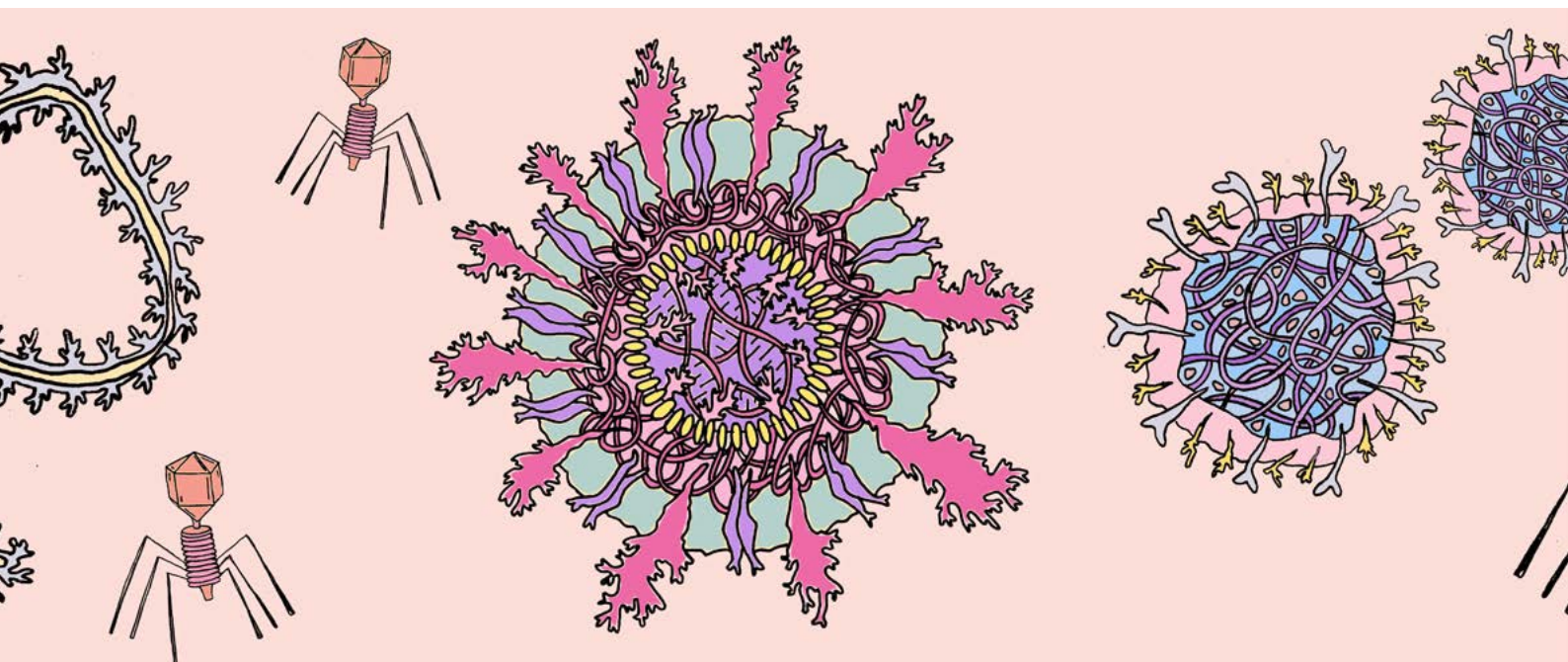


Teaching iThink Biology in your classroom

A guide to teaching the Rotavirus chapter



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 Rotavirus chapter. Please read through the section on [how to read iThink Biology](#) before using this resource.

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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 (ithinkbiology.in), 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 a garden. The possibility of such an engagement can be important to meet the learning objectives of the book.

