Worksheet 2.1

Bottle ecosystems

Introduction

An ecosystem is a community of interdependent organisms and the physical environment they inhabit. They exist on a range of scales (see pages 2–3 of the textbook). Simulated ecosystems can be set up in the lab in order to learn about ecosystems in the real world.

2-litre fizzy drink bottles can be used to create 'bottle ecosystems' – integrated ecosystems containing both terrestrial (land-based) and aquatic (water-based) systems.

Setting up the bottle ecosystems

- Take 5, 2-litre fizzy drinks bottles: cut and assemble as shown in the figure below (page 2).
- The bottom chamber forms the **aquatic** ecosystem, the middle one a **decomposition** chamber, and the top one a **terrestrial** ecosystem.
- Decide what components to include in each section (which organisms, type of soil, and so on). The content of the chambers is up to you – the figure and information contains suggestions (page 3).
- Draw a diagram of each of your bottle ecosystems and identify the abiotic factors (see pages 24–28 of textbook) and biotic factors (page 29).
- Draw the food chains you will find in each chamber and connect these to form a food web for each. Aim to identify every species you have added to each chamber (using dichotomous keys – see page 29 of textbook – as necessary).

Observing the bottle ecosystems

- Each week you can make observations of your bottle ecosystems. Each observation should include:
  - the date of your observations
  - the number of days the ecosystem has been running
  - pH (of soil/water)
  - temperature
  - dissolved oxygen content of the aquatic chamber
  - qualitative observations (e.g. plant growth, decomposition rate, turbidity of water, status of the species present, numbers of organisms)
  - additional measurements (e.g. analysis of nutrients – NPK content, etc).
- Many of the ideas contained in pages 24–30 of the textbook can be explored using the bottle ecosystems.

- The study can be written up as a lab investigation as part of your IA assessment. Use the guidelines on pages 319–322 of the textbook to help you, and pages 4–5 of this worksheet.

