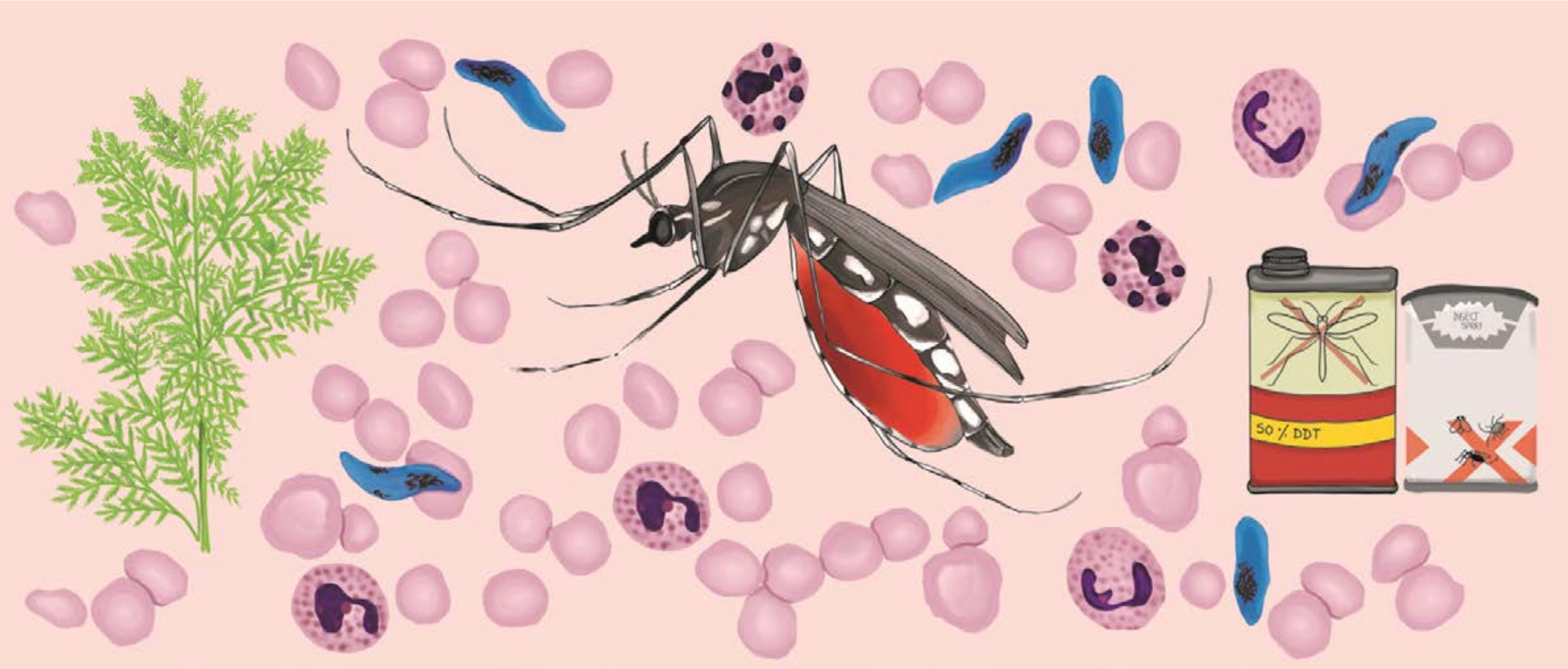
Azim Premji University

Teaching iThink Biology in your classroom

A guide to teaching the Malaria chapter



Twitter: @ithinkbiology **Instagram:** @iThink Biology **Facebook:** iThink Biology **LinkedIn:** iThink Biology iThink Biology is different from the types of science textbooks we are familiar within India. The content, organization and features of the e-book have been developed with different objectives in mind. We hope that the chapter-wise guides prepared by the iThink Biology team will help a teacher make the best use of the resource in their learning spaces. The following text is a guide to teaching the Malaria chapter. Please read through the section on *how to read iThink Biology* before using this resource.