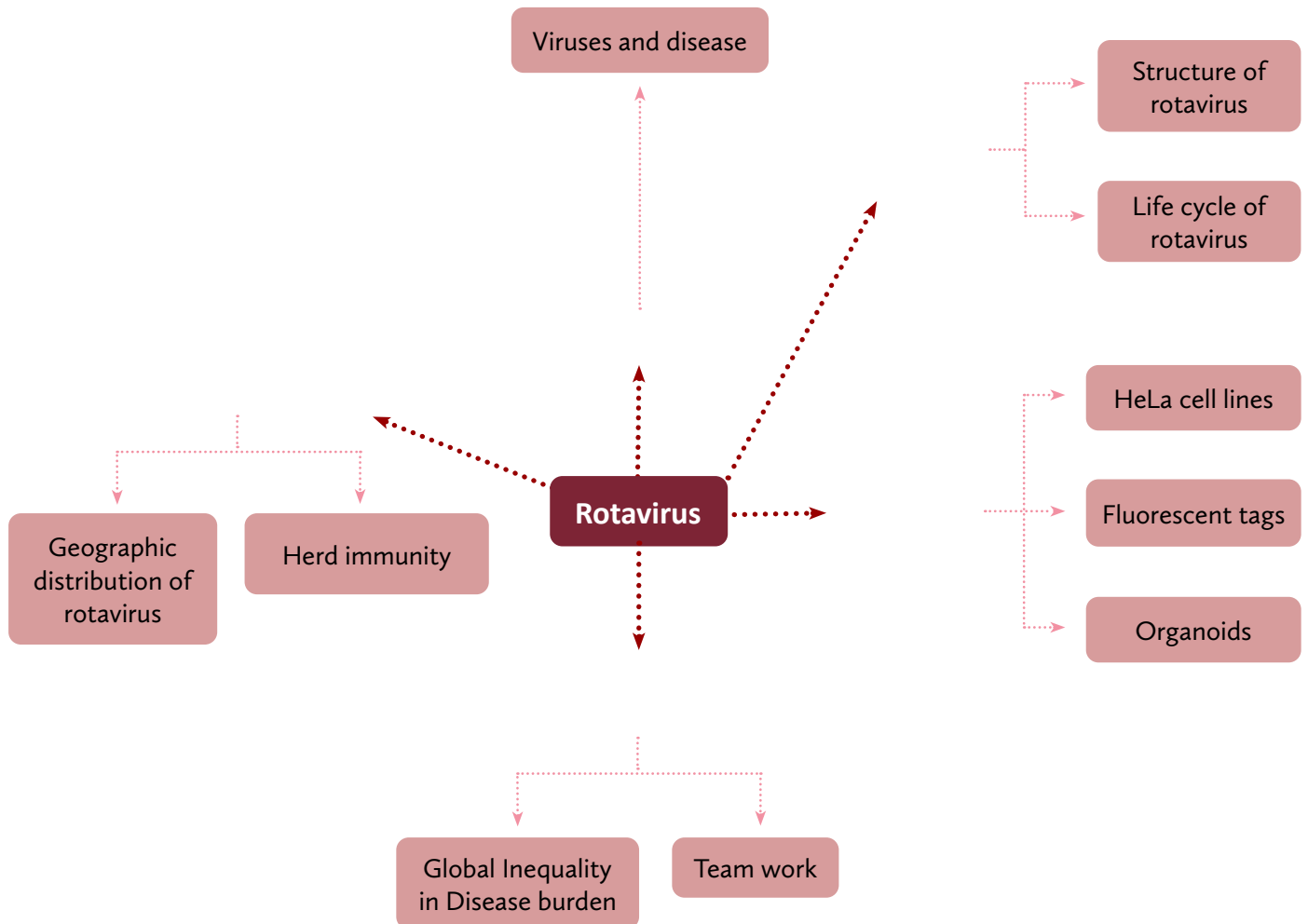
Content Mapping

This table will help you map parts of your syllabus to the content and capacity-building approach in iThink Biology. 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 iThink Biology. 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			
Unit, Topic	Headings/ Sections	Subsection	Concepts explored	Capacities
Virology , Introduction to viruses, nature and properties of viruses	Introduction	Viruses and disease	Introduction to rotavirus, structure of viruses, shapes and sizes of viruses, zoonoses	Reading and Interpreting
Virology , structure of viruses	Rotavirus: double-stranded RNA virus	Structure of rotavirus	Genome of rotavirus, mode of transmission	Reading and Interpreting, Quantitative skills
Virology , Viral replication, maturation and release		How does a rotavirus replicate inside a host cell and cause gastroenteritis?	Life cycle of rotavirus, virus-cell interaction	Reading and Interpreting
Genetics , Model organisms in genetic analyses and experimentation	How do we use model systems (including cell lines) to study rotavirus?	Model systems	Common model organisms,	Scientific process, Scientific tools
Animal cell biotechnology , cell lines, Research Methodology , ethical issues		Cell lines as model systems	HeLa cell line, ethical considerations	Scientific tools, Reading and Interpreting
Animal cell biotechnology , cell culture, medical microbiology , rotavirus		How rotavirus enters the cell using fluorescent tags in a cell line?	Fluorescent tag, colocalisation of proteins, knockout experiments	Scientific process, Scientific tools
Animal cell biotechnology, cell culture		Organoids as model systems	Human intestinal enteroid, host specificity	Scientific process
Virology , Viral diseases and their prevention, Immunology , vaccines	Team work: team science in developing the vaccine	Global inequality in disease burden	Reasons for inequality in disease burden	Reading and Interpreting
Virology , Viral diseases and their prevention, Immunology , vaccines		Team work in solving health problems and vaccine development	Universal Immunisation Programme, vaccines against rotavirus	Reading and Interpreting
Virology , Viral diseases and their prevention, Immunology , vaccines		A locally developed vaccine for India	ROTAVAC development, clinical trial, long-term surveillance programme	Scientific process, Reading and Interpreting,
Research Methodology , ethical issues		Data integrity and public responsibility	Ethical violations - case study	Reading and Interpreting

Existing syllabi	Corresponding Topics in iThink Biology			
Unit, Topic	Headings/ Sections	Subsection	Concepts explored	Capacities
Medical microbiology, rotavirus	Interpreting epidemiological data based on rotavirus	Geographic distribution of rotavirus	Risk of rotavirus in Indian children, disease distribution and incidence	Reading and Interpreting, Quantitative skills
Immunology, immunity, vaccination		What is herd immunity?	Building herd immunity by vaccination, herd immunity percentage threshold	Quantitative skills
Immunology, immunity, vaccination		The life span of herd immunity	Vaccination and reinfection	Scientific tools

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 followed different subsections from the iThink Biology book. We have suggested different activities focusing on understanding different concepts in the given chapter.

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 and suggested activities for each section in the book. 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 in 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.

CAPACITIES TAUGHT IN THIS CHAPTER



How can people work together to find a vaccine against a major disease?



Surveillance: How was the rotavirus spread before the introduction of the vaccine?



How does the rotavirus enter a cell?



Why is scientific integrity and personal responsibility important for society?



What is the epidemiology of rotavirus infections?

B2.1 Introduction

B2.2 Rotavirus: double-stranded RNA virus

Note: We have combined the activities for topics B2.1 and B2.2 to provide a cohesive understanding of the related topics.

Scientific process

Question

Given what you know about what defines life, would you classify viruses as living or not?

Hint

There is no correct answer to this question. Think of criteria that define life. Can these criteria apply to all life forms?

Suggested Activity

Suggested time: 1 class

Part 1

Start a class discussion by asking students ‘how do they define life?’ What are the different attributes of life that distinguish it from something non-living?

Write down all the criteria that students come up with on the blackboard for all students to access.

Given below are a few examples, ask students to categorise the given items as living or nonliving. Ask them to write how they determined whether an item was living or non-living.



Fir0002, [Wikimedia Commons](#), CC BY-SA 3.0

Chicken eggs - L/NL

Why? _____



TudorTulok, [Wikimedia Commons](#), CC BY-SA 4.0

Fruits and vegetables - L/NL

Why? _____



McLeod, [Wikimedia Commons](#), CC BY-SA 3.0

Sunflower seeds - L/NL

Why? _____



Vyacheslav Argenberg, [Wikimedia Commons](#), CC BY 4.0

Dried leaves - L/NL

Why? _____



Dinesh Valke, [Wikimedia Commons](#), CC BY-SA 2.0

Chrysalis -L/NL

Why? _____



Rbreidbrown, [Wikimedia Commons](#), CC BY-SA 4.0

Wood - L/NL

Why? _____



Joao Estevao Andrade de Freitas, [Wikimedia Commons](#), Public domain

Feather - L/NL

Why? _____



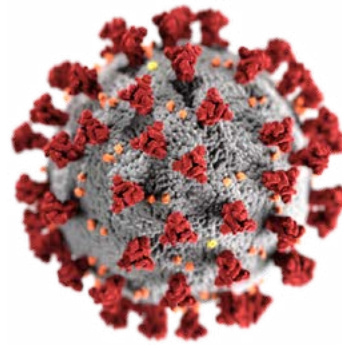
PalaeoMal, [Wikimedia Commons](#), CC BY-SA 4.0

Fossil - L/NL

Why? _____



Rossographer, [Wikimedia Commons](#), CC BY-SA 2.0



Alissa Eckert, MS; Dan Higgins, MAM, [Wikimedia Commons](#), Public domain

Car - L/NL

Why? _____

Coronavirus - L/NL

Why? _____

*L/NL - Living/ Nonliving

Once students fill out the worksheet. Discuss the following questions with them:

- How would you define 'life'?
- What are the characteristics of life? Think of the organisms that are alive but do not tick every box on the characteristics.
- What characteristics distinguish living organisms from inanimate matter?
- Do all the examples mentioned above share the same characteristics to be categorised as living?
- Why did they choose one category over the other?

Teachers can use the following points for discussion in the class:

- The definition of life is a complicated and multifarious concept. Life is a complex system of chemical reactions that enables organisms to grow, reproduce and evolve over time.
- Biologically, there are seven characteristics of life –
 - cellular organisation (a defined structure),
 - ability to grow and develop,
 - ability to produce offspring,
 - respond to stimuli,
 - maintain homeostasis,
 - energy processing (metabolism),
 - adaptation and evolution over time.
- The above characters distinguish living organisms from inanimate matter.
- There are various organisms that do not exhibit all the characteristics of life. Some of the examples are:
 - A mule is a hybrid of a horse and donkey – it is alive but sterile i.e., it cannot reproduce. However, they possess other characteristics of life.
 - In a bee hive, worker bees are living beings, they maintain the bee colony by performing various tasks such as the collection of pollen and nectar, building and managing the hive. However, they cannot reproduce but exhibit other characteristics of life.

