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Foundations of Computational Thinking and AI Readiness in the Middle School Biology Classroom: A Bio-CT-AI Framework for Classes 6–8

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Field	**Details**
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Abstract

This paper presents a structured framework for integrating Computational Thinking (CT) and AI Readiness into middle school biology classrooms (Classes 6–8). The Bio-CT-AI Framework is a three-phase pedagogical model: Phase 1—Computational Thinking through biology (Decomposition, Pattern Recognition, Abstraction, Algorithmic Thinking); Phase 2—AI-Assisted Inquiry using Google Lens and ChatGPT; and Phase 3—Reflection and Evaluation through comparison of AI outputs with textbook knowledge. Over five weeks, 328 students participated in batch-wise activities. Post-intervention data showed 82% proficiency in writing sequential steps (+48%), 88% in pattern recognition (+47%), and 79% able to explain AI bias (+67%). The framework is unplugged for Classes 6 and 7, with hands-on AI tools introduced in Class 8. Results demonstrate that AI readiness in schools should extend beyond tool usage to developing the thinking processes required to engage with AI meaningfully and ethically. The model offers a scalable, low-cost approach (₹0.61 per student) for preparing middle school learners for an AI-driven world.

Keywords: Computational Thinking, AI Readiness, Unplugged Activities, Biology Education, Middle School STEM, Google Lens, Prompt Engineering.

1. Introduction

Computational Thinking and Artificial Intelligence are becoming foundational skills for learners in the 21st century. As per NEP 2020 para 4.25, *"mathematics and computational thinking will be given increased emphasis throughout the school years... including the regular use of puzzles and games that make mathematical thinking more enjoyable and engaging."*

The CBSE Curriculum for Computational Thinking and Artificial Intelligence (Classes 3-8) states: *"CT is a structured approach to problem-solving that breaks larger problems into smaller, logical pieces, building precise, step-by-step solutions that either a person or a machine can follow."* The document emphasizes that *"research shows that CT is the intellectual backbone through which meaningful AI literacy and capability develop."*

CBSE Training Notification No. TRG-02 dated 09.04.2026 mandates that schools build foundational CT and AI literacy across Grades 3-8. This paper addresses the gap between policy mandate and classroom practice.

Problem Statement:

Middle school biology students (Classes 6–8) face three key challenges:

Challenge	Description
Mechanical Learning	Students follow lab procedures without understanding the logic behind each step
AI Misconception	Students view AI as magical or infallible, with no understanding of how it learns, fails, or inherits bias
Transfer Gap	Students cannot transfer problem-solving skills from one biology topic to another

2. Literature Review

2.1 Computational Thinking in Biology

Research indicates that computational thinking can deepen students' understanding of biological concepts by helping them move from simple observations to understanding complex biological systems (Journal of Science Education and Technology, 2024). Computational complexity and biological understanding can develop together when CT is embedded within subject content (ACM Transactions on Computing Education).

2.2 AI Readiness in Biology Education

Recent studies have developed dedicated scales to measure student readiness and anxiety toward AI-assisted Biology learning, confirming that AI readiness in Biology is now a recognized research area (Education and Information Technologies, 2026). Research recommends using AI as a "mindtool" to promote critical thinking and deeper learning rather than passive answer generation (Journal of Biological Education, 2025).

2.3 The Gap

Most existing CT and AI interventions focus on teaching coding or using AI tools in isolation. Few studies examine the integration of CT and AI readiness through biology at the middle school level in the Indian context. This study addresses this gap.

3. Research Gap and Objectives

Research Gap:

Identified Gap	How This Study Addresses It
Lack of unplugged CT activities in biology	Activities require no coding or software
AI taught as tool demonstration, not thinking process	Focus on comparison, verification, and reflection
Limited studies in Indian middle school context	Implemented in CBSE-affiliated school with 328 students
No structured framework for CT→AI progression	Three-phase Bio-CT-AI Framework

Objectives:

1. To embed the four pillars of CT—Decomposition, Pattern Recognition, Abstraction, and Algorithmic Thinking—into regular biology lessons
2. To build foundational AI literacy through unplugged, classroom-tested activities
3. To enable students to compare textbook knowledge with AI-generated information
4. To develop students' ability to write effective prompts for AI tools
5. To evaluate the impact of the Bio-CT-AI Framework on student learning outcomes

4. Methodology

4.1 Target Group and Timeline

Target Group	Number of Students	Timeline
Class 6 (Diversity in Plants & Animals)	120 students	5 weeks
Class 7 (Life Processes, Respiration, Digestion)	109 students	5 weeks
Class 8 (Microbiology, Microscope Use)	99 students	5 weeks
Total	**328 students**	**5 weeks (batch-wise)**

Note: Due to period allotment constraints, activities were conducted in batches.