Table of contents

Introductory notes

- The book has been written in an informal and conversational style of English and important or difficult concepts have been linked to the glossary or elaborated in detail within the text.
- The book is hosted on a website, so the reader will require a computer, mobile or tablet to access it. An internet connection will be required to access the different pages of the website, as well as the different interactive features of the book such as weblinks, glossary terms, video interviews, and downloadable research papers.
- Several exercises in the book may require students to step out of their classroom and observe their surroundings, such as a city area, water bodies or garden. The possibility of such an engagement can be important to meet the learning objectives of the book.

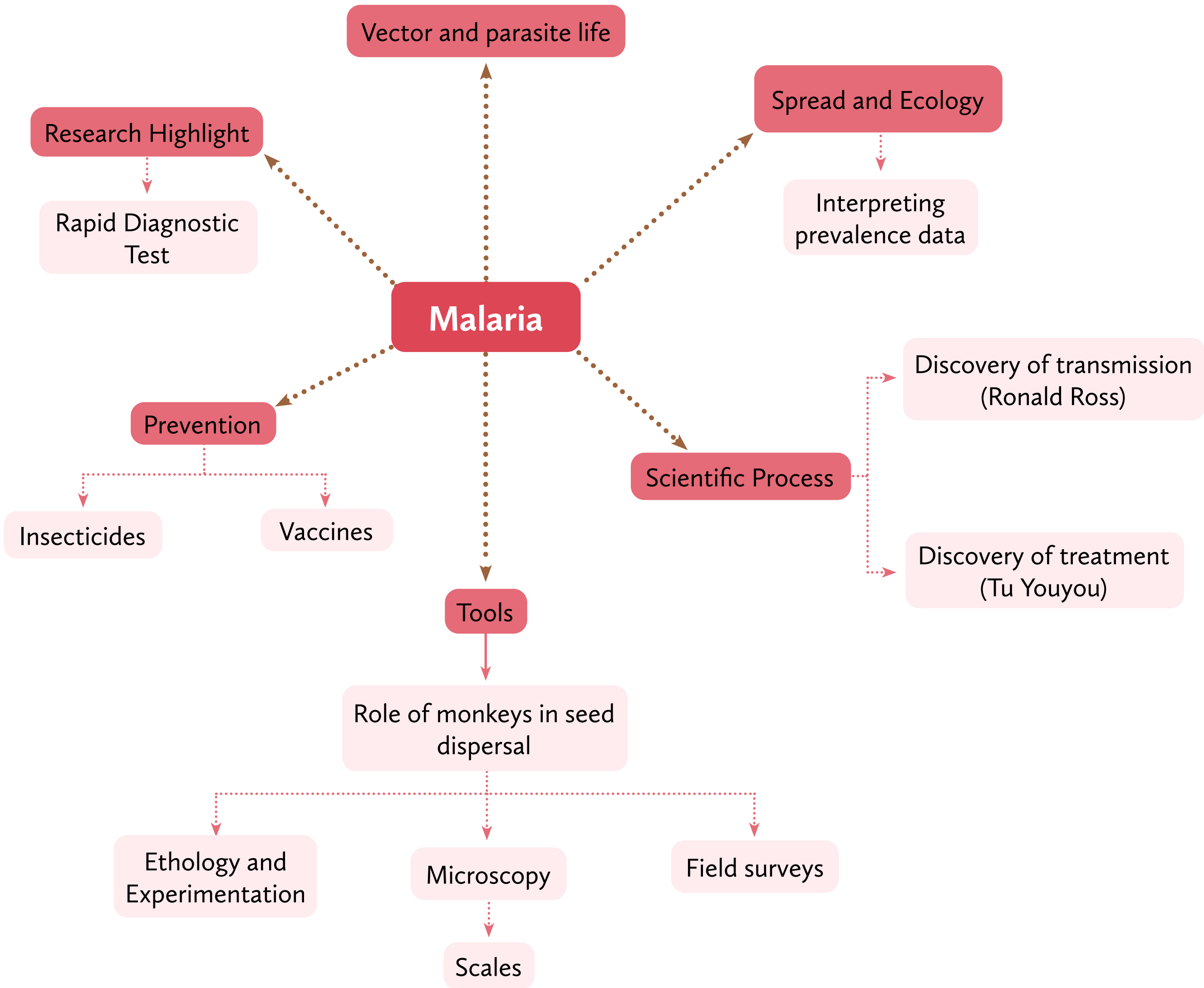
Content Mapping

This table will help you map parts of your syllabus to the content and capacity building approach in iThinkBiology. In the first column, you will find units and topics from your syllabus and the subsequent columns contain the sections, subsections and concepts from our book iThinkBiology. By using this table, you can easily identify the relevant concepts from the book that align with your syllabus.