Some entities do not check every criterion on the list and are still considered living. This shows that there is no clear distinction between living and nonliving, rather it is complex and nuanced. Such examples raise questions on how can we define life and how it applies to different entities.

After the discussion ask students if they can think of any other defining characteristics for living organisms. Think about how these characteristics might be important for different fields of biology or other scientific disciplines.

Suggested reading:

To understand what is life, read this article:

<https://www.forbes.com/sites/jvchamary/2019/03/27/what-is-life/?sh=3b3cc13a1c77>

Part 2

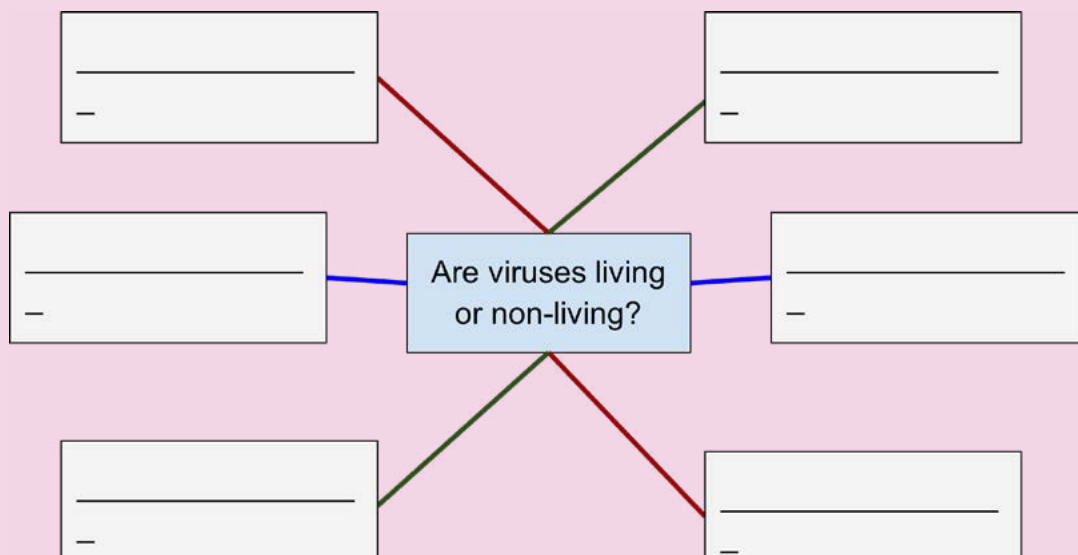
Divide students into groups of two (or more, depending on class strength) and give each group a spider diagram.

Each group will work on both the questions i.e., characteristics of viruses that make them living and characteristics that make them non-living.

They can write down their responses on the spider diagram given below. On the red lines, write why they think viruses are living, and on the green line write why they think viruses are nonliving. Finally, on the blue lines, they will conclude their findings.

**Give students 15 minutes to fill out this diagram.*

Note: To fill the spider diagram, reflect on the above discussion about what is life and its characteristics.



To fill out the spider diagram, ask students to reflect on the following questions:

- What is a virus? What attributes make a virus living and what characteristics set it apart from life?
- How do viruses increase in number?
- If you think viruses are non-living, how do they reproduce and how have they evolved over time?
- If you define viruses as living, then what are the limits of life?
- Why are living things important? Are non-living things not important?

Teachers can discuss and create this spider diagram on the board and write down the responses of different students and discuss their responses.

Teachers can use the following points for discussion in the class:

- A virus is an infectious agent that consists of a genetic material (RNA or DNA), enclosed in a protein coat. Viruses show the ability to evolve and adapt to changing environments, however, they cannot reproduce and carry out metabolic processes. They require a host's cellular machinery to carry out these processes. Viruses do not have a cellular structure, hence they are not considered living entities by many biologists.
- Viruses infect a host cell and use their cellular machinery to replicate their genetic material and form other viral components. They assemble into new viral particles inside the host cell and release by lysis of the host cell, thus, killing it in the process.
- Viruses multiply through the process of replication. They have evolved over time through mutations in their genetic material.
- Defining viruses as living or non-living is still debatable in the scientific community. If we define viruses as living organisms, then we need to broaden our definition of life. Viruses do not have a cellular structure; they cannot metabolise or maintain homeostasis without a host cell. Hence, they are not considered living entities by many biologists. However, they are capable of evolving and adapting to changing environments.

Living entities are important because they play a crucial role in sustaining ecosystems and life on Earth. They carry out essential processes such as metabolism, and reproduction. They play important functions in an ecosystem such as oxygen production, decomposition, climate regulation, etc. Non-living things such as water, air, soil, rocks, etc. are equally important as they form the physical framework on which living entities depend.

What does this question make students do?

The activity will make students learn to enquire about life, learn what are the limits to life and what can be defined as alive. It will help students to think critically.

Suggested reading:

Given the catastrophic events during the coronavirus pandemic, humans must have wondered what the world would be like if all viruses vanished from the globe. But what would be the consequences? Read this article to learn.

<https://www.bbc.com/future/article/20200617-what-if-all-viruses-disappeared>

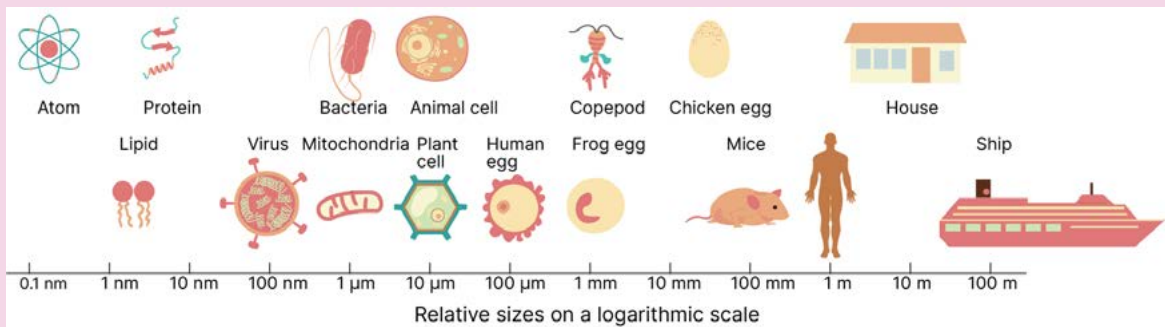
Quantitative skills**Question**

Calculate the relative sizes of different objects.

Hint

Use conversion to calculate the size of different organisms in different units.

Suggested Activity



Look at this length scale. Observe the relative sizes of different organisms/objects on the logarithmic scale.

Compare the relative size of the virus with the following items.

Teachers can provide worksheet-1 given in Annexure to students.

Question

How many times is the virus bigger compared to an atom?

Hint

To find how many times a virus is bigger than an atom, divide the size of the virus (100 nm) by the size of the atom (0.1 nm).

Solution

Size of virus/size of atom = $100 \text{ nm} / 0.1 \text{ nm} = 1000$
Therefore, the virus is 1000 times bigger than an atom.

Question

How big is a bacterial cell compared to a virus?

