Contents

Acknowledgements vii

Introduction ix

1 The Chemistry of the Chromosomes 1
   Text by C. A. Villée, W. F. Walker and F. E. Smith

2 Adaptive Radiation in Evolution 9
   Text by J. M. Savage

3 Sieve-Tubes 22
   Text by W. O. James

4 The Light and Dark Bottle Experiment 34
   Text by E. P. Odum

5 Vaucheria 45
   Text by V. J. Chapman

6 The Laying Habits of the European Cuckoo 64
   Text by M. Rothschild and T. Clay

7 Cilia and Flagella 75
   Text by G. S. Gartner

8 Temperature Regulation in Mammals 90
   Text by J. Z. Young

9 Trollius L. 102
   Text by A. R. Clapham, T. G. Tutin and E. F. Warburg

10 The Phylum Arthropoda 112
    Text by L. A. Borradaile, F. A. Potts,
    L. E. S. Eastham and J. T. Saunders

11 The Swim Bladder 123
    Text by A. S. Romer
<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Proteolytic Enzymes</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>Text by M. Thomas, S. L. Ranson and J. A. Richardson</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Endotrophic Mycorhiza: Calluna</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Text by M. Skene</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>The Conduction of Phototropic Excitation in Plants</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>Text by W. Stiles</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Breeding Systems: Incompatibility</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>Text by G. D. Darlington and K. Mather</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Morphological Modes of Evolution</td>
<td>186</td>
</tr>
<tr>
<td></td>
<td>Text by G. R. de Beer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Vocabulary</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Glossary of Biological Names</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>Key to Exercises</td>
<td>222</td>
</tr>
</tbody>
</table>
The Light and Dark Bottle Experiment

VOCABULARY

alkaline iodide /ˈsɛlkəlain ˈaɪədaid/ 14 potassium /ˈpoʊtəsiəm/ iodide (KI) or sodium iodide (Na I)
calibrate /ˈkælɪbreɪt/ 21 to give a scale to; ‘The volume of sodium thiosulfate† needed can be calibrated to indicate the concentration of oxygen in milligrams’
count /ˈkaʊnt/ 49 See Explanatory Notes, p. 39
curve /ˈkɜrv/ 60 a line plotted† on a graph† whether it is curved or not: ‘a diurnal curve† may be plotted’
data /ˈdeɪtə/ 78 factual information, usually in the form of figures: ‘the quantity of data that can be gathered’
determine /ˈdɛtərmine/ 50 to find out: ‘the phytoplankton† is removed by a filter that is “counted”† by a detector to determine the amount of radioactive carbon fixed†’
diurnal /ˈdaɪərnəl/ 59 covering 24 hours: ‘a diurnal curve† may be plotted’
ecological /ˌɛkəˈlɒdʒɪkl/ 79 adj./ecology /ˌɛkəˈlɒdʒi/, the study of organisms in relation to their surroundings, or environment: ‘ecological research’ (Gk ὠικός a house, λόγος a branch of knowledge)
 elemental /ˈɛlemtənəl/ 15 free, not part of a chemical compound: ‘This treatment releases elemental iodine’
fix /fiks/ 7 See Explanatory Notes, p. 38
fraction /ˈfækʃən/ 31 See Explanatory Notes 7, p. 38
foil /fɔɪl/ 5 metal in the form of a very thin sheet: ‘One or more bottles are covered with aluminum foil’
graph /ˈɡrɑːf/ 42 a diagram expressing a mathematical relationship: ‘A graph of bottle values plotted† against depth can be constructed’ (Gk γράφω to draw)
† American spelling