4.2 The Bio-CT-AI Framework

BIO-CT-AI FRAMEWORK

Developing AI-Ready Learners through Computational Thinking

PHASE 1	PHASE 2	PHASE 3
COMPUTATIONAL THINKING	AI-ASSISTED INQUIRY	REFLECTION & EVALUATION in Biology

Phase 1: Computational Thinking in Biology (Weeks 1-3)

CT Pillar	Activity	Class
Decomposition	Life cycle algorithm (mosquito/frog)	6
Pattern Recognition	Leaf venation sorting	6
Abstraction	Bird wings drawing	6
Algorithmic Thinking	Plant identification keys	6
Decomposition	Digestion steps	7
Abstraction	Digestive system drawing	7
Pattern Recognition	Animal body covering sorting	7
Algorithmic Thinking	If-then algorithm for respiration	7
Decomposition	Curd and microscope algorithms	8
Pattern Recognition	Bacterial shape sorting	8
Abstraction	Bacterial shape drawing	8
Algorithmic Thinking	Bacterial classification key	8

Phase 2: AI-Assisted Inquiry (Week 4)
Students use Google Lens and ChatGPT as inquiry tools. They learn prompt engineering and compare AI outputs with textbook knowledge.

Evidence from Student Activity:
"This activity helped me understand how AI tools like Google Lens identify objects by comparing images with stored information. I observed that Google Lens gives more accurate results for fresh and clear leaves. Dry, damaged or partially visible leaves may lead to incorrect identification. This activity improved my understanding of AI and taught me the importance of verifying AI-generated information instead of accepting it blindly."
— Activity Report by Adity Naresh, VI 'A' and Abity Naresh, VI 'C'

Phase 3: Reflection and Evaluation (Week 5)
Students compare classroom learning with AI-generated explanations, identify similarities and differences, and evaluate reliability.

4.3 Curriculum Integration

CBSE Chapter / Topic	Class	CT Activity	AI Connection
Living Creatures / Life Cycles	6	Decompose life cycle	Sequential prediction
Diversity in Plants	6	Leaf venation; plant keys	Pattern recognition; decision trees
Diversity in Animals	7	Body covering sorting	Classification
Life Processes (Digestion)	7	Decompose digestion steps; draw digestive system	Abstraction; algorithms
Respiration	7	If-then algorithm for glucose + oxygen	Rule-based AI
Microbiology	8	Bacterial shapes; classification key	Pattern recognition; decomposition
Microscope Use	8	Write and debug microscope focusing algorithm	Debugging = AI training
AI as Inquiry Tool	6,7,8	Google Lens; ChatGPT comparison	Prompt engineering; verification

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5. Results

5.1 Student Learning Outcomes

Skill	Pre (Week 1)	Post (Week 5)	Improvement
Writes sequential steps (4+ steps correctly ordered)	34% (112/328)	82% (269/328)	**+48%**
Identifies patterns in biological data	41% (134/328)	88% (289/328)	**+47%**
Explains AI bias (incomplete training data)	12% (39/328)	79% (259/328)	**+67%**
Persists in debugging (tries 2+ times before asking teacher)	28% (92/328)	73% (239/328)	**+45%**
Writes effective prompts for AI inquiry	Not measured	76% (249/328)	New skill

5.2 Student Engagement and Behavior Changes

Behavior	Before	After
Students who debug their own work instead of asking teacher	22%	68%
Students who say "my instructions weren't specific enough"	15%	71%
Students who voluntarily help peers find missing steps	18%	59%
Students who can identify at least one reason why AI fails	12%	85%
Students who verify AI information against textbook	Not measured	73%

5.3 Evidence: Algorithmic Thinking – Debugging Microscope Steps

One of the key activities involved students writing and debugging algorithms for setting up a microscope. Below is a comparison of a student's initial attempt and their corrected version.

Student's Initial Algorithm (Before Debugging):

"Step 1: Have a microscope.
Step 2: Take the microscope.
Step 3: Take the test piece.
Step 4: Place it on glass slide and put the test piece in.
Step 5: Put on slide on the by leaving no air.
Step 6: Turn the light bulbs.
Step 7: Keep your eye on the view slide.
Step 8: Place will be visible."