Hint

To compare the sizes of a bacterial cell and a virus, convert the sizes to the same unit of measurement.
Convert μm into nm
($1 \mu\text{m} = 1000 \text{ nm}$)

Solution

The size of the bacterial cell is $1 \mu\text{m} = 1000 \text{ nm}$
Size of the virus = 100 nm
Now, we can compare the sizes:
Bacterial cell size / Virus size = $(1000 \text{ nm}) / (100 \text{ nm}) = 10$
Therefore, a bacterial cell is 10 times bigger than a virus.

Question

Compare the size of the virus with a human egg.

Hint

To compare, convert the sizes to the same unit of measurement.
Convert μm into nm
($1 \mu\text{m} = 1000 \text{ nm}$)

Solution

The size of the human egg is $100 \mu\text{m} = 100,000 \text{ nm}$
Size of the virus = 100 nm
Comparing the sizes:
Human egg size / Virus size = $(100,000 \text{ nm}) / (100 \text{ nm}) = 1000$
Therefore, a human egg is 1000 times bigger than a virus.

Question

How small is an atom as compared to a frog egg?

Hint

To compare, convert the sizes to the same unit of measurement.

Convert mm into nm

(1 mm = 10^6 nm)

Solution

Size of the frog egg is: 1 mm = 10^6 nm

Size of the atom = 0.1 nm

Comparing the sizes:

Atom size / Frog egg size = $(0.1 \text{ nm}) / (10^6 \text{ nm}) = 10^{-7}$

Hence, an atom is 10^{-7} smaller than a frog egg.

Question

How big is a mouse compared to a plant cell?

Hint

To compare, convert the sizes to the same unit of measurement.

Convert mm into μm

(1 mm = 1000 μm)

Solution

Size of a mouse: 100 mm = $100 \times 1000 \mu\text{m} = 10^5 \mu\text{m}$

Size of a plant cell = 10 μm

Comparing the sizes:

Size of a mouse / Size of a plant cell = $(10^5 \mu\text{m}) / (10 \mu\text{m}) = 10^4$

Hence, a mouse is 10,000 times bigger in size than a plant cell.

Question

How many viruses will you need to join from end to end to make it equivalent to a plant cell?

Hint

Convert the sizes to the same unit of measurement.

Convert mm into nm

(1 μm = 1000 nm)

Solution

Size of the plant cell is 10 μm = 10,000 nm

Length of a single virus = 100 nm

Number of viruses = Length of plant cell / Length of a single virus

Number of viruses = 10,000 nm / 100 nm

Number of viruses = 100

Therefore, we would need to join 100 viruses end to end to span the length of a plant cell.

Calculate the sizes of the following objects around us in different metric units (mm, nm, μm):

- Pen that you are holding
- Notebook you are writing in
- Ant crawling on the ground
- Lizard on your wall
- Leaf of the tree around you

Note: Students can try converting more objects to the same scale to compare their relative sizes.

Supplemental Activity:

- Try and find out the dimensions of different furniture in your classroom such as the desk you sit on or the blackboard, etc. After finding the dimensions, estimate the volume and surface area of each.

Suggested reading:

- If you want to learn more about length and time scales in biology, read:
<https://ithinkbiology.in/book/text/pi-numbers-and-scales.html>

What does this question make students do?

The students will learn quantitative skills and develop an understanding of length scales and relative sizes. These activities will help students to improve their spatial reasoning and measurement skills.

B2.3 How do we use model systems (including cell lines) to study rotavirus?

Reading and Interpreting

Question

Different model organisms are used for clinical trials and more fundamental scientific investigations. Find out why these model organisms are used in biology. What are the advantages of using different model organisms?

Hint

Think of how different organisms can help in studying different characteristics.

Suggested Activity

Suggested time: 1 hour

Provide a worksheet to the students with common model organisms and ask them to find the genome size and life cycle of these organisms. Ask them to find out why these organisms are used as model organisms in different research areas. What are the limitations of using these organisms as models?

Model Organism	Genome size	Life cycle	Advantages	Disadvantages
<i>Escherichia coli</i> (Bacteria)	4.5 - 5.5 Mb	Doubles in 20 - 30 minutes.	<ul style="list-style-type: none"> Used to study basic cell biology. Can be used to synthesize medical compounds. Easy and inexpensive to maintain. 	<ul style="list-style-type: none"> It is a prokaryote so different from eukaryotic cells.
<i>Saccharomyces cerevisiae</i> (yeast)	~12 Mb	Doubles every 2 hours	<ul style="list-style-type: none"> Used to study basic cell biology Easy to grow on a large scale. Have similar cell functions as eukaryotes. 	<ul style="list-style-type: none"> Yeast is different from multicellular organisms.
<i>Chlamydomonas</i> (green algae)	110 Mb	Doubles every 8 hours	<ul style="list-style-type: none"> Used to study fundamental processes such as photosynthesis, cell-cell recognition, light perception, and motility. Simple and sequenced genome. 	<ul style="list-style-type: none"> Single-celled organisms, so they are different from multicellular organisms.
Fibroblast (cell line)	NA	Doubles in 24 hours	<ul style="list-style-type: none"> Used for cell biology research. Easy to work with and can be controlled. 	<ul style="list-style-type: none"> Grown in an artificial environment.
Organoid (tissue of differentiating cells)	NA	Variable	<ul style="list-style-type: none"> Used to study physiology, genetic conditions, and drug testing. 	<ul style="list-style-type: none"> Inter-organ connections cannot be studied.

Model Organism	Genome size	Life cycle	Advantages	Disadvantages
<i>Drosophila melanogaster</i> (fruit fly)	~ 180 Mb	8 to 14 days	<ul style="list-style-type: none"> Used in genetics research and drug development. Easy to study developmental biology. Have large chromosomes and mutants are easy to produce. 	<ul style="list-style-type: none"> Invertebrates, so very different from humans. Drug testing requires further testing on mammals.
<i>Hydra vulgaris</i> (hydra)	1250 Mb	Doubles in 4-5 days	<ul style="list-style-type: none"> Used in developmental biology and regeneration studies. Easy to control their external environment. 	<ul style="list-style-type: none"> Cannot be studied without the use of a microscope. Simple body plan.
<i>Dugesia tigrina</i> (Planaria)	1-2 Gb	Regenerates in 2 weeks	<ul style="list-style-type: none"> Used to study regeneration, stem cell research, development and toxicology. 	<ul style="list-style-type: none"> Hard to measure age. Invertebrates, so very different from higher organisms.
Tardigrade (water bears)	~ 55 Mb	14 days	<ul style="list-style-type: none"> Can survive in extreme environments. Used to study the evolution of body plans in animals. 	<ul style="list-style-type: none"> Developmental and evolutionary mechanisms are not completely understood.
<i>Caenorhabditis elegans</i> (roundworm)	100 Mb	3.5 days	<ul style="list-style-type: none"> Used to study nerve cell development. Genome has been sequenced. Easy and economical to culture. 	<ul style="list-style-type: none"> Invertebrates, so very different from higher organisms. Drug testing on worms requires further testing on mammals.
<i>Zea mays</i> (maize)	2,365 Mb	60-100 days	<ul style="list-style-type: none"> Used for studies of genetics and plant diseases. Easy and economical to maintain. 	<ul style="list-style-type: none"> Cellular processes are different from animals.
<i>Arabidopsis thaliana</i> (Arabidopsis)	125 Mb	5-6 weeks	<ul style="list-style-type: none"> Used to study plant development. Smallest and sequenced genome which is easy to manipulate (transgenics). 	<ul style="list-style-type: none"> It is a dicot (while most crops are monocots).
<i>Xenopus laevis</i> (frog)	3.1 Gb	14 weeks	<ul style="list-style-type: none"> Vertebrates. Used to study embryonic development because of large, transparent embryos. Easy to manipulate genetic material. 	<ul style="list-style-type: none"> Their life cycle is very different from humans.
<i>Mus musculus</i> (mouse)	~2.5 Gb	50-60 days	<ul style="list-style-type: none"> Share 80% similarity with human genes, making them useful to study genetic diseases. Used to study surgical techniques. 	<ul style="list-style-type: none"> Different from humans. Results may not be directly applicable to humans.
<i>Danio rerio</i> (zebrafish)	~1.5 Gb	10-12 weeks	<ul style="list-style-type: none"> Vertebrates. Used to study regeneration. Used to study embryonic development because of transparent embryos. Genome has been sequenced. 	<ul style="list-style-type: none"> Different from humans. Drug testing requires further testing on mammals.