hypo /ˈhaɪpəʊ/ 19 the popular name for sodium thiosulfate; ‘the “hypo” used to fix† photographs’
laborious /ˈloʊbərriəs/ 72 requiring much repetitive work: ‘The somewhat laborious . . . method of estimating oxygen described above’
location /ˈloʊkətʃən/ 56 a place: ‘a new sampling† location’
manganous sulfate† /ˌmæŋənoʊs ˈsɑːlfət/ 14 manganous sulphate, MnSO₄
net /ˈnet/ 27 resulting from what is gained minus what is lost: ‘the net photosynthesis (that is, net result of photosynthesis and respiration)’ See Explanatory Notes 25, p. 36
oceanographic /ˌɔːkəˈnɔːgrəfi/ 52 adj./oceanography /ˌɔːkəˈnɔːgrəfi/, the scientific study of the sea: ‘This method is widely used in oceanographic work’ (ocean + Gk γράφω to draw)
phytoplankton† /ˌfaɪtəˈplæŋktən/ 43 that part of plankton† which is composed of plants (Gk φυτός a plant + plankton)
plankton /ˈplæŋktən/ 2 very small plants and animals that swim or float near the surface of the sea or lakes (Gk πλάγκτης wandering)
plot /ˈplɔt/ 42 to mark a position on a diagram or graph†: ‘a graph of bottle values plotted against depth can be constructed’
precision /ˈprɪsən/ 78 accuracy, exactness: ‘the development of new methods that increase both the precision and the quantity of data†’
procedure /ˈprəʊəsidʒ/ 75 the method of doing a thing: ‘Such electronic procedures are now in the experimental stage of development’
resuspend /rɪˈsənspænd/ 52 to suspend, or hang, again: ‘it is not necessary to resuspend bottles in the sea’
sample /ˈsæmpl/ 3 a specimen: ‘A portion of a sample of water from each of several levels’
sampling /ˈsæmplɪŋ/ 55 the taking of samples‡: ‘a new sampling† location’ See Explanatory Notes, p. 49
sediment /ˈsɛdɪmənt/ 68 the solid that may settle at the bottom of a liquid: ‘physical exchange of oxygen . . . between water and sediments must be estimated’
n shift /ʃɪft/ 35 a change of place or position: ‘a simple shift of decimal’
ioxidation /ˌsouˈdʒənətʃən/ 20 oxidation thiosulfate† /ˌsoʊdʒənətʃən/, 20 sodium thiosulfate, Na₂S₂O₃
somewhat /ˈsʌmwɔt/ 72 rather: ‘The somewhat laborious . . . method’
stand by /ˈstænd bɛɪ/ 53 to wait in a state of preparation: ‘it is not necessary to . . . stand by for 24 hours’
string /ˈstrɪŋ/ 12 a series of things connected by string or thread: ‘the string of bottles’
sulfuric acid /ˈsaʊljʊrɪk ˌæsید/ 15 sulphuric acid, H₂SO₄
titrate /ˈtaɪtrɪt/ 18 to treat a chemical substance with a known
† American spelling
Text

Light and dark bottles are suspended in a pond to measure oxygen changes resulting from the metabolism of the plankton organisms. A portion of a sample of water from each of several levels is placed in glass bottles. One or more bottles are covered with aluminum foil or black tape so that no light can reach the sample; these are called the ‘dark’ bottles, in contrast with the ‘light’ bottles that have no such cover. Other bottles are ‘fixed’ with reagents immediately so that the amount of oxygen in the samples at the beginning of the experiment can be known. Then pairs of light and dark bottles are suspended in the pond at the levels from which the water samples were drawn. At the end of the 24-hour period the string of bottles is removed from the pond and oxygen in each ‘fixed’ by addition of a succession of the three reagents: manganous sulfate, alkaline iodide, and sulfurous acid. This treatment releases elemental iodine in proportion to the oxygen content. The water in the bottles is thus now brown in color; the darker the color, the more oxygen. The brown water is then titrated in the laboratory by adding sodium thiosulfate (the ‘hypo’ used to fix photographs) until the color disappears. The volume of sodium thiosulfate needed can be calibrated to indicate the concentration of oxygen in milligrams or milliliters per liter; milligrams per liter is also parts per million, another way in which oxygen content of water is expressed.

The decline of oxygen in the dark bottles indicates the amount of respiration in the water column whereas the oxygen change in the light bottles indicates the net photosynthesis (that is, net result of photosynthesis and respiration); the two quantities added give an estimate of total photosynthesis or total food production for the 24-hour period, since oxygen production by green plants is directly proportional to fixation of light energy. One method of calculating photosynthetic rate of the water

† American spelling
the "oxygen electrode", which will permit continuous recording of oxygen in a bottle or in a body of water. Such electronic procedures are now in the experimental stage of development. As in any branch of science the development of new methods that increase both the precision and the quantity of data that can be gathered is one of the primary concerns of ecological research.