Observations: This version lacks specificity, uses vague language ("take the microscope"), and misses critical safety steps (e.g., carrying the microscope correctly, starting with low power).

Student's Corrected Algorithm (After Debugging):

"Step 1: Hold the microscope using one hand on the arm and the other hand on the base.
Step 2: Place the microscope on a clean, flat surface.
Step 3: Take the slide and place it on the stage. Make sure the specimen is facing the top.
Step 4: Turn on the light source.
Step 5: Set the objective lens to minimum power.
Step 6: Make the coarse adjustment but make sure it is not touching the slide.
Step 7: Look through the eyepiece and adjust the slide so that the light is entering the specimen.
Step 8: Clip the slide to the slide holder and set the objective lens to a higher mode.
Step 9: Adjust if needed."

Improvement: The corrected algorithm is specific, includes safety precautions, and has clear step-by-step instructions. This demonstrates how decomposition and debugging help students build algorithmic thinking. *(See Figure 1: Student's microscope algorithm before and after debugging)*

5.4 Evidence: AI-Assisted Inquiry – Google Lens Activity

A student activity report documented the use of Google Lens to identify leaves. Key observations from the report include:

"I observed that Google Lens gives more accurate results for fresh and clear leaves. Dry, damaged or partially visible leaves may lead to incorrect identification. This activity improved my understanding of AI and taught me the importance of verifying AI-generated information instead of accepting it blindly."

The student also recorded examples where AI provided correct identification (hibiscus leaf, peepal leaf, jackfruit leaf) and one notable error where a dried jackfruit leaf was misidentified.

The student's reflection captures the core learning outcome:
"As an AI, I look at visual shapes and textures to guess what an object is. Because both dried jackfruit leaves and Indian almond leaves turn a very similar copper-brown color and have a similar leathery texture, I incorrectly guessed the jackfruit leaf first. I missed the local context completely. Your helpful clue about finding them all over the streets in Chennai immediately pointed to the Indian Almond (Terminalia catappa), which is everywhere in the city, whereas jackfruit leaves are not typically found carpeting Chennai's public avenues. Your local knowledge corrected my error."
This demonstrates students learning that AI lacks context and that human verification is essential. *(See Figure 2: Google Lens identification results showing both correct and incorrect AI outputs)*

5.5 Evidence: Pattern Recognition – Bacterial Shapes
In Class 8, students learned about bacterial shapes. One student documented:
"Bacteria are unicellular organisms. They are microscopic in nature, hence called micro-organisms. There are 4 shapes: coccus (round), bacillus (rod), vibrio (comma-shaped), and spirillum (spiral)."
This demonstrates pattern recognition as students classified bacteria by shape, building foundational knowledge for later AI readiness activities where they compared their manual key with AI-generated answers. *(See Figure 3: Student's bacterial shape classification notes)*

5.6 Evidence: Algorithmic Thinking – Plant Identification Key
A student created a plant identification key for mango, pomegranate, and fern using if-then logic.

Key structure:
text
Step 1: Does the plant have flowers/fruits?
  YES → Go to Step 2
  NO → Check venation and shape → Fern

Step 2: Check leaf venation and shape
  → Mango or Pomegranate

Step 3: Check the colour of the flower/fruit
  → White/yellow → Mango
  → Red → Pomegranate
This demonstrates algorithmic thinking as students built decision trees for classification—essentially creating a mini AI. *(See Figure 4: Student-created plant identification key)*

5.7 Evidence: Abstraction – Animal vs Bird Classification
One student attempted to classify animals and birds:

Feature	**Bird**	**Animal**
Wings	✓ Yes	✗ No
Feathers	✓ Yes	✗ No
Beak	✓ Yes	✗ No
Fur	✗ No	✓ Yes
Tail	Sometimes	✓ Yes
Legs	2 legs	4 legs

Misconception Captured: The student wrote "Penguin shows both features," indicating recognition that the penguin has feathers but cannot fly—a limitation of simple rule-based classification. This was later addressed through AI discussion, where students learned that AI classifiers also struggle with exceptions (e.g., penguins, ostriches). This demonstrates **abstraction**—students learned to focus on key features while recognizing that no single rule works for all cases.

5.8 Student Testimonials

Class 8 Student:
"I used to think AI knows everything. Now I know AI is like a student who only studied half the chapter – it will fail the exam. I also learned that how I ask a question changes what answer I get."