Note: the table given here is for the reference of teachers. We have provided worksheet-2 in annexure that teachers can provide to students.

Once students have filled out the worksheet, discuss with them the advantages and disadvantages of using different model organisms.

Ask them to reflect on the following questions:

- What are the ethical considerations of using model organisms in research?
- Do all model organisms have similar ethical considerations, or does it vary?
- Why is it ethically okay to use some organisms and not others?
- Ask students to find out ethical quandaries for each model organism.
- Can students think of any other model organisms?
- Should we at all use model organisms for research? Is it necessary and justifiable to use model organisms in research?

Teachers can use the following points for discussion in the class:

- Using model organisms for research can raise a number of ethical considerations, such as animal welfare. It is crucial that animals used for research purposes are given humane treatment with proper care, food, housing, etc. Researchers should make sure to minimize the pain and suffering during experiments. For some model organisms, such as genetically modified organisms, it is important to assess for any possible environmental risk.
- The ethical considerations for using model organisms may vary from organism to organism. For example, using animals with high cognitive abilities such as apes may create more complex ethical issues than using simple organisms such as bacteria. Ethical considerations also depend on the regulations of a particular country or region. One can assess the ethical implications of using models for research on a case-by-case basis.
- Using certain model organisms for research over others is a complex process. It depends on various factors such as availability, cost, type of research and the level of consciousness an organism possess. Some organisms are considered to be more conscious than others, for example, mammals are more complex and conscious as compared to invertebrates. The type of research is equally important in determining the ethical implications. For example, using an organism for medical research may be acceptable under suitable circumstances as it could lead to new treatments, however, using an organism for cosmetic testing might be viewed as unnecessary. Additionally, the cultural significance of a particular organism also plays a role in the ethical dilemma of using it for research.
- For the organisms provided in the above table, students can try and find out the ethical considerations associated with each individual organism.
- Some other model organisms are: *Neurospora crassa* (fungus), slime mold, *Oryza sativa* (rice), *Rattus norvegicus* (rat), etc.
- Use of model organisms in research has a huge contribution to the advancement of biological sciences and medicine. However, using model organisms raises ethical concerns and one must consider the potential benefits of the research and the possibility of using any alternative methods, such as cell lines, invitro testing etc. In case, it is unavoidable to use model organisms, one must ensure that they are guided by ethics and reduce the harm to the organism involved.

What does this question make students do?

The students will learn about different model organisms used in research. They will reflect upon ethical dilemmas for using different model organisms.

Reading and Interpreting

Question

What is a green fluorescent protein? How is it used to study cells?

Hint

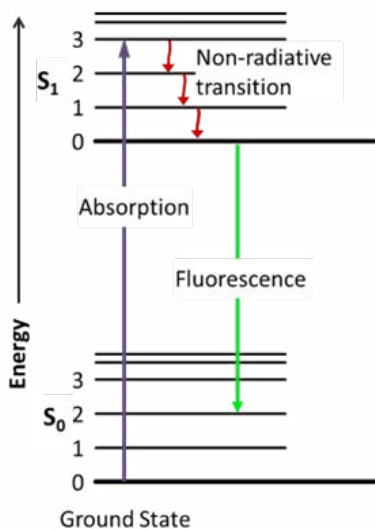
Find out what GFP is and why it is used in scientific research.

Background information:

To understand GFP, it is essential to have a basic knowledge of absorption and fluorescence.

Absorption: It is a process in which a material absorbs light energy of a particular wavelength. This leads to the excitation of electrons in the material to a higher energy state.

Fluorescence: It is a process in which a substance absorbs light at one wavelength and then re-emits the light energy at a higher wavelength. When a molecule absorbs energy it enters an excited state, and then while returning to the ground state, it emits energy as light.



Fluorescence

Jacobkhed, [Wikimedia Commons](#), Public domain

GFP: Green fluorescent protein (GFP) is a small protein of 238 amino acid residues that shows the phenomenon of fluorescence. It was first discovered in a jellyfish, *Aequorea victoria*. This protein absorbs blue light and emits green light. It is used in biological research to visualise and localised proteins or any molecules of interest.

Suggested Activity

Suggested time: 1 hour

Give students an introduction about GFP protein and start a discussion in the class. Divide students into groups of five and ask them to reflect on the following questions:

- *Why do humans care about a small protein obtained from a jellyfish?*

Hint: GFP is one of the most important tools in scientific research. It helps in understanding the workings of a cell. It is easier to study as it glows bright green under UV light.

- *How does GFP help in scientific research?*

Hint: GFP can be inserted into any sample of interest to study processes in living cells. For example, it can be attached to any protein to study its movement by imaging the fluorescence inside the cell. Or, GFP could be attached to a virus and the journey of the virus inside the host cell.

- *How have scientists improved GFP over time?*

Hint: Many scientists have mutated GFP protein to fluoresce different colours such as blue or yellow. Such proteins react to a wider wavelength of light. They have also created biosensors using GFP that allow studying levels of ions or pH.

- *When a protein is marked with GFP, does it affect the function of the protein?*

Hint: In most cases, GFP does not interfere with any biological processes. It is a small protein and fusing it with a target protein doesn't interfere with the protein's function. However, in some cases, GFP can cause misfolding of the target protein. To minimise any changes in proteins, one can use a single GFP molecule to tag and before taking any data, make sure that the protein function is not altered.

- *What are some fluorescent proteins other than GFP that are used to tag a protein?*

Hint: TurboGFP, mNeonGreen, Red fluorescent proteins, mCherry.

B2.4 Teamwork: team science in developing the vaccine

Reading and interpreting

Question

How can you work as a team to develop a research question and work on it?

Hint

Work in groups where each team member has a particular assigned task.

Suggested Activity

For this activity, divide students into teams to work together on a research question. Divide the students into groups of 4-5. Assign a particular role to each member of the group.

Encourage students to come up with a simple research question to investigate.