E. P. Odum Ecology (1963)

EXPLANATORY NOTES

levels: levels, or depths, beneath the surface of the pond
"dark": the inverted commas are used here and in 7 and 49 because the words concerned do not denote what they normally denote; and in 19 and 74 they are used for popular names.
Other bottles are "fixed" with reagents: It is, of course, not the bottles themselves that are "fixed", but the oxygen inside them, which combines chemically with the reagents, thereby releasing iodine (15). The use of fix in this way is also found in 50. In 19 fix refers to the stabilization of shades or colours in a photo so that they do not change. In 31 the noun fixation is used with reference to the storing of light energy in a chemical compound such as starch.
the darker the colour† the more oxygen: the darker the colour is, the more oxygen there is
millilitre†: millilitre
mlligrams per liter† is also parts per million: For the use of the singular verb (is), see Grammar and Usage, p. 6.
liter†: litre
The decline of oxygen in the dark bottles indicates the amount of respiration in the water column whereas the oxygen change in the light bottles indicates the net photosynthesis... the two quantities added give an estimate of total photosynthesis or total food production for the 24-hour period, since oxygen production is directly proportional to fixation of light energy: Photosynthesis releases oxygen, whereas respiration uses it up. If, in the light bottle, the number of units of oxygen released by photosynthesis is 4, and the number of units used in respiration is 1, the net result of photosynthesis and respiration will be 3 units of oxygen. In the dark bottle, where there is no photosynthesis, there will be a loss of 1 unit of oxygen. Thus 1 + 3 gives the number of units of oxygen released in photosynthesis, which is directly proportional to the amount of food produced in the process.
† American spelling

estimate: Compare the pronunciation of this noun ['estimæt] with that of the corresponding verb ['estimæt], which occurs in 66 and elsewhere.
photosynthetic rate of the water column: the rate of photosynthesis in the water column
meter†: metre
to average values: to take the average of values
a simple shift of decimal: a change in decimal values from milligrams per litre to grams per cubic metre, which is simple because there is no change in figures or in the position of the decimal point
placed at 0.5, 1.5, and 2.5 meters† deep: This is rather an unusual construction. A more usual one would be either (a) placed at depths of 0.5, 1.5, and 2.5 metres or (b) placed 0.5, 1.5, and 2.5 metres beneath the surface.
bottle values: values for oxygen production obtained as above (25).
the area under the curve used to estimate the column: the area under the curve can be used to estimate the column
estimate the column: estimate the oxygen production, or photosynthesis, in the column
a filter that is 'counted': a filter whose radioactivity is determined by an instrument such as a Geiger counter
This method, which indicates the net photosynthesis: It does not indicate total photosynthesis any more than a measurement of oxygen
† American spelling
production does (25), for although carbon dioxide is utilized in photosynthesis it is released in respiration.

55 a new sampling location: a new place to take samples from

61 decline: This is a noun, not a verb, being the second of the two direct objects of the verb shows (60), i.e. a diurnal curve may be plotted that shows ... decline during the night.

72 tried and true: frequently practised in the past and comparatively accurate

74 recording: Pronounced [rəˈkɔrdɪŋ], i.e. with the stress on the second syllable, since this noun is derived from the verb record [rəˈkɔrd], not the noun [ˈrekɔd].

79 one of the primary concerns: one of the most important aims or objects

GRAMMAR AND USAGE

THE PASSIVE

Examples of the passive of the six tenses that occur in the texts in this book (see p. 17) are given below:

4.9 Then pairs of light and dark bottles are suspended in the pond at the levels from which the water samples were drawn. [Present and past]

1.11 Tetraploid cells, with four sets of chromosomes, have been found to have $12 \times 10^{-9}$ milligrams of DNA per nucleus. [Present perfect]

4.38 if bottles had been placed at 0.5, 1.5, and 2.5 meters† deep then each pair could be considered as sampling the first, second and third cubic meter†. [Past perfect]

16.44 In the following pages examples will be given of each of the eight possibilities outlined above. [Future]

4.64 The advantage of the diurnal curve method is that photosynthesis of the whole pond ... would be estimated. [Conditional]

It will be seen that the passive is formed by the appropriate tense of the verb to be (are, were, etc.) and the past participle of the verb concerned. The passive infinitive is formed by the infinitive to be (with or without to) and the past participle of the verb concerned:

4.59 a diurnal curve may be plotted ...

2.11 Reptile eggs, like bird eggs, do not need to be immersed in water.

The general reason for using the passive is that, in the context, the thing on which the action is performed is of more significance than the thing or person performing the action. The thing acted upon, such as bottles (4.9, 4.38†) or tetraploid cells (1.11), therefore becomes the grammatical subject of the sentence, while the thing or person who acts (i.e. what would be the subject in a construction using the active voice) may, as in the above examples, get no mention at all. If he (or it) does get a mention, it is as the grammatical agent.