Existing syllabi	Corresponding Topics in iThink Biology			
Subject, Topic	**Headings/ Sections**	**Subsection**	**Concepts explored**	**Capacities**
Zoology- Insect Vectors, Animal diversity	Introduction	Mosquito life cycle	Life cycle of mosquito from egg to adult stage	Reading and Interpreting
Zoology, Microbiology Parasitic protozoan		The *Plasmodium* parasite	Host and parasite interaction, *Plasmodium* life cycle in humans and mosquitoes	Reading and Interpreting
Economic Zoology, Insect Vectors – Malaria, Microbiology, Immunity and health **Biostatistics,** Graphs and data interpretation		Malaria in India	Temporal and special distribution of malaria cases in India, Symptoms of the disease	Quantitative skills, Bridging science, society and environment
Zoology, Insect Vectors – Malaria	Process and History of Science	Disease transmission: Ronald Ross in India	Life history of Ronald Ross, Discovery of malaria disease transmission through mosquito	Scientific process, Scientific tools
Microbiology, Immunity and health, Biotechnology, Drug discovery		Modern chemistry and traditional medicine: Tu Youyou in China	Life history of Tu You you, Drug discovery for treatment of malaria using modern medicine and ancient Chinese knowledge	Scientific process, Bridging science and society

Existing syllabi	Corresponding Topics in iThink Biology			
Subject, Topic	**Headings/ Sections**	**Subsection**	**Concepts explored**	**Capacities**
Agriculture, Environment, DDT, **Biodiversity,** Biomagnification	Preventing Malaria	Insecticides	DDT and its impact, Biomagnification	Reading and Interpreting, Quantitative skills
Microbiology, Immunology, Immunity and health		Vaccines against malaria	Immune system, adaptive immunity through vaccination	Reading and Interpreting
Microbiology, Microscopy, Microbial diagnostics and health	Scientific tools	Microscopy: a tool for disease diagnosis	Preparation of samples for microscopy, types of microscopes, Components and working of the microscope, length scales in biology	Scientific tools, Quantitative skills
Research design, public health		Field surveys: a tool for disease surveillance	Field survey design, implementation and data analysis	Scientific tools, Bridging science and society
Evolution, Animal behaviour, Zoology, Insect vectors		Behavioural tools to understanding biology: How do mosquitoes detect humans?	Nikolas Tinbergen's framework to explain animal behaviour, human detection by mosquitoes using various sensory organs	Reading and interpreting, Scientific tools
Immunology, **Zoology**, Medical diagnosis, Insect vectors		Rapid diagnostic testing of malaria	Immunochromato-graphic antigen detection, HRP2 rapid diagnostic test for malaria	Reading and interpreting, Bridging science and society

Concepts introduced in the chapter



Capacities developed in this chapter

You will notice that every chapter has a set of questions appearing at the beginning of the chapter. These describe the content (indicated by the questions) related to the capacity (indicated by the icon).

In this guide, we have suggested different activities that are focused on teaching different concepts given in the chapter. We have added one annexure to this guide. Annexure-I has two worksheets that teachers can provide students to record observations for different suggested activities.

CAPACITIES TAUGHT IN THIS CHAPTER

- How were discoveries made?
- Which tools are the most appropriate for malaria research?
- What is the life cycle of the malarial parasite in its vector and its host?
  How has malaria been treated in the past?
  How are new methods of diagnosis discovered?
- How can we prevent malaria?
- Is the incidence of malaria changing?