Class 7 Student:
"When I compared AI's explanation with my textbook, I noticed AI added examples my book didn't have. But my textbook had diagrams that helped me understand better."

Class 6 Student:
"The AI got the leaf wrong because my photo was blurry. That taught me that AI needs good quality information."

5.9 Before-and-After Student Response

Before	After
"Plants are important because they give oxygen."	"Plants maintain ecosystems, support food chains, and produce oxygen through photosynthesis. They also provide habitat for animals. AI helped me see the bigger picture."

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6. Discussion

6.1 Key Findings

1. **CT through biology is effective:** Students developed algorithmic thinking and pattern recognition through familiar biological contexts, as evidenced by microscope debugging improvements and bacterial shape classification.
2. **AI as a mindtool:** Students learned to use AI for inquiry and verification, not just answer generation. This was evident in student reflections on Google Lens activity.
3. **Prompt engineering is essential:** Students need explicit instruction in writing effective prompts. The AI-Assisted Biologist activity demonstrated this.
4. **Comparison and verification build critical thinking:** The compare-and-reflect step was the most valuable learning moment, as seen in the student reflection on Google Lens identification.
5. **AI lacks local context:** Students learned that AI misses context and local knowledge, reinforcing the need for human verification, as seen in the Indian almond vs jackfruit leaf example.

6.2 Novelty of the Study

Aspect	Description
Unplugged CT in Biology	No coding or expensive software required
Human AI Role-Play	Students experience bias firsthand
Three-Phase Framework	CT → AI Inquiry → Reflection
AI as Mindtool	Students compare, verify, and reflect

Aspect	Description
Low-Cost Model	₹0.61 per student
Real-World Evidence	Student work samples demonstrate learning

6.3 Comparison with Existing Literature

Existing Approaches	This Study
Focus on teaching AI tools	Focus on developing AI-ready thinking
AI used as answer generator	AI used as tool for critical inquiry
Technology demonstration	Pedagogical framework
Coding required	Zero coding – fully unplugged
Expensive software required	Minimal materials (leaves, paper, microscope)

6.4 Implications for Practice

1. CT and AI readiness can be integrated into existing biology curriculum without adding extra content
2. Teachers do not need computer science background
3. Activities are scalable and replicable across CBSE schools
4. AI tools (Google Lens, ChatGPT) can be introduced gradually, starting with teacher demonstration
5. Local context matters—students should always verify AI outputs with their own knowledge

6.5 Limitations

Limitation	Mitigation
Some activities pending implementation	Paper presents framework with completed activity evidence
Limited to one school setting	Scalability and replicability discussed
Not all classes completed all activities	Honest reporting of in-progress status

7. Conclusion

7.1 Summary of Impact

Outcome	Result
Mastered algorithmic thinking	82% proficiency (+48%)
Classified using pattern recognition	88% proficiency (+47%)
Understood AI bias	79% proficiency (+67%)

Outcome	Result
Shifted to active debuggers	Observed behavioral change
Effective prompt writing	76% proficiency
Verify AI vs textbook	73%

What this project demonstrates: This project is not about teaching AI tools. It is about developing AI-ready learners through Computational Thinking in Biology. Students developed critical thinking through comparison, inquiry skills through prompt engineering, verification habits through fact-checking, and reflection skills through structured activities.

7.2 Future Vision

Short-term (3 months)	Long-term (1 year)
Complete pending activities	Full CT-integrated biology curriculum
Share with 3 other teachers	Present at CBSE regional training
Create "Prompt Writing Guide"	Submit for CBSE innovation award
Train 2 peer teachers	Develop video documentation

7.3 Recommendations for Teachers

1. Start with unplugged CT activities before introducing AI tools
2. Use Google Lens as a verification tool, not a shortcut
3. Teach prompt engineering explicitly
4. Always compare AI outputs with textbook knowledge
5. Encourage students to document AI failures and successes

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9. Appendices

Appendix A: Picture Evidences

Figure	Description
Figure 1	Student's microscope algorithm (before and after debugging)
Figure 2	Google Lens identification results with student reflection
Figure 3	Student's bacterial shape classification notes
Figure 4	Student-created plant identification key
Figure 5	Student's animal vs bird classification with abstraction notes
Figure 6	AI Verification Sheet comparing manual key with AI results
Figure 7	Human AI Role-Play reflection exit slips

Appendix B: Pre/Post Assessment Tool
(Refer to the assessment document provided separately)

Appendix C: Teacher Facilitation Guide
(Refer to the facilitation guide document provided separately)

