Introduction (for students)

Biology For You is designed to introduce you to the basic ideas of Biology. These ideas will show you how living organisms are able to exist, from the smallest microbe to the largest whale; from the tiniest spore to the tallest tree. These ideas will also show you how plants and animals interact with each other and with their environment. You will learn how differences between living organisms are passed on to the next generation and how they can change with time.

This book is based on successful earlier editions of the same name, but new pages and questions have been added to cover the latest requirements of the new GCSE examinations.

Biology For You has been designed to be interesting and to help you to pass your exams, whether you are using it for a Biology course or as part of a Combined Science course. The book is carefully laid out so that each new idea is introduced and developed on a single page or on two facing pages. Words have been kept to a minimum and as straightforward as possible.

Throughout the book there are many simple experiments and investigations for you to do. The safety sign: ☑ means your teacher should give you further advice (for example, to wear safety glasses).

Each new biological word is printed in heavy type or is in a box. There is a summary of important facts at the end of each chapter. Also near the end of many of the chapters are ‘Biology at Work’ pages. They show you how Biology can be useful to us in everyday life.

On-line, at www.biologyforyou.co.uk you can download a wide range of extra resources, as well as a ‘specification map’ to help you to focus on revision for your particular exam.

At the back of the book there is advice for you on working scientifically, practical work, advice on careers, revision and examination techniques, as well as help with mathematics.

Questions at the end of a chapter range from simple fill-in-a-missing-word sentences (useful for writing notes in your notebook) to more difficult questions that will need more thought. At the end of each main topic you will find a section of further questions taken from actual GCSE examination papers. All the answers are available on-line.

I would like to thank my family, Diana, Jill and Gail, for all their help and encouragement during the writing of this book. I hope you will find Biology interesting as well as useful. Above all, I hope you will enjoy using Biology For You. Gareth Williams

Introduction (for Teachers planning for the new GCSEs in September)

In considering the implementation of the new GCSE Biology specifications for September, there are a number of things for you to take into account:

- **Coverage of the new Content in the specification**
  There are many key areas of content that have changed in the new specifications. Some examples of the new content required by Ofqual include: Infection and response, with greater detail on viral and bacterial diseases and the inclusion of fungal diseases in both humans and plants. The content of inheritance, variation and evolution has been expanded. The role of hormones in human reproduction and their role in contraception and the treatment of infertility. An increased coverage of biodiversity, food production and sustainability. The increased use of mathematics in answering questions.

- **Accessibility & Readability**
  If your students are going to use the book as a backup to your teaching, then they need to be able to study and understand independently. Accessibility, readability, layout and clarity of presentation are all vital here. Judge for yourself by looking at the sample pages we’ve included. And perhaps ask your students what they think?

- **Support for your students, across the full ability range**
  Your students will be supported not only by the clear layout and the accessible reading age, by the helpful worked examples and many ramped questions... but also by the extra support for Maths and the sections on Revision Technique and Examination Technique. Answers to questions are provided on-line.

  The on-line support of free downloadable answers, Help Sheets and Extension Sheets is now extended to give a much wider range of support. Detailed ‘Specification Maps’ will also be provided once the final specs are approved by Ofqual.

In updating and expanding the very successful earlier editions, we have taken great care to provide a quality textbook. One that is clearly written, strongly supportive, and with a slight touch of humour to present a friendly face of Biology. I hope you will find it a useful and significant support to boost your teaching and enhance your results.

Gareth Williams
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Answers to questions, with Help Sheets and Extension sheets and Revision support, will be on line at: www.biologyforyou.co.uk
**Osmosis in plant cells**

Osmosis is the way in which many living things take up water.

- Water will move into plant cells by osmosis.
- The cell membrane of the plant cell acts as a partially permeable membrane.
- The cell sap inside the vacuole is a strong solution.
- Water passes into the plant cell by osmosis.
- The concentration of the sap in the vacuole is now weaker.
- Water passes from the weak solution into the strong solution in the next cell by osmosis.

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**Experiment 2.4 An osmometer**

You can see the effects of osmosis if you set up this apparatus:

- Fill the partially permeable membrane with strong sugar solution.
- Tie it to a capillary tube and stand it in a weak sugar solution.
- Use your ideas about osmosis to explain why the liquid rises in the tube.

**Turgidity**

When plant cells are placed in water, the water enters the cells. This is because their cell sap contains a strong solution. So water passes into the cells by osmosis. The cell membrane is the partially permeable membrane.

As water enters it makes the cell swell up. The water pushes against the cell wall. Eventually the cell contains as much water as it can hold. It’s like a blown-up balloon. The strong cell wall stops the cell bursting. We say that the cell is turgid.