Notes for Instructors

In this document, we provide some suggestions for instructors on how to get students to engage with the critical thinking questions that are present throughout the chapter. We have provided the answers, suggested activities and learning objectives for each critical thinking question. It would be ideal to use these questions along with the book chapter but do adopt these questions and activities to related topics in your curriculum. We hope that this document encourages you to create similar critical thinking questions for the concepts in your course syllabus.

In our experience, there is much value in group work conducted between students. If a student can be accompanied by even one other student while attempting some of the exercises, it will make a difference to their learning experience.

If you do conduct these exercises in groups, ensure that the group sizes are not too large (not more than 5 students per group) so that all the students participate in the discussions. Students tend to be curious, but having a few pre-prepared questions and hints to promote conversation in groups might be helpful. A wrap-up discussion to combine and connect the individual group learnings is essential to ensure learning objectives are achieved. Do keep some extra time while conducting group work since they tend to run longer than the time estimated.

B1.1 Introduction

Reading and interpreting

Question

Why do you think patients with malaria develop severe anaemia and respiratory distress?

Hint

Think of the role of red blood cells.

Answer: Red blood cells (RBCs) are primarily responsible for oxygen transport. Anaemia and respiratory distress both are results of impaired oxygen delivery or absorption. *Plasmodium* disrupts the function of red blood cells. This is likely the reason for these symptoms for a malaria patient.

Suggested Activity

Discuss the thought process students had to undergo to answer this question. How did they make connections?

Ask students to generate their own critical thinking questions based on the reading of section B1.1. Ask students to reflect on and make a flow chart to show the thought process required by the person answering their question.

What does this question make students do?

This question requires the reader to link the function of the red blood cells (previous knowledge) to their reading of the text on the life cycle of *plasmodium*.

Intended Learning Objective

Read and interpret the text to answer the critical thinking question.

Reflect on this practice.

B1.2 Process and History of Science

Bridging science, society and the environment

Question

How are scientists regarded in your society?

What social, political pressures or environmental difficulties might scientists face during their research?

Hint

Think about access to resources such as infrastructure, staff and funding, conflicts between scientists, and political pressures.

Answer: There is no right or wrong answer to these questions. However, one may wish to consider whether there is skepticism about current discoveries as compared to more traditional/ancient knowledge within one's community.

Scientists often work in government institutions funded by taxpayers. What responsibility do scientists have in this case? Is it different for scientists who work in private organisations?

Scientists may experience pressure in many different forms. For example, scientists have to publish their work in reputed journals, or they are often expected to show direct applications to their work. There could be other pressures such as urgent societal needs (for example the requirement of vaccines, drugs, or technological solutions).

At another extreme scientists are regarded as being beyond fault because of years of training.

Finally, what is the profile of a scientist? Do you imagine a scientist to be a man, a woman, or transgender?

There may also be conflicts between scientists who have competing interests. For example, one scientist may be interested in the development of new technology, another may be concerned about the environmental impact of that technology.

What does this question make students do?

This question helps students understand the role of science, and scientists in society.

Intended Learning Objective

Bridging science and society

B1.3 Preventing Malaria

Reading and interpreting

Question

What are the complexities of malaria that may hinder the development of a vaccine?

Hint

Plasmodium changes its antigens continuously. Think about antibody-antigen specificity.

Answer: As outlined in the chapter, our immune system develops a memory (adaptive immunity) of the *plasmodium* parasite it encounters based on the surface proteins (or antigens) of *plasmodium*. This allows our bodies to mount an immune response on the next encounter with the *plasmodium*, and fight off the pathogen. However, if the antigens keep changing, immunity will fail. Most vaccines help the immune system build such a memory. This memory fails to trigger the immune system if the same antigens are not presented again. Therefore, vaccines are difficult to develop against malaria.

What does this question make students do?

The question requires the student to read and understand the concept of adaptive immunity. They then have to apply this knowledge to a novel question based on changing antigens.

Suggested Activity

Ask students to use their knowledge of adaptive immunity to reflect on why booster vaccines are often required.

Intended Learning Objective

Read and interpret the text to answer the critical thinking question.
Reflect on this practice.