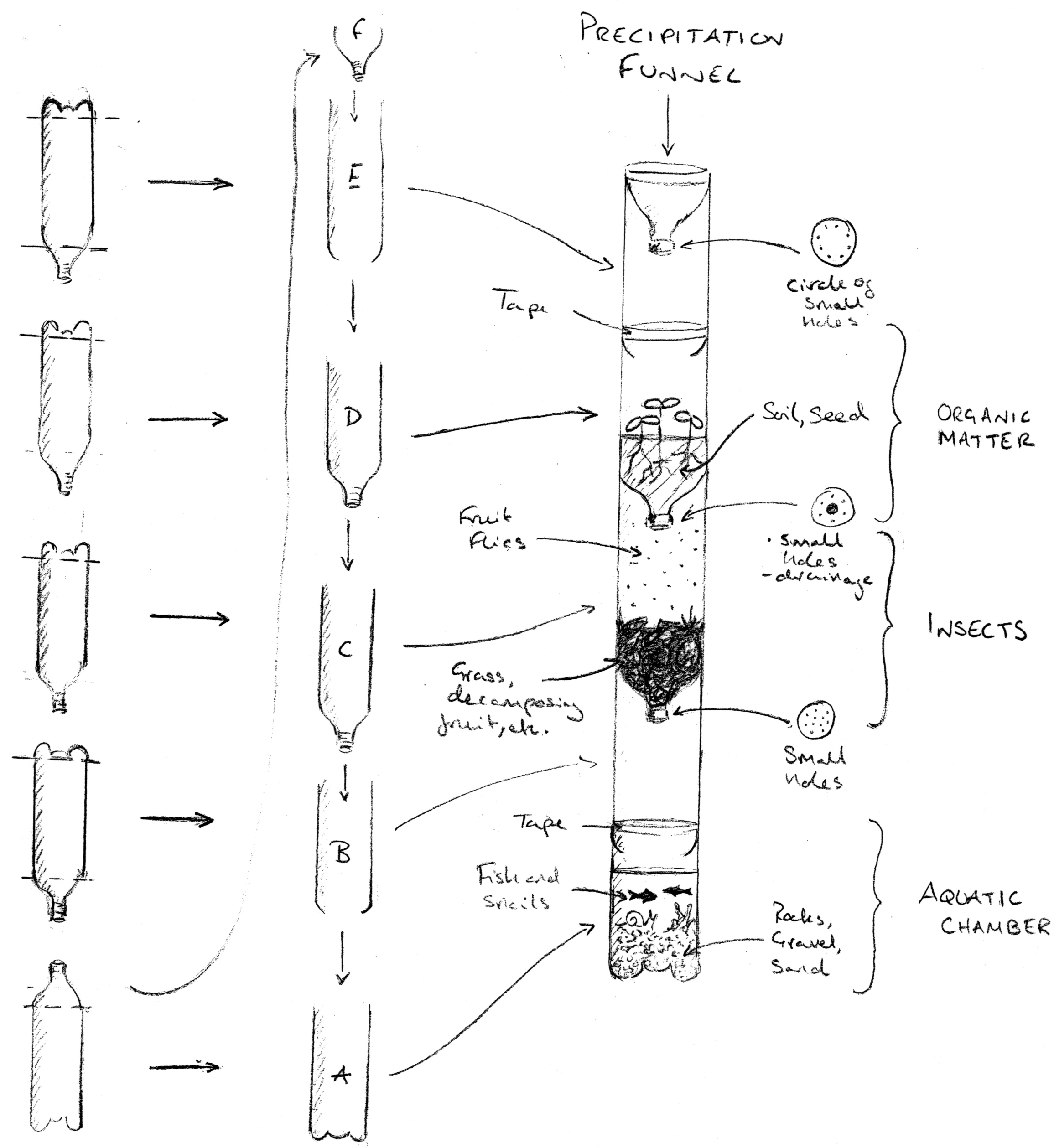

Figure: Creating bottle ecosystems. Cut 5, 2-litre fizzy drinks bottles as shown on left of figure, and assemble as indicated. The bottom chamber (bottle A) forms the *aquatic* chamber, the middle chamber (bottle C) a *decomposition* chamber, and the top chamber (bottle D) a *terrestrial ecosystem*. The worksheet contains information about possible abiotic and biotic components for each ecosystem (Artwork by Freddie Crossley).

Ideas for chamber components (abiotic and biotic factors)

Terrestrial chamber

Soil – The productivity of soil depends on mineral content, drainage, water-holding capacity, air spaces, biota (animals present e.g. earthworms) and the potential to hold organic matter. For the soil in the terrestrial chamber you may want to use one that is locally available, or create your own using information on pages 125–127 of the textbook. The most productive soil is loam soil (page 125).

Seeds – As you have a limited growing space, your plants will need to be small. You should avoid fast-growing plants such as beans. Cress may be a suitable plant to use, although there are many other options. Visit your local garden centre and see what is available.

The terrestrial chamber should be watered regularly. Water will filter down into the lower ecosystems. Use trial-and-error to see how much water is needed to support all ecosystems.

Decomposition chamber

Organic matter – A mix of leaves, grass, and easily decomposed food such as fruit (do not include citrus fruit or peelings) should make up the material in this chamber. Think carefully about what proportion of each of these components you should use.

Insects – Insects such as fruit flies (*Drosophila*) can fly between terrestrial and decomposition chambers and help decompose the detritus in the decomposition chamber. What other insects could you include? Do you want to put them in the terrestrial or decomposition chamber?

Aquatic chamber

Water – Tap water may be treated with chemicals and so should not be used in the aquatic chamber. Should you use distilled water or pond water?

Substrate – You should put gravel or sand at the bottom of this chamber. Organisms you put in this chamber may need this substrate as part of their life cycle, or as a refuge.

Organisms – Pond weed (*Elodea*), snails and fish could be used in your aquatic chamber. Be careful to select the fish carefully, and limit the number of larger organisms in this chamber. Add only the number of consumers you think that the chamber will support.

Bottle ecosystem write-up instructions

This page contains suggestions for your bottle ecosystem write-up.

1. **Hypothesis**
   Write a hypothesis for each chamber. What do you think will happen in each of the ecosystems? Why do you think this will be the case?

2. **Diagrams**
   Draw a diagram that shows your column of chambers and annotate the contents of each. List the abiotic and biotic components. Each member of the class will have different components in their ecosystems – this will make comparisons between different ecosystems possible.

3. **Variables**
   Ideally in an experiment one variable is changed (the independent variable) and one is measured (the dependent variable). In ecosystems, there are many different variables operating at the same time. What variables will you be measuring in each chamber? You may want to try and change one variable and record the effect on a linked dependent variable. Which variables will you be aiming to keep the same (control variables)? It is possible that you will not be able to control other variables – these should therefore be recorded.

4. **Food chains and webs**
   Draw food chains you expect to see in each chamber.
   - Draw each organism as a circle and give the names where possible (scientific or common name).
   - Identify the role of each organism using appropriate letters, for example; producer – P; primary consumer (or herbivore) – C1; secondary consumer (omnivore/carnivore) – C2; tertiary consumer (carnivore) – C3; decomposer – D.
   - Draw flows of energy between different organisms. The arrows should be directed from the energy source towards the organism that gets that energy (the arrows represent energy flow).
   - Connect different food chains within each ecosystem to form food webs. Arrange the food webs so producers appear at one level (the bottom of the figure), primary consumers at the next level, and so on. Does each organism appear at the same trophic level in each food chain?

5. **Presentation and analysis of data**
   - Record your data in tables. Make sure you include all relevant units.
   - Analyse your data – do variables change over time, and what trends do they show?
   - Plot relevant graphs to illustrate your data. Make sure you label axes and include relevant units.

6. **Discussion and conclusions**
What were the main findings of your study? What scientific theory did they illustrate? Can you find references from other sources (e.g. books, the internet) that support your findings? You may want to focus your discussion on the food webs in each chamber using the following questions.

- What are the top consumers in each ecosystem?
- How does the productivity of the producers affect the trophic levels above?
- What would happen to these consumers if all the primary consumers were to die?
- What would happen if the decomposers were removed?
- Which ecosystem do you think would be the most resistant to disturbance – one with few food webs or one with many? Justify your answer (see pages 69 and 186 of the textbook to help you).

7. **Evaluation**
What were the main limitations of your study (include at least five)? How may these limitations have affected your experiment? How could you avoid these limitations if you were to do the experiment again?