If you've cut chips and put them into water you will know that they soon go firm. This is because they have taken in water by osmosis and are now turgid.

**Can you think why turgid cells are useful to plants?**

Turgid cells give the plant support. They keep the stems of many plants upright.

But what happens when these cells lose water? The cells are no longer firm and turgid. Plant stems that have lost water wilt.

**Investigation 2.6 Plan an investigation into the effects of sugar solution on potato cells**

You could find out how different concentrations of solutions affect the mass or the length of potato chips. You could also measure the flexibility of the chips. You could find out the effect of temperature on turgidity.

Before carrying out your plan, check with your teacher that it is safe to do so.
**Bacterial diseases**

**Salmonella food poisoning**

Food poisoning caused by *Salmonella* occurs suddenly as a result of the presence of large numbers of bacteria (it is not very virulent). The symptoms occur within 12–24 hours of eating contaminated food. Symptoms include fever, vomiting, diarrhoea and abdominal pain.

*Salmonella* bacteria from an animal’s gut can contaminate other parts of the animal’s body during slaughter and processing. The meat is then chilled or frozen, so little bacterial growth will occur until defrosting. Bacteria may be transmitted during defrosting if any water drips onto other foods and contaminates them. Bacteria can also be transmitted by handling raw chicken. Inadequate cooking accelerates bacterial growth.

Precautions include the adequate thawing of frozen food and thorough cooking. Raw and cooked foods should be stored separately in fridges and the transfer of bacteria from raw to cooked foods via hands, utensils and work surfaces should be avoided by proper handling and cleaning.

**Cholera**

Cholera is a bacterial disease carried in water. It tends to occur in areas where there is a lack of proper sanitation, and unclean water supply or contaminated food. Water supplies become contaminated when infected people pass large numbers of bacteria in their faeces.

Transmission can occur by drinking contaminated water or by infected people handling food or cooking utensils without washing their hands.

The bacteria multiply in the small intestine and secrete a toxin which prevents the normal absorption of salts and water. The symptoms are severe diarrhoea and loss of fluid. Dehydration can cause death if the condition is not treated within 24 hours.

The sufferer can be treated by oral rehydration therapy. This involves the patient drinking a solution of salts and glucose. Treatment is often effective since the glucose takes salts with it as it is absorbed into the blood in the small intestine. When these salts are reabsorbed they cause water to be absorbed by osmosis to make up for the water that was lost in diarrhoea.

Effective treatment of sewage and adding chlorine to drinking water mean that cholera is virtually unknown in developed countries.

**Fungal diseases**

**Rose black spot**

As its name suggests, Rose black spot (*Diplocarpon rosae*), forms black spots all over the foliage (stems and leaves) of rose bushes. If left untreated, this fungal disease can cause a rose bush to totally defoliate. Dark brown to black spots first develop on the upper leaves, which eventually become yellow and drop.

Spraying with a fungicide in early spring, when the leaf buds of the rose bushes start to develop, is often effective. Other control measures include good spacing of planting sites, the use of resistant strains and pruning any diseased stems.

**Barley powdery mildew**

Powdery mildew commonly lowers the yield of barley by 10 to 15%, but it can affect it by 40%. An infestation of the fungus *Erysiphe* will result in poorer, shrivelled grain.

This plant disease spreads in warm, humid weather and wind assists in the spread of its spores. White fluffy structures appear on the leaves, stems and ears of the barley.

With time, black spore cases can be seen embedded in the fungus. The correct use of fungicides combined with a good choice of variety can control the fungus over the growing period of the crop.

**Ash dieback**

In 2012 the beginning of ash dieback was reported in the UK. The cause is the fungus *Chalara fraxinea*, which is thought to have reached England by being blown over the English Channel or imported by nurseries. The fungus leads to a blocking of the xylem vessels. It causes the crown of ash trees to blacken and wither, and can kill younger trees.

Ash is a valuable timber as well as being the sole habitat for around 45 other species. Although there is no known cure for ash dieback, in 2014 scientists announced progress in the development of a new fungicide designed to stop the growth of *Chalara*. Other ways to control it include replacing the infected young trees with a different species and identifying *Chalara*-resistant strains of ash.
Classification
Estimates of the number of different species in the world vary from 3-30 million. So far, over 2 million different kinds of organisms have been described and identified. Scientists have traditionally looked at the differences and similarities between organisms.

The pentadactyl limb
Similarities between organisms may occur because they have evolved along the same lines. For instance, the limb bones of mammals follow a similar pattern known as the pentadactyl limb. Look at the front limb bones of three different species of mammals shown here. Each has one upper limb bone (blue), two lower limb bones (yellow) and five digits (green, numbered 1-5).