For example,

To one group, give a research question like –

- What kind of water do you drink at home? Is the type of water used for drinking in a household the cause of waterborne diseases in a family??

Let's say there are five students in a group. For each student, tasks may look like this:

Student 1: Preparing research plan

Student 2: Data collection

Student 3: Data collection

Student 4: Analysis of the findings

Student 5: Writing the report

Please note, even if each student has an individual task, they are supposed to brainstorm together for the research activity.

To come up with a research plan, ask students to think about the following questions:

- How many households will they want to visit to collect data?
- Can they collect this data by talking to their peers in the classroom?
- What parameters do they want to collect?

Household	Locality	Number of members	Age of members	Type of water used (B, RO, T)*	Any water-borne disease (name)	If yes, frequency of the disease.
1						
2						
3						
4						
5						
6						
7						
8						

*B-boiled, RO- Reverse osmosis (Filtered), T- Tap Water

At the end of the activity, ask students to reflect on the following questions?

- Were they able to perform their assigned tasks?
- Were they able to work as a team?
- What qualities did they learn to help them work in a team?
- Were there any conflicts while working as a team? How did they resolve them?
- What is the importance of working as a team?
- How have your individual roles helped with research?

Note: Different groups of students can come up with different research questions.

We are providing a few examples:

1. How frequently do youngsters consume junk food?
To answer this research question, think of the following:
 - a. What type of junk food does a person eat?
 - b. Do they eat junk food instead of a meal?
 - c. How many times do they eat junk food in a week or a month?
2. Does listening to a particular type of music help students to focus on their studies?
To answer this research question, think of the following:
 - a. Do students listen to music while studying?
 - b. What kind of music do students listen to in general and while studying?
 - c. Are they able to focus better while listening to music or without it?

What does this question make students do?

This activity will teach students to work as a team. They will be able to come up with research questions and hypotheses.

B2.5 Interpreting epidemiological data based on rotavirus

Quantitative skills

Question

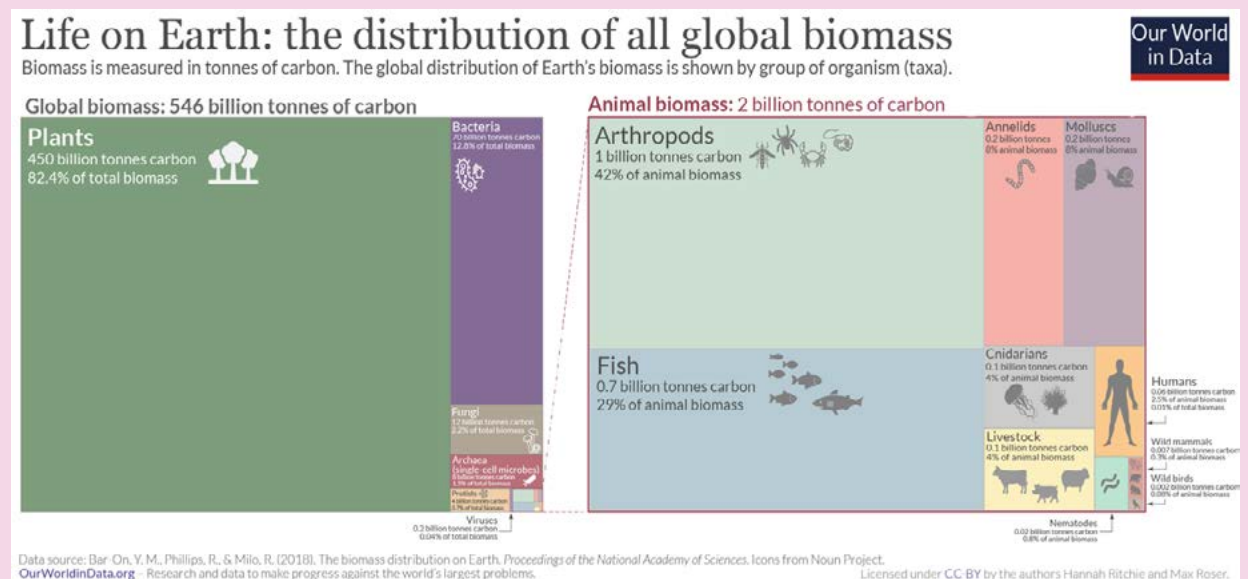
How to study graphs and data?

Hint

Analyse the given data carefully.

Suggested Activity

Given below is a set of data about the global biomass of life on Earth. Ask students to study the data carefully and answer the questions.



Study the chart given above carefully and answer the following questions:

Note: the table given here is for the reference of teachers. We have provided worksheet-3 in the annexure that teachers can provide to students.

Question

What percentage do animals collectively contribute to global biomass?

Solution

Given,

Global biomass = 546 billion tonnes of carbon

Animal biomass = 2 billion tonnes of carbon

Percentage of animal biomass = $(\text{Animal biomass} / \text{Global biomass}) \times 100$

Percentage of animal biomass = $(2 \text{ billion tonnes of carbon} / 546 \text{ billion tonnes of carbon}) \times 100$

Percentage of animal biomass = 0.36%

Question

Which comprises higher biomass of total biomass – Humans or livestock?

Solution

Global biomass = 546 billion tonnes of carbon

Biomass of livestock = 0.1 billion tonnes of carbon

Percentage of livestock biomass = $(0.1 / 546) \times 100\% = 0.02\%$ of total biomass

Percentage of human biomass = 0.01% of total biomass

Livestock accounts for more biomass than all humans on Earth; more than 50% greater than humans.

Question

Find the percentage of the total biomass of arthropods, fish, annelids, molluscs and cnidarians, respectively.

Solution

Global biomass = 546 billion tonnes of carbon

The total biomass of arthropods, fish, annelids, molluscs, and cnidarians is 1, 0.7, 0.2, 0.2, and 0.1 billion tonnes of carbon, respectively.

Percentage = $(\text{Biomass of group} / \text{Total biomass}) \times 100\%$

Arthropods:

Percentage = $(1 / 546) \times 100\% = 0.18\%$

Fish:

Percentage = $(0.7 / 546) \times 100\% = 0.13\%$

Annelids:

Percentage = $(0.2 / 546) \times 100\% = 0.04\%$

Molluscs:

Percentage = $(0.2 / 546) \times 100\% = 0.04\%$

Cnidarians:

Percentage = $(0.1 / 546) \times 100\% = 0.02\%$

Question

Which has higher biomass – viruses or humans?

Solution

The total biomass of viruses on Earth is approximately 0.2 billion tonnes of carbon and the biomass of humans is approximately 0.06 billion tonnes of carbon. Therefore, surprisingly, viruses have a much higher biomass than humans.