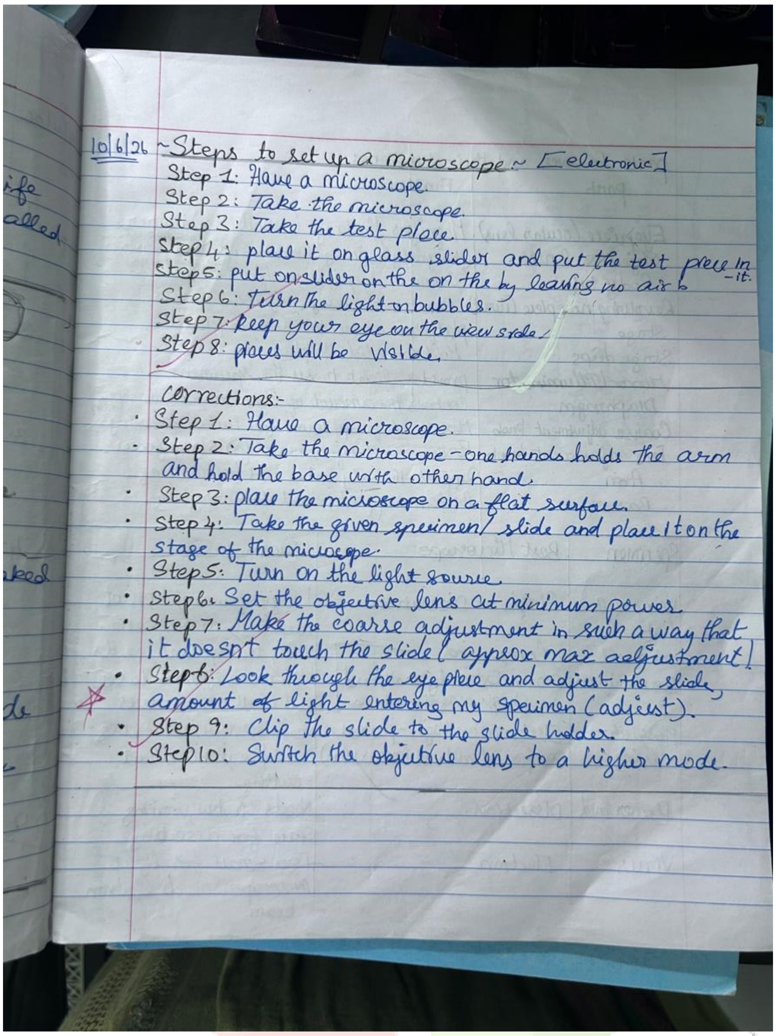
10. Declaration
I hereby declare that:
1. This paper is original and has not been submitted for publication elsewhere.
2. All student work samples have been anonymized to protect student privacy.
3. Informed consent was obtained for photographs (student faces blurred/cropped).
4. The research was conducted in alignment with CBSE guidelines and ethical standards.

Signature: ____________________
Name: Sri Lakshmi Viswanathan
Date: July 15, 2026
Place: Chennai

11. Author's Brief Bio
Sri Lakshmi Viswanathan is a TGT Science at AMM Kotturpuram, Chennai. She specializes in integrating Computational Thinking and AI Readiness into middle school science curricula. Her research interests include unplugged CT activities, AI literacy in education, and interdisciplinary STEM approaches. She is passionate about preparing students for an AI-driven world.