B1.4 Scientific Tools

Quantitative skills

Question

Looking at the length scales in Figure B1.16, can you estimate where the *Plasmodium* sporozoite should be placed?

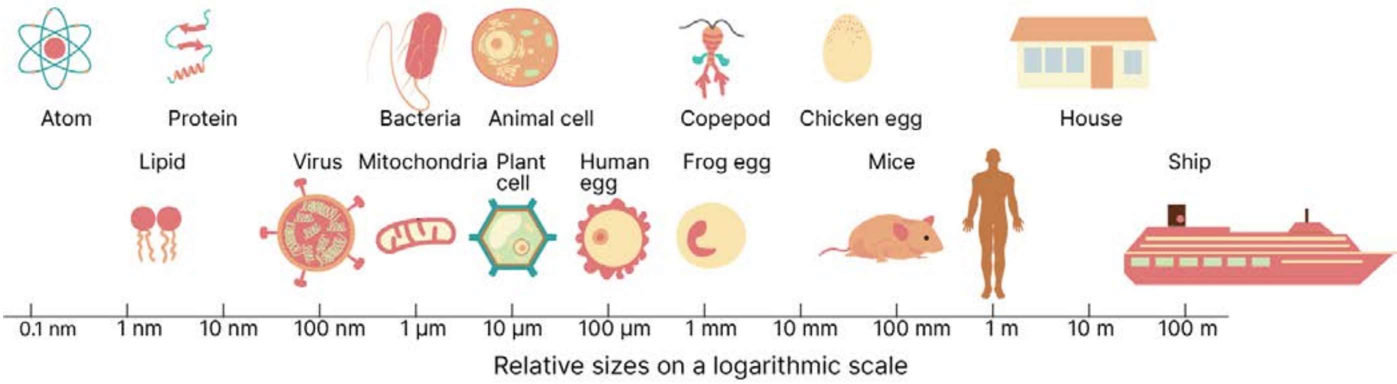
How do you calculate how many times larger a chicken egg is than a *Plasmodium* sporozoite?

Hint

A sporozoite is 8 to 14 µm.

Divide the size of the chicken egg by the size of the sporozoite.

Answer: Looking at figure B1.16, reproduced below, one can see that the sporozoite is close to the size of an animal cell.

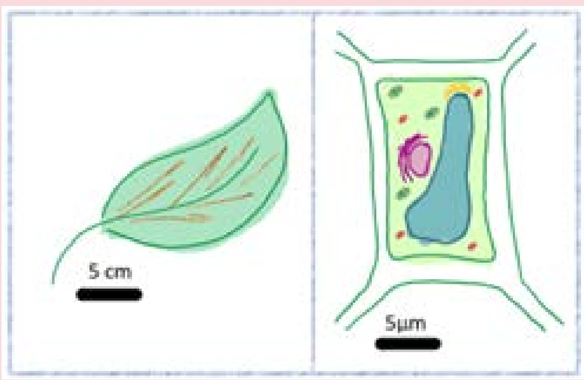


What does this question make students do?

Placing the object of interest along this scale also allows the reader to identify what kind of optical tool is required to visualize it. The sporozoite can be viewed with a light microscope, but not with the naked eye. Microscopy is often essential to the practice of contemporary biology.

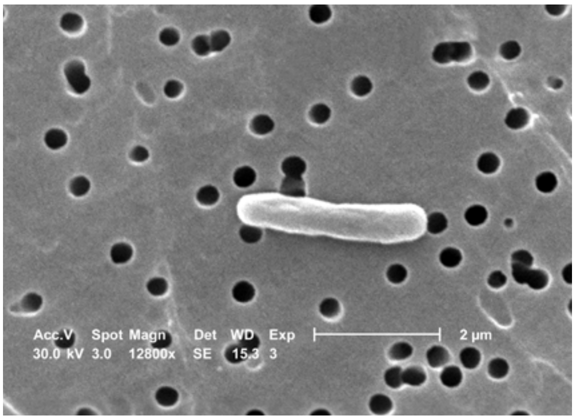
Suggested Activity

A scale bar is a line that represents the proportions of a drawing to the actual object. In the drawings below, the same bar represents 5 cm in the image of the leaf and 5 µm in the image of the plant cell. Ask students to estimate the length of the leaf, and the length of the cell using the scale bars.