Question

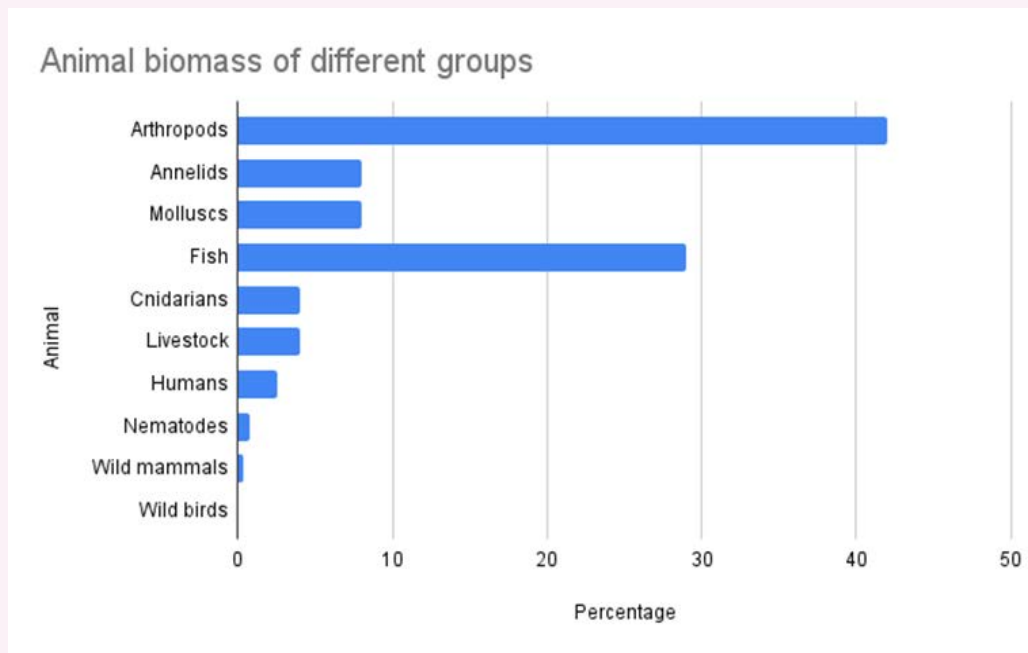
Create a pie chart of animal biomass of different animals. Which is a better representation of data – the pie chart or the graph given above?

Solution

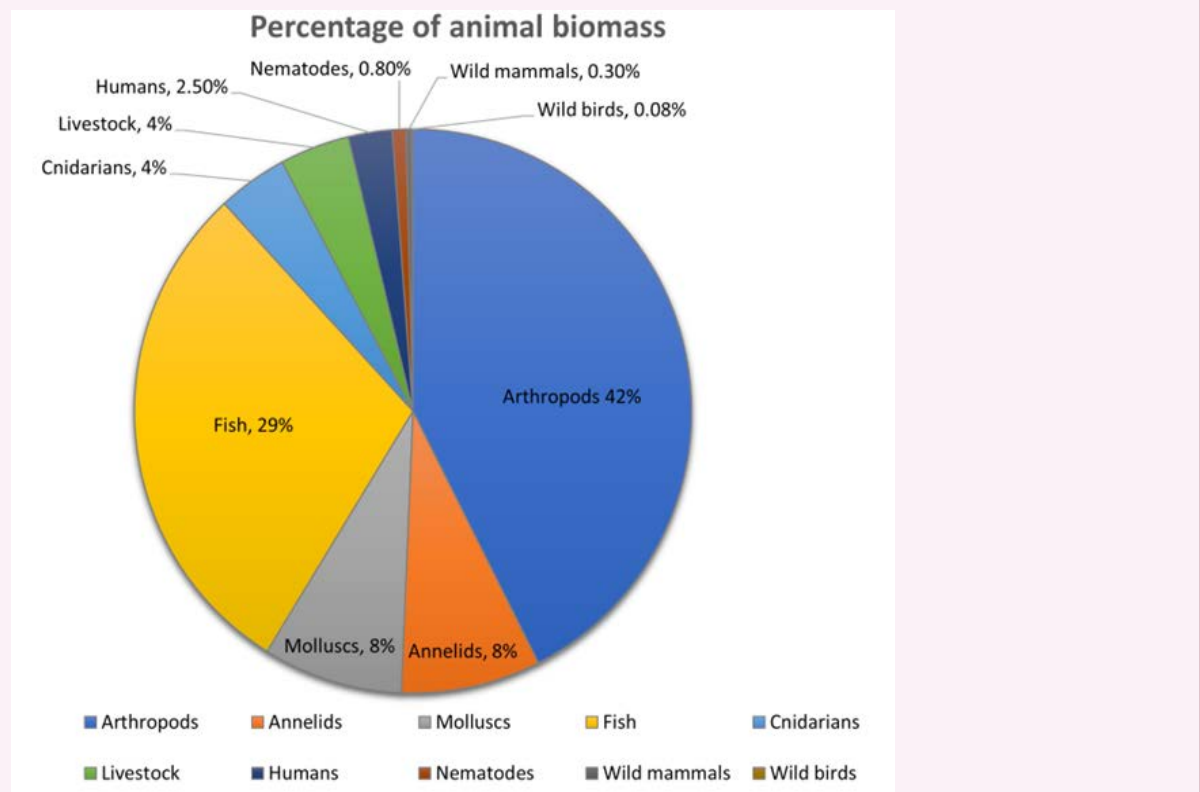
Animal	Percentage of animal biomass
Arthropods	42
Annelids	8
Molluscs	8
Fish	29
Cnidarians	4
Livestock	4
Humans	2.5
Nematodes	0.8
Wild mammals	0.3
Wild birds	0.08

Using the data given in the table above, here is a bar graph and a pie-chart

Bar Graph



Pie-chart

**Suggested reading:**

Of total global biomass, humans occupy only 0.01%. Have you ever wondered, how much anthropogenic biomass have humans contributed to the Earth? Read this article to find out:

<https://www.weforum.org/agenda/2021/12/weight-accumulation-human-made-mass-earth/#:~:text=It's%20predicted%20that%20total%20anthropogenic,concrete%20attributing%20to%20over%2033%25.>

To learn more about interpreting graphs and data, head to the chapter 'Waterscapes' in the book and attempt Exercise A2.1. Here is the link: <https://ithinkbiology.in/book/text/a2-waterscapes.html#a22-why-does-land-harbour-more-diversity-than-water>

What does this question make students do?

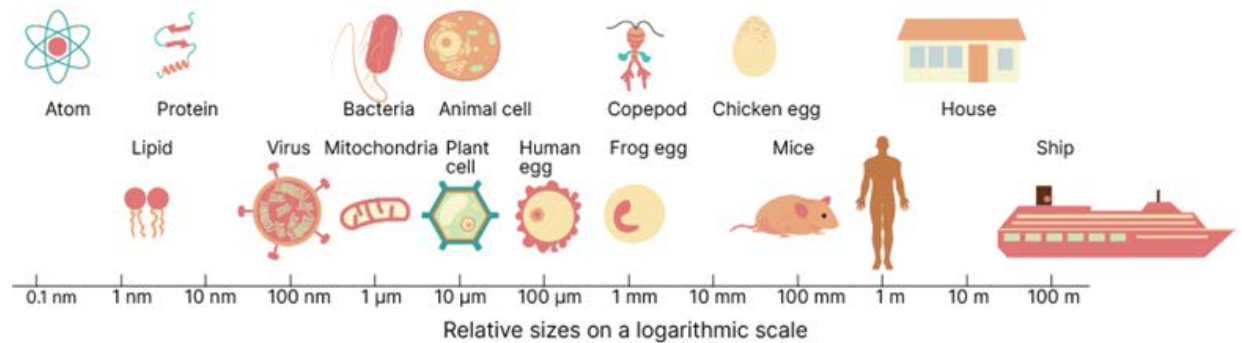
These questions will help students to learn to interpret graphs and calculate proportions.