So the front limb bones of these three mammals have the same basic plan, but each has evolved along different lines. To obtain evidence from evolutionary relationships, scientists study not only the anatomy of organisms and the fossil record, but also protein structure and the sequence of bases in their DNA.

A hierarchical system
Any system of classification tries to place similar organisms together, and dissimilar ones further apart. Large groups of organisms can be divided into smaller groups. The smallest group is the species. In a hierarchical system, groups are ranked in the smallest group first and ending with the largest. Starting with the smallest group:

- **Species** - a group of similar individuals that can breed freely to produce fertile offspring. For example, Homo sapiens (humans).
- **Genus** - a group of very closely related species. For example, Canis latrans (coyote) and Canis lupus (wolf).
- **Family** - a grouping of similar genera (plural of genus). For example, the buttercup family also includes the cumbine and the larkspur.
- **Order** - a grouping of related families. For example, the falcons.
- **Class** - a grouping of similar orders. For example, all fish.
- **Phylum** - a large grouping of all the classes that share some common features. For example, the arthropods, which includes crabs, spiders, centipedes and insects.
- **Kingdom** - the largest grouping of all. For example plants and animals.

The five kingdoms
The first classification systems were mainly based on a two kingdom plan: the plants and the animals. But there were some organisms that did not fit into either category. For instance, into which group does the single-celled Amoeba fit?

The five kingdom classification is now generally accepted. It recognises two basic cell types: prokaryotes and eukaryotes (animals, plants, fungi and protists).

The three domains
New techniques in biochemistry have helped determine how closely one species is related to another. Large biological molecules such as nucleic acids and proteins are found in all living cells, but they are not identical. These differences can be used to reflect evolutionary relationships. Another grouping called the domain has been suggested.

The domain is a much larger grouping than a kingdom. In 1990, Carl Woese suggested the three domains as a result of a detailed study of RNA. It divides prokaryotes into two groups: the Bacteria and the Archaea.

All other organisms are placed in the third group, the Eukaryotes.

This system of classification emphasises that Bacteria and the Archaea are two distinct groups that arose separately from a common ancestor. (Archaea are primitive bacteria usually living in extreme environments.

Evolutionary trees
Evolutionary trees are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms, and fossil data for extinct organisms.

Look at this evolutionary tree:

The diagram shows six different species: A–F which have evolved from a common ancestor.

Can you see that D and E are the most closely related species because they have evolved more recently than the others? Also species A and B are less closely related to each other than B and C, because B and C share a common ancestor more recently than they do with A.
**Predation**

**Predators** kill other animals (their **prey**) for food. Predators are usually bigger and fewer in number than their prey. Why do you think this is?

Look at the wolf:

What things make it a good predator?
It has sharp teeth and claws, but also its eyes are at the front of the head to judge size and distance.
What other things make predators successful?

- Some hunt in a pack. They work together to catch the prey and share it.
- Attacking prey that is young, old, sick or injured. These prey are easier to overpower and kill.
- This also ‘weeds out’ the weaker individuals in the prey population.
- Catching large prey means that there is more food for the predator per kill.
- Not depending on one particular species of prey. If numbers go down, the predator can switch to another prey species.
- Migrating to areas where the prey is more plentiful.

**Human predators**

Humans still hunt and kill wild animals. The best example is commercial fishing. Improved fishing technology means more fish are caught.
We hunt the fish using powerful fishing vessels, sonar to detect shoals, and huge plastic nets. Fishermen are so well equipped that they could remove all of the fish from the sea.

Many species are now **overfished**. Humans have been such successful predators that future fish stocks are threatened.
International agreements have so far failed to control the amount of fishing.

We should agree quotas on how many fish can be caught. We should avoid fishing during the breeding season and use nets that catch only non-breeding adults, leaving the small fish to survive and breed.

The size of fish stocks is being reduced to such an extent that many are now on the verge of extinction.

**Predator–prey cycles**

Predators try to kill their prey. So obviously they have a big effect on the size of the prey population. But have you ever thought how the number of prey affects the predator?

What would happen to a predator if the animals it fed upon all died of disease? Such drastic events do not happen often. But if the prey becomes scarce, the predator suffers too.

Look at the graph carefully:

1. The prey has plenty of food. It breeds and increases in number.
2. The increase in prey numbers means that there is more food for the predator. So the predator breeds and increases in number.
3. There are now lots of predators so more prey will be eaten. The number of prey goes down.
4. There are now less prey for the predator to feed on. Food will be scarce and many predators starve.
5. With fewer predators, more prey survive to breed. The prey numbers increase, and so the cycle continues.

One of the best-known examples of the predator–prey cycle is that of the lynx and the snowshoe hare.

