-25
```

```
Grace                                                   Seed Germination Rates
Record germination
Assigned             21-APR-25
Omar                                                    Leaf Size and Photosynthesis
Leaf area analysis
In Progress          22-APR-25
Brianna                                                 Aquaponics Nutrient Flow
Check water tank
Completed            23-APR-25
Justin                                                  pH Tolerance Thresholds
Test pH levels
Assigned             24-APR-25

10 rows selected.


ROLE
--------------------------------------------------
Botanist
Intern
Technician
Manager


STATUS               TASK_COUNT
-------------------- ----------
Completed                     3
Assigned                      5


  STAFF_ID FIRST_NAME                                           LAST_NAME
ROLE                                                    EMAIL
---------- -------------------------------------------------- ------------------------
-------------------------- -------------------------------------------------- --------
------------------------------------------------------------------------------------------
------
         1 Dylan                                                Harrison
Botanist                                                dharrison@example.com
         4 Monica                                               Jordan
Intern                                                  mjordan@example.com
         7 Grace                                                Bishop
Botanist                                                gbishop@example.com
         8 Omar                                                 Lopez
Intern                                                  olopez@example.com
        10 Justin                                               Chan
Botanist                                                jchan@example.com


NAME_LENGTH
-----------
         10
         14
          9
         15
          9
          8
         11
         10
         10
          8

10 rows selected.


  STAFF_ID FIRST_NAME                                           LAST_NAME
ROLE                                                    EMAIL
---------- -------------------------------------------------- ------------------------
-------------------------- -------------------------------------------------- --------
------------------------------------------------------------------------------------------
------
        10 Justin                                               Chan
Botanist                                                jchan@example.com
```

```
ASSIGNMENT_ID   STAFF_ID EXPERIMENT_ID
TASK_DESC
DATE_ASSI STATUS               DUE_DATE
------------- ---------- ------------- ----------------------------------------------
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------
---------------------------------- --------- -------------------- ---------
          108         10            10 Test pH
levels
10-APR-25 Assigned             24-APR-25


1 row deleted.


1 row deleted.


  STAFF_ID FIRST_NAME                                                 LAST_NAME
ROLE                                                EMAIL
---------- -------------------------------------------------- -------------------------
-------------------------- ------------------------------------------------------- --------
--------------------------------------------------------------------------------
------
         1 Dylan                                                    Harrison
Botanist                                            dharrison@example.com
         2 Lindsey                                                  Walsh
Manager                                             lwalsh@example.com
         3 Carlos                                                   Nguyen
Technician                                          cnguyen@example.com
         4 Monica                                                   Jordan
Intern                                              mjordan@example.com
         5 Nina                                                     Foster
Technician                                          nfoster@example.com
         6 Evan                                                     Steele
Manager                                             esteel@example.com
         7 Grace                                                    Bishop
Botanist                                            gbishop@example.com
         8 Omar                                                     Lopez
Intern                                              olopez@example.com
         9 Brianna                                                  Parker
Technician                                          bparker@example.com

9 rows selected.


Rollback complete.


INVENTORY_ID EXPERIMENT_ID ITEM_NAME
QUANTITY COST_PER_UNIT LAST_UPDA
------------ ------------- ------------------------------------------------------------
---------------------------------------- ---------- ------------- ---------
         132            10 pH meter
3            55 03-AUG-25


1 row updated.


INVENTORY_ID EXPERIMENT_ID ITEM_NAME
QUANTITY COST_PER_UNIT LAST_UPDA
------------ ------------- ------------------------------------------------------------
---------------------------------------- ---------- ------------- ---------
         132            10 pH meter
3         49.99 03-AUG-25


Rollback complete.
```

```
INVENTORY_ID EXPERIMENT_ID ITEM_NAME
QUANTITY COST_PER_UNIT LAST_UPDA
------------ ------------- ------------------------------------------------------------
---------------------------------------- ---------- ------------- ---------
         128             6 Thermometer
6          18.3 03-AUG-25
         123             1 Grow light
5            45 03-AUG-25
         129             7 Seed tray
12           9.99 03-AUG-25
         124             2 Soil mix
20           12.5 03-AUG-25
         130             8 Measuring tape
4            6.5 03-AUG-25
         126             4 Pollination net
10         15.75 03-AUG-25
         127             5 Pesticide
8          22.4 03-AUG-25
         132            10 pH meter
3            55 03-AUG-25
         125             3 Water pump
3            60 03-AUG-25
         131             9 Water tank
2           120 03-AUG-25

10 rows selected.


TITLE
PLANT_COUNT
------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------
---------------------------- -----------
pH Tolerance Thresholds
1
Optimize Growth in Shade
1
Aquaponics Nutrient Flow
1
Seed Germination Rates
1
Pest Resistance
1
Water Retention Trials
1
Temperature Tolerance
1
Soil Nutrition Balance
1
Leaf Size and Photosynthesis
1
Pollinator Attraction
1

10 rows selected.


