

What is biochemistry?

Biochemistry can be described as ‘the chemistry of life’ and is central to all areas of the biological and life sciences. Biochemists study the chemical processes that take place inside all living organisms – from viruses and bacteria to plants and animals. As the name suggests, biochemistry brings together biology and chemistry, by using chemical knowledge and techniques to help understand and solve biological problems.

What makes biochemistry different to other biological subjects?

Many other biological science subjects are concerned with parts of organisms, whole organisms or even groups of organisms. But biochemistry is different. It considers how things work on a much smaller scale – at the molecular level.

At the molecular level we can examine what happens inside cells. For example how the different components within the cell (such as proteins, lipids and DNA) work together and allow the cell to function. This involves studying processes such as:

- how our cells convert the food we eat into energy
- how important biological molecules are made in our bodies
- how our DNA determines which proteins are made and the effect this has on what we look like and how our bodies function.

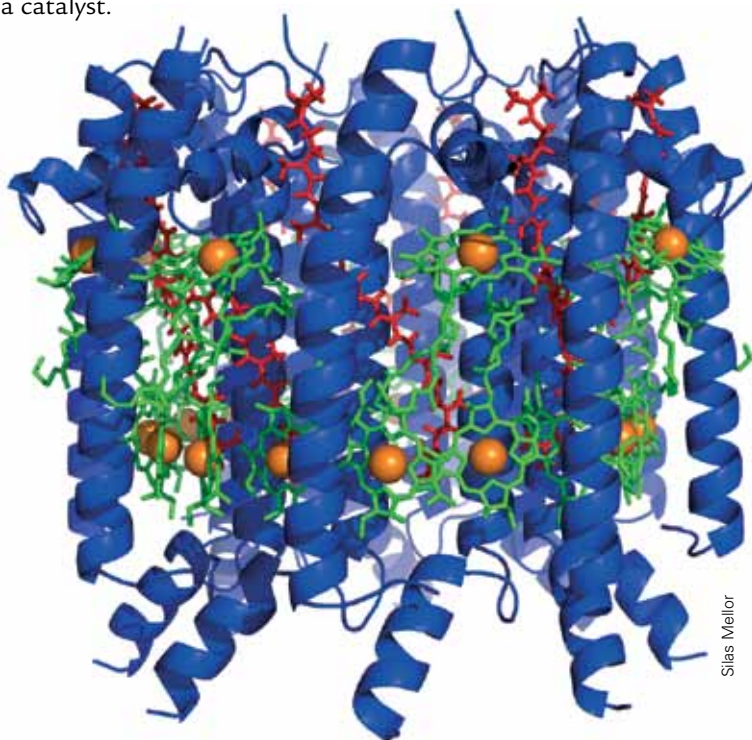
Many of these processes are the same in all organisms – from bacteria to humans!

Communication: Biochemistry also investigates how cells communicate with each other. This helps us to understand how our bodies grow and develop, how our immune system works and how our cells repair themselves when they get damaged.

Structure and function: An important part of biochemistry is understanding how the 3D shape, or structure, of molecules allows them to carry out their role within the cell – for example, how the shape of an enzyme’s active site relates to its specific substrate and allows the enzyme to act as a catalyst.

Key words

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cell functions
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gel electrophoresis



Stiles Mellor

A complex protein from a bacterium. Biochemists study the structure of molecules and complexes to understand how they function within the cell.

This type of information allows us to predict how molecules will function, meaning we can use computers to model how different molecules might interact with each other. This is helpful when designing new medicines – if we know the shape of the molecule in the body that we need to target, then we can try and design a drug that has the right shape to interact with it.

DNA – the blueprint of life

Biochemistry also allows us to decode the genetic information found in our DNA. Genes are small sections of DNA that code for a particular sequence of amino acids which, in turn, form specific proteins. By decoding the information in DNA, we can identify particular genes and the proteins they code for. We can then try and find out what function these proteins perform. All this information helps to enhance our knowledge of how cells work and how processes are controlled.

It also helps us understand what happens when things go wrong, for example when a DNA mutation leads to the production of a faulty protein. Understanding how and why things go wrong allows us to predict how we can fix them and therefore how to treat or cure disease.

The foundation for other life sciences

Since biochemistry allows us to study life at the molecular level, it helps us to understand a wide range of other scientific disciplines. For example, it provides the foundations of genetics, forensics, microbiology, plant science, and even medicine! This breadth makes it difficult to draw a neat border around “biochemistry”, and highlights just how important the subject is.

Biochemical challenges and breakthroughs

So, now we know what biochemistry is, but why is it important? Over the past 100 years, biochemists have been responsible for a huge number of important breakthroughs that have helped to

develop our understanding of living organisms. These discoveries have had a big impact on other areas of science, including environmental science, agriculture, biotechnology, veterinary science and medicine.

One of the most exciting biochemistry-related ventures is the Human Genome Project – described as ‘the largest international collaboration ever undertaken in biology’. The project began in 1990 with the aim identifying every single gene present in human DNA (approximately 20 500!). Although the sequence was completed in 2003, analyses of the data are on-going and have so far revealed new information about things like cancer, allergies and inherited diseases.

Biochemistry has also allowed us to understand the causes of many serious diseases, including sickle-cell anaemia and skin cancer. It has also helped us to develop powerful techniques for diagnosing diseases in patients. For example, by measuring the activity of particular enzymes, or using DNA probes to detect certain genetic disorders.