Both these animals were trapped for their fur. The Hudson Bay Fur Company in Canada kept records of the number of skins that trappers brought in. The graph shows the numbers between 1845 and 1935:

Can you see a pattern in the curves?
Mathematical skills for Biologists

All good Biologists need a basic understanding of mathematical skills. In your examination you will be expected to be able to apply these skills. The following section gives you a summary of the specific skills, together with examples and references to where you can find their use in this book.

Arithmetic and numerical computation

Using decimal form
When Biologists make measurements or carry out calculations with numbers smaller than one they use decimal fractions. They are written with a decimal point, such as 0.568. The digits after the decimal point represent tenths, hundredths, thousandths etc. You can add and subtract decimals in a similar way to whole numbers but you must remember to line up the decimal points.

Using powers and standard form
A number raised to a power is that number multiplied by itself, the same number of times as the power. So $10^3$ is $10 \times 10 \times 10 = 1000$.

We can use powers of 10 in the conversion of units. We could write 2500 mm as $2.5 \times 10^3$ m. This is known as standard form.

In Biology we often use ordinary numbers from 1 to 10 raised to powers, which are often negative. $10^{-3}$ is the same as $\frac{1}{10^3}$, so multiplying an ordinary number by $10^{-3}$ is the same as dividing that number by $10^3$. Negative powers help us to write very small numbers in a convenient way.

To multiply by $10^y$ you simply move the decimal point in the number $y$ times to the right: $8.06 \times 10^2 = 806.0$.

To multiply by $10^{-y}$ you simply move the decimal point in the number $y$ times to the left: $8.06 \times 10^{-2} = 0.0806$.

We can use powers to calculate outcomes in Biology.

Example
Some bacteria can divide and increase in number very quickly. We call this exponential growth (see page 310 for more detail). Starting with a single bacterium, the population doubles in number every hour. After 1 hour there would be two bacteria $(2^1)$, after 2 hours four bacteria $(2^2)$. How many after 24 hours? We can work this out using powers. Using your calculator the key sequence is:

```
2  xy  24  = 2^24
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We can use powers to calculate outcomes in Biology.

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Biology at work: Using monoclonal antibodies

Monoclonal antibodies can be made that bind to specific antigens on cancer cells. This can help doctors to diagnose prostate cancer at an early stage. The PSA blood test detects the presence of antibodies that bind to prostate-specific antigens in the blood.

Monoclonal antibodies are being increasingly used to treat various forms of cancer. Some antibodies attach to the antigens on cancer cells making it easier for the immune system to find them. Other antibodies can be attached to the toxic drugs or radioactive substances used in cancer treatment. These substances stop cells growing and dividing, and the antibody delivers them directly to the cancer cells. Antibodies used in this way help to lessen the side effects of these traditional cancer treatments.

Treatment with monoclonal antibodies can have its own side effects. The most common is an allergic reaction. This can give a range of symptoms including fever, headaches and breathlessness. In rare cases, monoclonal antibody treatments can have more serious side effects, such as heart disease. For this reason a lot of this type of treatment is still experimental.

One of the most familiar uses of monoclonal antibodies is in pregnancy testing kits. The antibodies can be used to detect the presence of human chorionic gonadotrophin (hCG). This is a hormone found in the urine of women in the early stages of pregnancy.

The simplest form of this test uses a dipstick which has a band of antibodies on its surface. When this stick is dipped in a urine sample these antibodies bind to any molecules of hCG that are present.

The hormone and antibody then move up the stick. Eventually it reaches another band of antibodies which also bind to hCG. At this point the combination of antibodies and hCG will show up as a coloured line. This represents a positive result for pregnancy.
GCSE Biology for You is an exciting textbook to help you if you are following any course for GCSE Biology.

Using the same winning style as Gareth Williams’ Advanced Biology for You, it has been carefully designed to help you enjoy Biology and make good progress.

This revised edition will be extensively updated to match the new (9-1) GCSE Biology specifications for 2016, as well as international specifications.

- Topics are laid out as single pages or double-page spreads, in full colour, with helpful diagrams and clear text to make it easy for you to understand Biology and gain success.
- The key points are clearly highlighted, with useful end-of-chapter summaries, and a friendly reading level throughout.
- Examples give you support throughout the course, with a large number of questions for you to practise, helping you to gain confidence and do better in your exams.
- Questions on each topic begin with a simple straightforward question, and there are 7 sections of past exam questions.
- Answers to questions, with Help Sheets and Extension sheets and Revision support, plus specification matching grids will be on-line at: www.biology for you.co.uk
- ‘Biology at Work’ pages enrich your understanding of the many applications and uses of Biology in the real world.
- Additional sections give you help on:
  ✓ Maths skills required in the new specifications
  ✓ practical skills to be tested in your written examinations
  ✓ study skills, revision and exam technique
  ✓ thinking about a career using Biology.