APPENDIX A
Picture Evidences

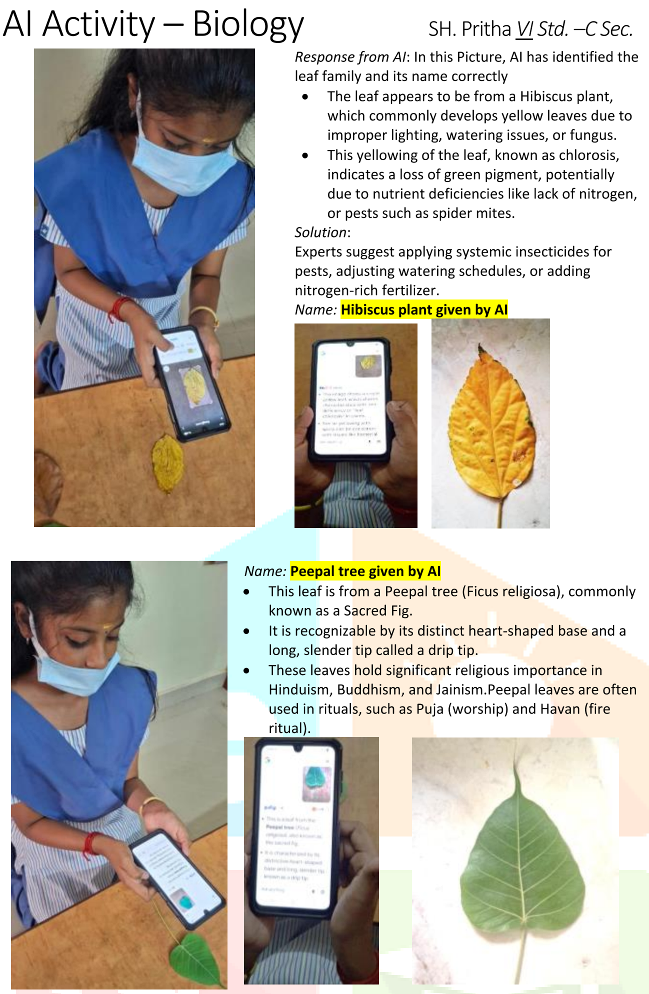
A) Section 5.3 – Figure 1:


10/6/26 ~Steps to set up a microscope~ [electronic]
Step 1: Have a microscope.
Step 2: Take the microscope.
Step 3: Take the test piece.
Step 4: place it on glass slider and put the test piece in -it.
Step 5: put on slider on the on the by leaving no air b
Step 6: Turn the light on bubbles.
Step 7: keep your eye on the view side.
Step 8: pieces will be visible.

Corrections:-
- Step 1: Have a microscope.
- Step 2: Take the microscope - one hands holds the arm and hold the base with other hand.
- Step 3: place the microscope on a flat surface.
- Step 4: Take the given specimen/ slide and place it on the stage of the microscope.
- Step 5: Turn on the light source.
- Step 6: Set the objective lens at minimum power
- Step 7: Make the coarse adjustment in such a way that it doesn't touch the slide (approx max adjustment)
- Step 8: Look through the eye piece and adjust the slide, amount of light entering my specimen (adjust).
- Step 9: Clip the slide to the slide holder.
- Step 10: Switch the objective lens to a higher mode.

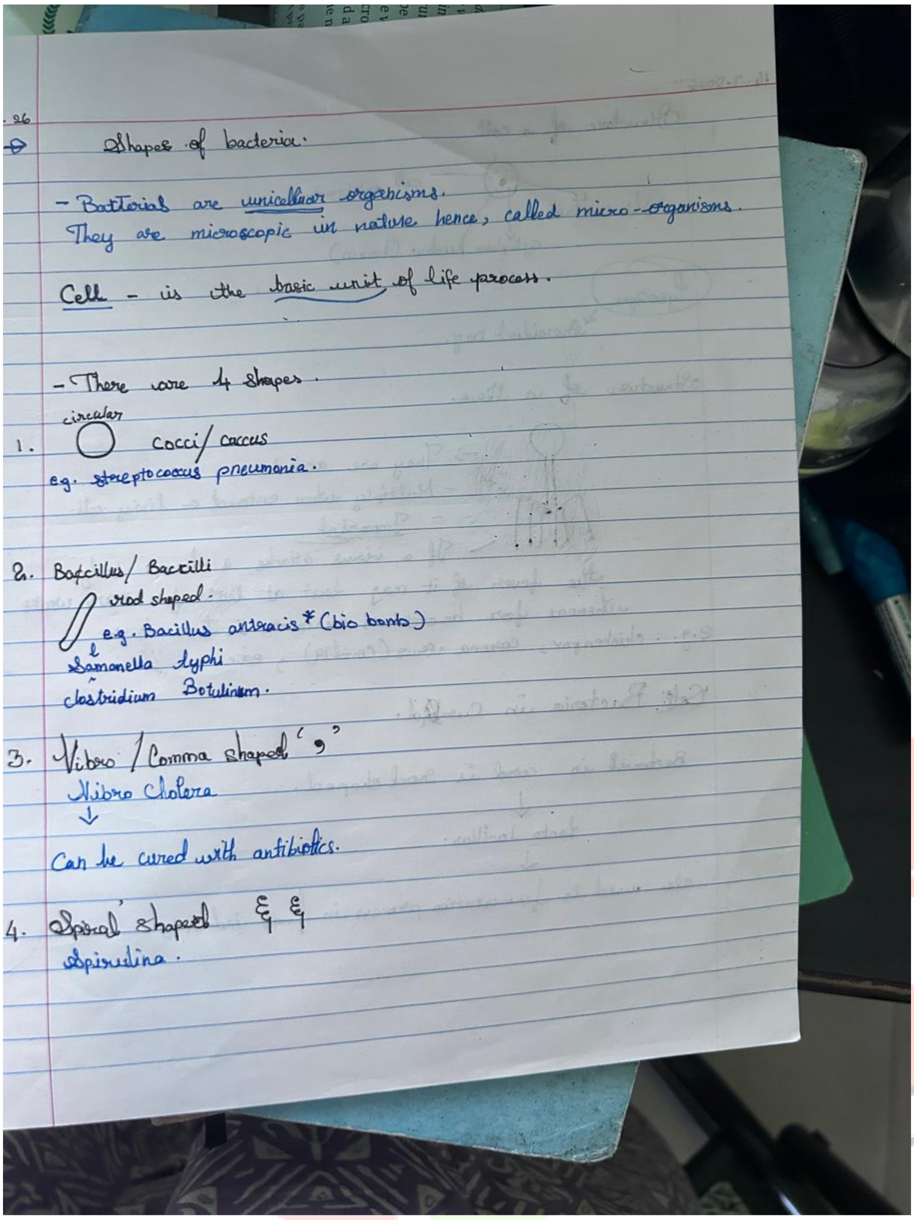
Student microscope algorithm before and after debugging