  STAFF_ID FIRST_NAME                                         LAST_NAME
ROLE                                                EMAIL
---------- -------------------------------------------------- -------------------------
-------------------------- ---------------------------------------------------- --------
------------------------------------------------------------------------------------------
------
         1 Dylan                                              Harrison
Botanist                                            dharrison@example.com
         4 Monica                                             Jordan
Intern                                              mjordan@example.com
         5 Nina                                               Foster
Technician                                          nfoster@example.com
         7 Grace                                              Bishop
Botanist                                            gbishop@example.com
```

```
        10 Justin                                                  Chan
Botanist                                          jchan@example.com


FIRST_NAME
TASK_DESC
TITLE
-------------------------------------------------- ----------------------------------
---------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------
-------------------------------------------------- ----------------------------------
---------------------------------------------------------------------------------------
---------------------------------------------------------------------------
Brianna                                           Check water
tank
Aquaponics Nutrient Flow
Carlos                                            Adjust
irrigation
Water Retention Trials
Evan                                              Log temperature
data
Temperature Tolerance


  PLANT_ID SPECIES
LOCATION_DESC
HEALTH_STATUS                                     EXPERIMENT_TITLE
---------- ---------------------------------------------------------------------------
------------------------- ------------------------------------ ----------------------
----------------------------------- ---------------------------------------------------
----- ---------------------------------------------------------------------------------
---------------------------------------------------------------------------------------
----------------------------------
       130 Carrot
Taylor Row
Healthy                                           Leaf Size and Photosynthesis
       128 Kale
Brandi Plaza
Healthy                                           Temperature Tolerance
       123 Lettuce
Wendy Junction
Healthy                                           Optimize Growth in Shade
       126 Pea
Sean Ford
Healthy                                           Pollinator Attraction
       132 Radish
Franklin Summit
Healthy                                           pH Tolerance Thresholds
       124 Tomato
Catherine Greens
Healthy                                           Soil Nutrition Balance

6 rows selected.


STATUS               ASSIGNED_COUNT COMPLETED_COUNT
-------------------- -------------- ---------------
Completed                         0               3
In Progress                       0               0
Assigned                          5               0


SPACE_TYPE                                         NUM_PLANTS
-------------------------------------------------- ----------
Bed                                                         2
Tray                                                        2
Bench                                                       3
Rack                                                        3
```

```
  PLANT_ID   SPACE_ID EXPERIMENT_ID SPECIES
PLANTED_D HEALTH_STATUS
NOTES
---------- ---------- ------------- --------------------------------------------------
-------------------------------------------------- --------- -------------------------
------------------------- ------------------------------------------------------------
--------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------
-----------------------
       128          6             6 Kale
18-MAR-25 Healthy                                          Compact
growth
       123          1             1 Lettuce
01-MAR-25 Healthy                                          Growing
fast
       129          7             7 Basil
20-MAR-25 Unhealthy
Droopy
       124          2             2 Tomato
05-MAR-25 Healthy                                          Needs
support
       130          8             8 Carrot
22-MAR-25 Healthy                                          Root
developing
       126          4             4 Pea
12-MAR-25 Healthy
Flowering
       127          5             5 Bean
15-MAR-25 Recovering
Pruned
       132         10            10 Radish
27-MAR-25 Healthy                                          Ready
soon
       125          3             3 Spinach
10-MAR-25 Unhealthy                                        Yellowing
leaves
       131          9             9 Cucumber
25-MAR-25 Recovering                                       Needs
watering

10 rows selected.
```

Database Administration and Monitoring

User Access and Roles

Role based access control was implemented to manage permissions based on job responsibilities. Researchers were given read only access, while technicians were granted permissions to insert and update data, ensuring both security and usability.

Data Integrity and Validation

Sequences and triggers were used to generate surrogate primary keys automatically, providing unique identifiers for every record. Additional integrity was enforced through constraints such as NOT NULL, CHECK, and FOREIGN KEY rules, ensuring valid and consistent data across all tables.

Backup and Recovery

Regular backups are performed using tools like mysqldump or Oracle export utilities, depending on the environment. Daily backups are retained for one week, and full weekly backups are archived monthly to external storage to prevent data loss.

Monitoring and Performance Optimization
Indexes were created on key fields such as STAFF_ID, EXPERIMENT_ID, and SPACE_ID to improve query speed. Database views summarize important data like inventory usage and experiment status. Query execution plans were analyzed during development to detect and resolve performance issues.

Error Logging and Auditing
While full auditing features are not yet active, the system was designed to support logging through future AFTER INSERT or UPDATE triggers that could write to audit tables. Errors are monitored using system alert logs and session level diagnostics.

Scalability and Maintenance
The database schema was structured to accommodate future expansion, including new experiments, plants, and staff. Regular maintenance routines such as rebuilding indexes and updating table statistics are scheduled during low usage periods to ensure optimal performance.