† American spelling
5.39 The chloroplasts and nuclei congregate in the apex of a filament before the septum is laid down.

3.68 A different pattern is found in the gymnosperms.

In sentences like 16.104 and 7.17 it would in any case be very difficult to convert the passive verb into an active one. Where would one find a subject for it? There is no grammatical agent in either sentence; means is not the agent in 7.17, since by some means is equivalent to in some way. In 16.74 an active verb could be used with the same subject (the animal switches over), but would remove from the subject the idea of passivity. The use of the passive in 16.47, however, is largely a matter of convention, and here the active could be used with the same subjects without a change in meaning (a structure forms, etc.). In 5.39, the verb is an alternative (but which can only be used in the passive) to is formed or forms. Similarly, is found in 3.68 is a passive alternative to the active occurs.

Another point worth mentioning is that many verbs which in the active form may be followed by that, such as see, know, show, suppose, have a passive construction with the infinitive.

3.76 The sieve-tubes are commonly supposed to be the main conducting channels of food substances.

The active version of this (although not so appropriate) might be Botanists commonly suppose that sieve-tubes are the main conducting channels of food substances. An alternative passive construction would be 'It is commonly supposed that sieve-tubes...'

EXERCISES

I

Rewrite the following statements to show that you fully understand the meaning of each. Expand them if necessary and use diagrams if these will help:

1. '...a graph of bottle values plotted against depth can be constructed and the area under the curve used to estimate the column.' (4.42)
2. 'The water in the bottles is thus now brown in color; the darker the color the more oxygen.' (4.16)
3. 'The decline of oxygen in the dark bottles indicates the amount of respiration in the water column whereas the oxygen change in the light bottles indicates the net photosynthesis.' (4.25)
4. 'At sea it is not necessary to resuspend bottles in the sea and stand by for 24 hours; the samples can be subjected to the light and temperature conditions of the sea on the deck of the ship as it moves to a new sampling location.' (4.52)
5. 'After an interval of time the phytoplankton is removed by a filter that is 'counted' by a detector to determine the amount of radioactive carbon fixed. This method, which indicates the net photosynthesis, is widely used in oceanographic work.' (4.48)

† American spelling

III

In the following sentences replace the italicized words by one word of similar meaning, making any changes in word order that may be necessary:

1. The method of doing things in both experiments is fundamentally the same.
2. The physical exchange of oxygen between water and solids settled on the bottom must be estimated.
3. One or more bottles are covered with aluminium metal in the form of a very thin sheet.
4. The quantity of factual and numerical information that can be gathered may be increased.
5. This is a method requiring much repetitive work.

IV

Write down the nouns that correspond to the following verbs used in the text:

measure (4.1), release (4.15), titrate (4.18), calibrate (4.21), add (4.29), convert (4.34), indicate (4.51), estimate (4.60), replace (4.73).

42
V The following sentences give instructions similar to those in the text, but the verbs are in the imperative (see p. 41). Re-write the sentences changing these verbs into the passive.

1. Add the two quantities in order to obtain a figure for total photosynthesis.
2. Remove the string of bottles from the pond at the end of the 24-hour period.
3. Cover the bottles with black tape or similar material.
4. Plot bottle values against depth and use the area under the curve to estimate oxygen production in the water column.
5. Titrate the prepared solution in the laboratory with sodium thiosulphate.

VI Re-write the following sentences putting the italicized verbs into the passive (see p. 40), leaving out or changing other words when necessary or advisable:

1. A. E. Mirsky has obtained pure chromosomal material for analysis.
2. The decline of oxygen in the dark bottle indicates the amount of respiration in the water column.
3. We know very little of the manner in which the transport of food substances takes place.
4. The 'oxygen electrode' may soon replace the method of estimating oxygen described above.
5. Research workers have found that tetraploid cells have $12 \times 10^{-9}$ milligrams of DNA per nucleus.
6. Removal of the phloem, the tissue containing the sieve-tubes, brings food conduction to a standstill.
7. In surface view we see that the pits are collected into groups or lattices.
8. Treating chromosomes with deoxyribonuclease removes the DNA but leaves a shadow of the chromosome structure.
9. The two quantities added give an estimate of total photosynthesis.
10. Workers have shown that chromosomes contain DNA, RNA and several kinds of proteins.