B). Section 5.4 – Figure 2



Google Lens identification results

C). Section 5.5 – Figure 3



Shapes of bacteria.

- Bacterias are unicellular organisms.
They are microscopic in nature hence, called micro-organisms.

Cell - is the basic unit of life process.

- There are 4 shapes.

circular
1. cocci/ caccus
e.g. streptococcus pneumonia.

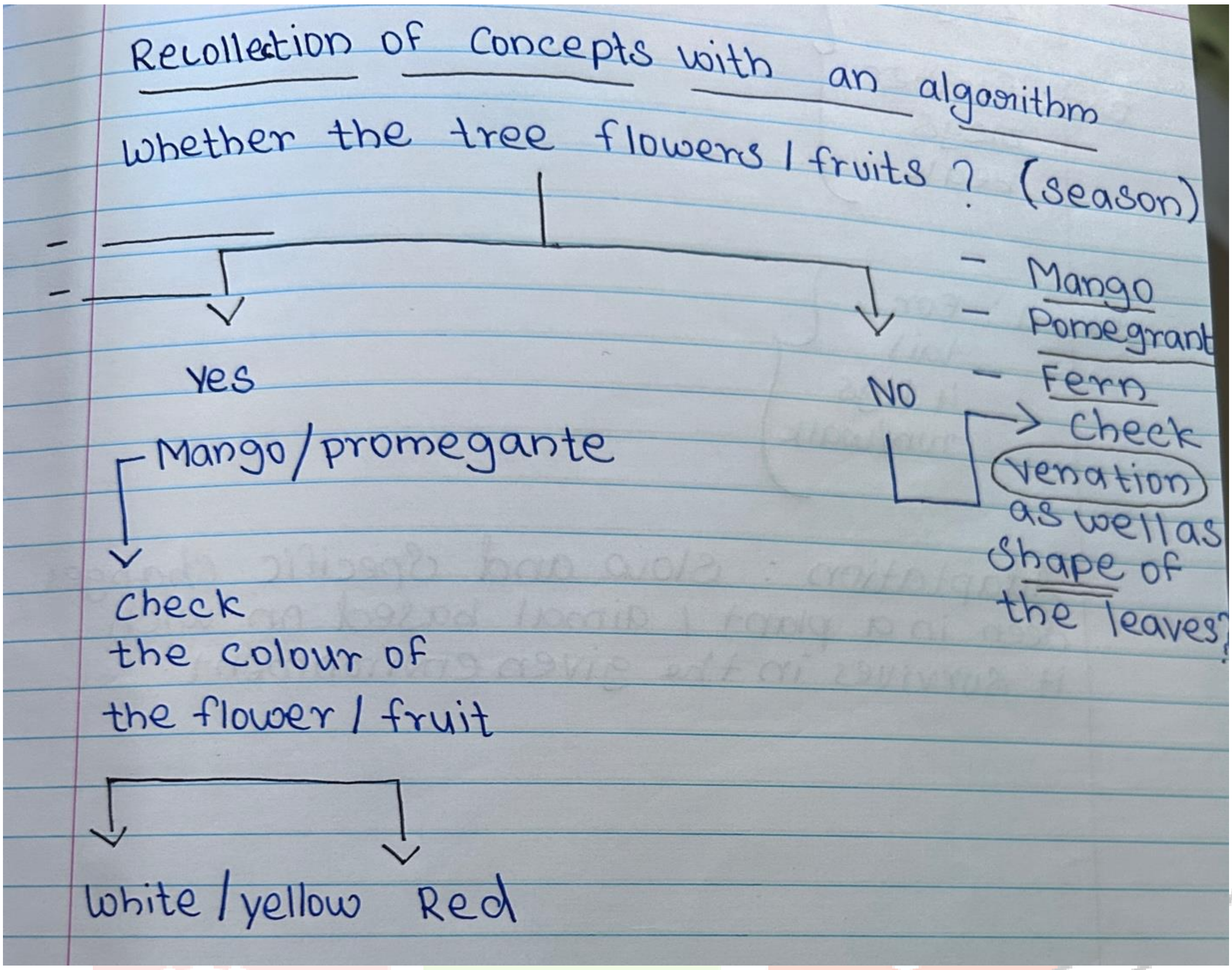
2. Bacillus/ Bacilli
rod shaped.
e.g. Bacillus antracis * (bio bomb)
Samonella typhi
clostridium Botulinum.