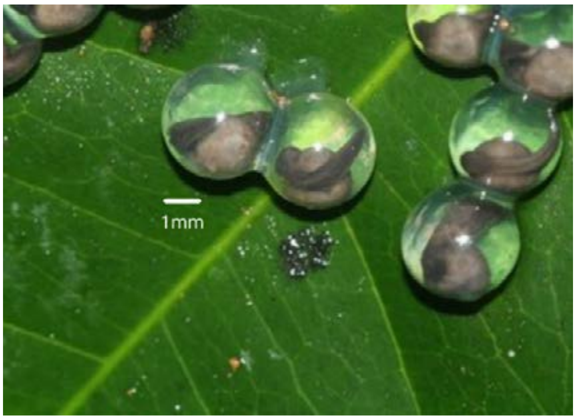


Answer: The plant leaf is about 15 cm long because we can fit about 3 of the scale bars along the length of the leaf. The plant cell is about 20 µm long because we can fit about 4 of the scale bars along the length of the leaf.

Ask students to estimate the size of the following objects using the scale bar given. Note that a scale bar may be used for images that are larger than, or smaller than the real object.



1. ***Answer***: *Escherichia coli* **– 3 µm**
(CDC/Evangeline Sowers, Janice Carr, *Wikimedia Commons*, Public Domain)



2. ***Answer***: **Night frog** *(Nyctibatrachus)* **egg – 2.5mm**
(Pooja Rathod, *Wikimedia Commons*, CCBY-SA 4.0)

3. ***Answer***: Common Lime Butterfly
(*Papilio demoleus*) – 8cm
(CDC/Evangeline Sowers, Janice Carr, *Wikimedia Commons*, Public Domain)

4. ***Answer***: **Adult Female Sperm Whale – 11 meters**
(Gabriel Barathieu, *Wikimedia Commons*, CCBY-SA 2.0))

Teachers can provide **worksheet-1** given in **annexure I** to students to write their responses. We suggest that teachers may use their own images to create scale bars and ask students to estimate the size of the object. The exercise may be extended by asking students to estimate the volume of the object.

Intended Learning Objective

The reader learns about the utility of the microscope, an essential scientific tool. The reader also develops an understanding of length scales.

Reading and interpreting

Question

Consider the fact that peacocks have brilliantly coloured feathers. Frame 'how' and 'why' questions in order to understand this fact. What are the costs and benefits of a peacock's tail?

Hint

Think of the mechanism behind colourful feathers, and the reasons for them.

Answer: *Ultimate, 'Why' questions with answers*

Under what circumstances would it be beneficial to have brilliantly coloured feathers?

- These feathers may be helpful in competing for and attracting mates. Attracting a healthy and fit mate enables successful reproduction.

Does producing feathers that are so attractive has an associated cost?

- The large, brilliant feathers of a peacock may attract mates, but it may also attract predators more easily.
- Producing so many feathers is a large energy investment, and also a lot of mass to carry around while moving around.

Proximate, 'How' questions with answers

How does the peacock generate such brilliant colours on its feathers?

- Peacock feathers are actually pigmented brown. However, the microscopic structure of the feather changes the pattern of light reflection resulting in the iridescent colours we see on peacocks.

How does a female (peahen) benefit from the feathers of potential mates?

- The feathers of a peacock help the peahen spot the peacock from long distances across forest foliage.

What does this question make students do?

The question allows to read and interpret statements. In the process of formulating questions, they become aware of the difference between proximate and ultimate questions. With further practice, they may also begin recognizing the differences in methodology required to answer proximate and ultimate questions.

Mechanism (causation)	Ontogeny (development)
Adaptive value(function)	Phylogeny (evolution)

Table B1.1 Tinbergen's four categories of question to explain animal behaviour.

Suggested Activity

Ask students to generate proximate and ultimate questions (how and why questions) to address other observations. Some examples are given to facilitate this activity for the instructor.