Biochemistry can also be used to make molecules used in treating diseases. For example, genetic engineering is a technique that introduces a new gene into the DNA of an organism. This can be used to make bacteria capable of producing large amounts of valuable proteins, such as insulin for use in the treatment of diabetes.



Mis-shapen red blood cells like the one on the right may be a sign of sickle-cell disease.



Biochemists help to develop artificial sweeteners to replace sugar.

The biochemistry of everyday life

Biochemistry may be used to study the properties of biological molecules, for a variety of purposes. For example, a biochemist may study the characteristics of keratin (a protein found in hair) so that a shampoo may be developed that enhances curliness or volume.

Biochemists find uses for molecules found in biology (such as proteins, lipids and carbohydrates), in areas like medicine or the food industry. For example, they may add a certain carbohydrate to food to change its texture or flavour – such as pectin, which is used as a gelling agent in jam-making.

Alternatively, a biochemist might find a substitute for common biological molecules. For example, they help to develop artificial sweeteners to replace sugar in your tea or coffee.

Biochemists can help cells to produce new products or provide new characteristics. For example, genetic engineering can be used to introduce a new gene into a plant to make it more resistant to drought. The plant can then be grown in dry areas where crops are difficult to grow and food is scarce.



Wheat seeds treated with bacteria like those growing in this Petri dish are nearly immune to wheat take-all, a root-destroying fungal disease. The sequencing gel in the background shows the genetic code for bacterial enzymes that synthesize natural antibiotics.

Other burning questions

Biochemistry is also helping us to answer many other important questions in biology. For example, what causes cancer? How do embryonic stem cells 'know' which body cells they should develop into? How are memories formed? How do our bodies fight disease? Our understanding of these processes has improved dramatically in recent years, but there is still plenty more to discover.

With all the advancements biochemistry has provided over the past 100 years, who knows what it might offer us in the future.

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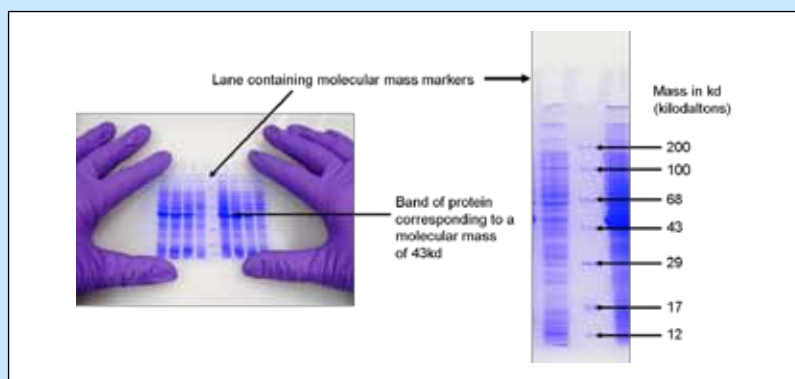


Preparing DNA samples for analysis by gel electrophoresis

Gel electrophoresis: a biochemical technique

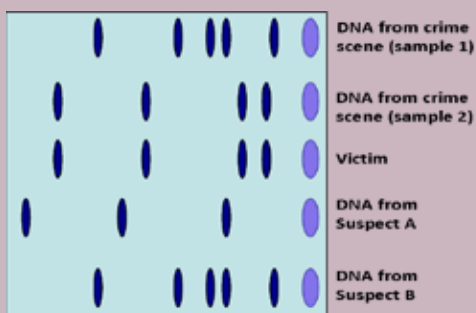
Gel electrophoresis is used to separate pieces of DNA (which may have been sliced into fragments using an enzyme), RNA or protein molecules. The technique uses an electric field applied across a small, jelly-like slab called a gel matrix.

DNA, RNA and protein molecules all bear an electric charge. DNA and RNA have a slight negative charge. Protein molecules can be positive or negative depending on which amino acids they contain. When an electric field is applied across the gel, the molecules move towards the oppositely charged electrode (for example, negatively charged DNA moves towards the positively charged anode).



The gel allows the molecules to be separated on the basis of their size. Smaller, lighter molecules can move more easily and therefore more quickly through the gel.

Once electrophoresis is complete, the molecules in the gel can be stained with a dye to make them visible. The picture shows the result: a series of distinct bands on the gel. Each band contains a molecule (or mixture of molecules) of a particular size that was present in the original mixture.



In this example, eight separate protein samples were used (shown in the eight dark blue lanes). The middle lane shows the molecular mass marker. The bands have been stained with blue dye. Darker bands indicate the presence of a higher concentration of protein. Kilodaltons (kd) are units of mass used for proteins.

Biochemists often load several different samples into adjacent wells in the gel. The separate samples run in parallel in their individual lanes. This allows biochemists to compare the composition of different mixtures. Bands in different lanes that travel the same distance through the gel contain molecules that moved through the matrix at the same speed. This usually means they are approximately the same size. Molecular mass markers (containing compounds of known molecular mass) are used in one lane to help determine the mass of molecules in each sample.

Gel electrophoresis has wide range of applications, including DNA fingerprinting, which is used in both forensics and genetics to compare samples of DNA. The picture shows five DNA fingerprints from DNA found at a crime scene, from the victim, and from two different suspects. Can you work out which suspect was present when the crime was committed? Answer on page 21.

Look here! For further information, see the Biochemical Society's website: www.biochemistry.org/Education.aspx