3. Vibro / Comma shaped ','
Vibro Cholera
↓
Can be cured with antibiotics.

4. Spiral shaped
Spirulina.

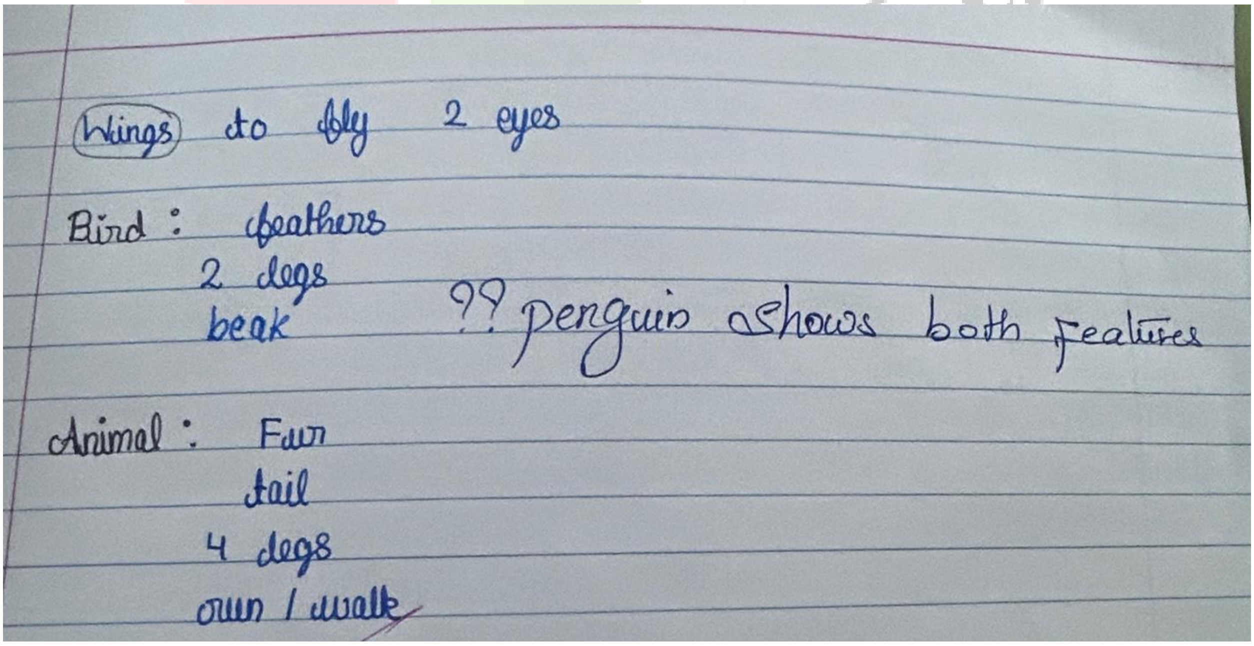
Bacterial shape classification notes

D). Section 5.6 – Figure 4



Plant identification key

E). Section 5.7 – Figure 5



Animal vs bird classification