- Cells are the unit of life. Most cells, whether they are from an elephant, a blue whale, a monkey, a fox, a mouse, a fungus, a fern, or a human are about the same size, with a diameter of about 10 µm.
- Vestigial organs are organs that are genetically determined but do not have a known function. The human appendix could be a vestigial organ.
- As the sun rises and travels across the sky, sunflowers tilt their faces throughout the day to ensure they are always facing the sun. This is known as heliotropism.

Intended Learning Objective

Reflect on the difference between proximate and ultimate questions.

Participate in the process of formulating scientific questions, as well as interpreting answers.

Reading and interpreting / Scientific process

Question

Mosquitoes use vision to detect the presence of humans. But many mosquitoes bite us at night. How would you find out whether mosquitoes are using their eyes to locate us in the dark?

Hint

Different mosquitoes are active at different times of the day. Make sure you are studying a night-active mosquito. Think about how you could find out how important visual cues are to a nocturnal mosquito.

Answer: To verify that mosquitoes have vision, one may try to impair the eyes' function and observe a behaviour change. Blocking mosquito vision is not so easy of course since they are small, and one is likely to need a microscope. Paint on their eyes, or placing drops of wax on the eyes may be useful to block their eyes so that they can't see. Once this is done, one would have to check if the mosquitoes can still find their host. If they can, then it suggests visual cues are not important.

What does this question make students do?

Note that this question is building on the previous one. Here students are being asked to first identify that an ultimate question is being asked, and then to figure out a means to answer the questions by suggesting experiments.

Suggested Activity

This activity is slightly longer and may work more efficiently when conducted in groups. However, group work is not compulsory, and this can be done individually as well.

Ask students to suggest how they would tackle each of the questions given below. Note that students should identify a hypothesis to test and an experimental method that could be used. For the questions below, potential hypotheses and suggestions for experiments are given.

Teachers can provide **worksheet-2** given in **annexure I** to students to write their responses.

Questions with Answers

1. **How could you verify whether a mouse is capable of chemotaxis via olfaction (attraction to a chemical gradient via odour)?**

   Hypothesis – Mice are capable of chemotaxis via olfaction

   Experiment – To verify whether a mouse is capable of chemotaxis via olfaction, one can place a mouse in a box with an odour that is attractive to the mouse. If it moves towards the source of the odour, where the concentration would be strongest, then it would mean that the mouse is capable of chemotaxis via olfaction. Placing the same mouse in a box without any odour and examining the movement of the mouse is important to establish that the mouse movement is based solely on odour.

2. **How could you verify whether a particular bacterial species' growth capability is sensitive to temperature?**

   Hypothesis – Bacterial growth is sensitive to temperature

   Experiment – To verify whether temperature affects the growth of a particular bacterial species, one can grow the bacteria at different temperatures and observe their growth at different time intervals. If the growth of bacteria varies at different temperatures, then it would mean that the particular bacterial species' growth is sensitive to temperature. It is important to introduce equal amounts of bacteria in each temperature set up so that the effect of temperature and not the quantity of bacteria is observed.

3. **How could you verify whether plants are capable of sensing sound vibrations?**

   Hypothesis – Plants are capable of sensing sound vibrations

   Experiment – One can verify this by placing plants in the vicinity of sound vibrations of different frequencies. If there are any changes in the plant, either in the leaves, stems or roots upon placing them near sound vibrations, then it could suggest that the particular plant is capable of sensing sound vibrations. It might be advisable to choose a plant where responses can be observed easily, such as *Mimosa pudica* (touch-me-not plant), where leaves close when they are touched.

Intended Learning Objective

To engage in the scientific process by designing specific experiments.

To understand the importance of controls in an experiment.

Annotated Papers – Research Highlights

Many chapters in iThink Biology include a *Research Highlight*. These research highlights give the reader an introduction to a scientific journal article, and at the end allow students to download an annotated PDF of the article. The annotations are meant to clarify difficult concepts, or jargon, and they also point to conventions that scientists follow in publications that a beginner may not be familiar with.

All of these papers are based on work that has been done in India.

In the malaria chapter, the research highlight is of a publication that describes a new antigen target for a rapid diagnostic test for malaria. The introduction explains how an RDT works (see *Figure B1.17*).