Annexure

Worksheet - 1

Look at this length scale. Observe the relative sizes of different organisms/objects on the logarithmic scale.

Compare the relative size of the virus with the following items.



Question

How many times is the virus bigger compared to an atom?

Hint

To find how many times a virus is bigger than an atom, divide the size of the virus (100 nm) by the size of the atom (0.1 nm).

Solution

Question

How big is a bacterial cell compared to a virus?

Hint

To compare the sizes of a bacterial cell and a virus, convert the sizes to the same unit of measurement.
Convert μm into nm
(1 μm = 1000 nm)

Solution

Question

Compare the size of the virus with a human egg.

Hint

To compare, convert the sizes to the same unit of measurement.

Convert μm into nm

(1 μm = 1000 nm)

Solution**Question**

How small is an atom as compared to a frog egg?

Hint

To compare, convert the sizes to the same unit of measurement.

Convert mm into nm

(1 mm = 10^6 nm)

Solution**Question**

How big is a mouse compared to a plant cell?

Hint

To compare, convert the sizes to the same unit of measurement.

Convert mm into μm

(1 mm = 1000 μm)

Solution**Question**

How many viruses will you need to join from end to end to make it equivalent to a plant cell?

Hint

Convert the sizes to the same unit of measurement.

Convert mm into nm

(1 μm = 1000 nm)

Solution

Worksheet-2

Different model organisms are used in biological research. Find out the genome size, life cycle, advantages and disadvantages of using different model organisms.

Model Organism	Genome size	Life cycle	Advantages	Disadvantages
<i>Escherichia coli</i> (Bacteria)				
<i>Saccharomyces cerevisiae</i> (yeast)				
<i>Chlamydomonas</i> (green algae)				
Fibroblast (cell line)				
Organoid (tissue of differentiating cells)				
<i>Drosophila melanogaster</i> (fruit fly)				
<i>Hydra vulgaris</i> (hydra)				
<i>Dugesia tigrina</i> (Planaria)				
Tardigrade (water bears)				
<i>Caenorhabditis elegans</i> (roundworm)				
<i>Zea mays</i> (maize)				
<i>Arabidopsis thaliana</i> (Arabidopsis)				
<i>Xenopus laevis</i> (frog)				
<i>Mus musculus</i> (mouse)				
<i>Danio rerio</i> (zebrafish)				

Worksheet -3

Study the chart given below carefully and answer the following questions:

Life on Earth: the distribution of all global biomass

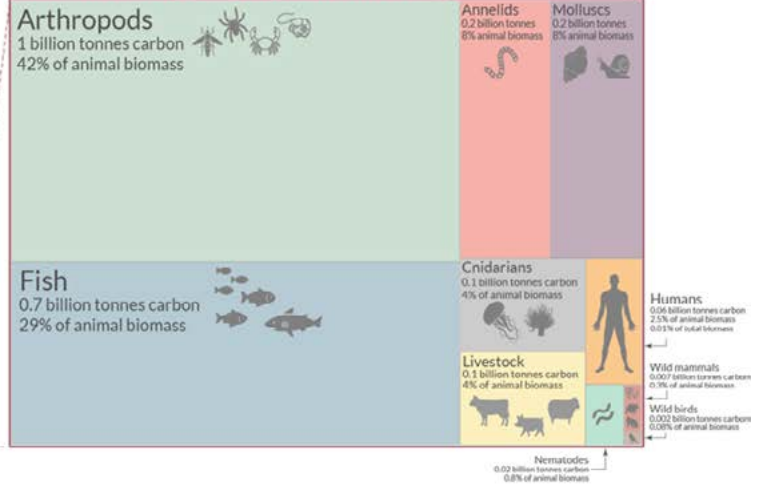
Biomass is measured in tonnes of carbon. The global distribution of Earth's biomass is shown by group of organism (taxa).



Global biomass: 546 billion tonnes of carbon



Animal biomass: 2 billion tonnes of carbon



Data source: Bar-On, Y.M., Phillips, R., & Milo, R. (2018). The biomass distribution on Earth. *Proceedings of the National Academy of Sciences*. Icons from Noun Project. OurWorldinData.org - Research and data to make progress against the world's largest problems. Licensed under CC BY by the authors Hannah Ritchie and Max Roser.

Question
What percentage do animals collectively contribute to global biomass?

Solution

Question
Which comprises higher biomass of total biomass – Humans or livestock?

Solution

Question
Find the percentage of the total biomass of arthropods, fish, annelids, molluscs and cnidarians, respectively.

Solution

Question

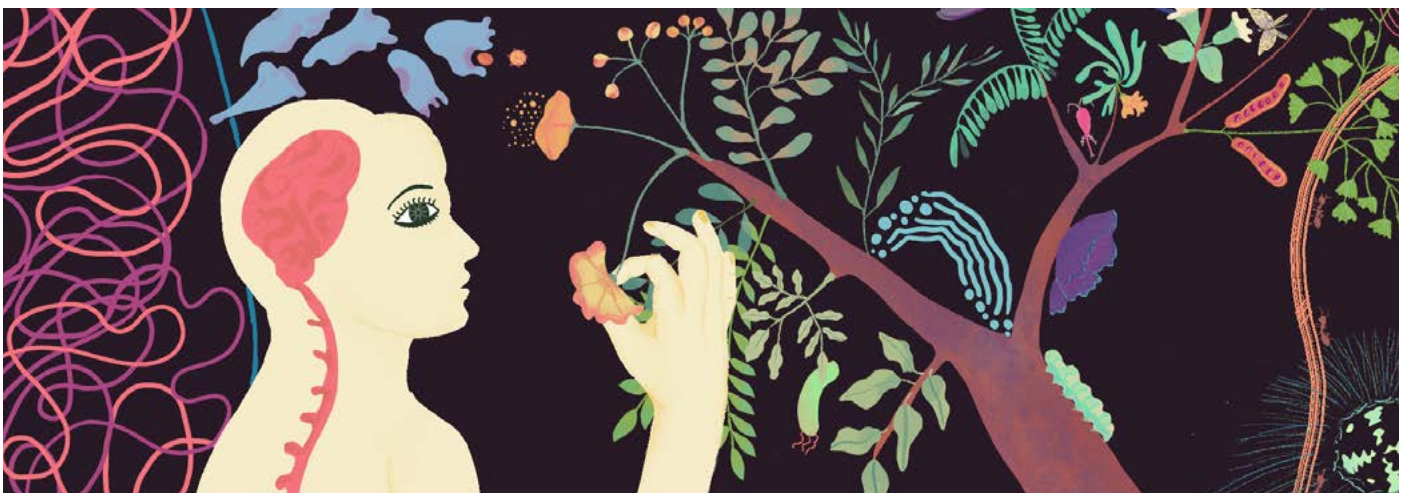
Which has higher biomass – viruses or humans?

Solution

Question

Create a pie chart of animal biomass of different animals. Which is a better representation of data – the pie chart or the graph given above?

Solution



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