This exercise is extremely useful in training students to read primary literature. Here are some suggested steps on how to use the annotated paper#:

1. **Teach the concept of an RDT from** *Figure B1.17*
2. **Read the abstract of the paper collectively, and clarify difficult concepts.**
3. **Show students the types of annotations available**
   a. Highlight of conventions (such as protein names in capital letters, and gene names in small letters)
   b. Definitions
   c. Annotations of important statements
   d. Highlights of features of the article (abstract, introduction, discussion, etc)
   e. Highlight critical thinking questions

4. **Ask students to read sections of the paper collectively.**
   a. **Day 1**

      Ask student to discuss the abstract, and then move on to the materials and methods section. Students often get intimidated and scared of the amount of jargon and detail in the methods section. Ensure that they understand the overall goal of each method, and that they realise they need not focus on the detail (for example concentrations for buffers are not essential for this exercise). Ask to students to make a glossary of terms they do not understand using the internet.

   b. **Day 2**

      Ask student (groups) to collectively study the figures, and figure captions. Have them summarise answers to the following questions for each figure:

      - What are they testing and what method did they use?
      - What are they presenting?
      - What is the conclusion?

   c. **Day 3**

      Though the paper may have addressed several 'sub questions', ask students to summarise the one overarching/major question/problem authors are addressing. Depending on instructor's time and constraints, students may present or submit a summary of the paper.

Suggested format for summary paper or presentation

Introduction
Use background information to give some context - why was this an important discovery? What is the history behind it?
Introduce the one overarching/major question/problem authors are addressing.

Subheadings
Use figures as a guideline to discuss what question was addressed, and which experiments were done to address it.

Conclusion and Discussion
Critically assess the paper by addressing whether the major question was addressed i.e., do their results support their conclusions.
Did they do all the necessary control experiments?
Why is the result important, how does it add to a larger body of work?
What else could be done, what have authors missed out on?
What could be tested next?

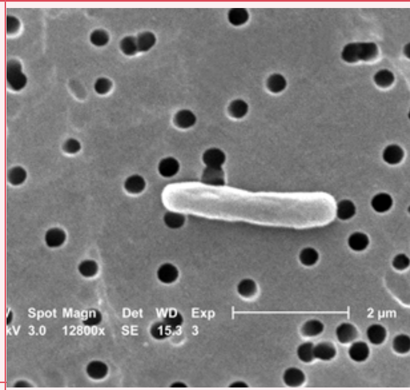
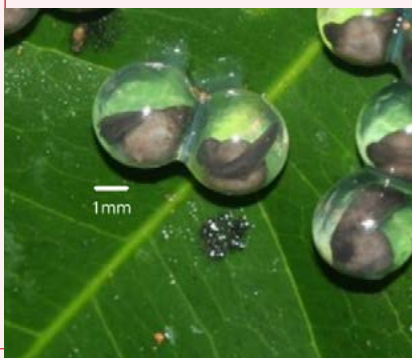
References/Citations

Annexure-I

Worksheet - 1

Estimate the size of the following objects using the scale bar given.

Note: *a scale bar may be used for images that are larger than, or smaller than the real object.*

Organism	Image	Estimated size
Escherichia coli		
Night frog (*Nyctibatrachus*) egg		
Common Lime Butterfly (*Papilio demoleus*)		
Adult Female Sperm Whale		

Worksheet - 2

Generate proximate and ultimate questions (how and why questions) to address the following observations. You are encouraged to add more observations and questions.

Observation: Cells are the unit of life. Most cells, whether they are from an elephant, a blue whale, a monkey, a fox, a mouse, a fungus, a fern, or a human are about the same size, with a diameter of about 10 µm.
'Why' question with answer
'How' question with answer
Observation: Vestigial organs are organs that are genetically determined but do not have a known function. The human appendix could be a vestigial organ.
'Why' question with answer
'How' question with answer
Observation: As the sun rises and travels across the sky, sunflowers tilt their faces throughout the day to ensure they are always facing the sun. This is known as heliotropism.
'Why' question with answer
'How' question with answer

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