Questions 31–35

Focusing In on Cells

Cells are the basic building blocks of all organisms. In multicellular organisms, several cells of one particular kind interconnect with each other and perform shared functions to form tissues, such as connective tissue. Tissues combine to form organs – such as the stomach and heart – and several organs together make up an organ system such as the digestive system. Several systems functioning together form an organism, such as a human being. There are many types of cells, and all are grouped into one of two broad categories: prokaryotic and eukaryotic. Animal cells, plant cells, fungal cells and protist cells are classified as eukaryotic, whereas bacteria and archaea cells are classified as prokaryotic.

Cells vary in size, but with few exceptions, individual cells are too small to be seen with the naked eye. For instance, a typical human red blood cell is about eight millionths of a metre or eight micrometres (abbreviated as µm) in diameter; the head of a pin is about two thousandths of a metre (millimetres, or mm) in diameter. This means that approximately 250 red blood cells could fit on the head of a pin. Given their size, scientists use microscopes, instruments that magnify objects, to study cells. Had it not been for the invention of the microscope, scientists would potentially still be unaware of the existence of cells and believe that life spontaneously arises from non-living things.

Modern-day microscopes can be divided into a few main categories. Most of the ones used by students are classified as light microscopes. With these, visible light both passes through and is bent by the lens system to enable the user to see the specimen. Due to the fact that they use two sets of lenses to magnify the image, light microscopes produce an inverted image. That is, a specimen that is right side up and facing right on the microscope slide will appear upside down and facing left when viewed through a microscope, and vice versa. Similarly, if the slide is moved left while looking through the microscope, it will appear to move right, and if moved down, it will seem to move up. Light microscopes commonly used in undergraduate laboratories magnify specimens up to approximately 400 times, but specimens can be magnified up to 1,000 times when oil immersion is used. This makes it possible to study smaller cells, such as most prokaryotic cells. Light microscopes are advantageous for viewing living organisms, but since individual cells are generally transparent, their components are not distinguishable unless they are coloured with stains. This process, however, usually kills the cells.

A second type of microscope used in laboratories is the dissecting microscope. These microscopes are often used to study surfaces because they have a lower magnification (20 to 80 times the object size) than light microscopes. Like light microscopes, most modern dissecting microscopes are binocular, meaning that they use dual lens systems – one for each eye – creating a three-dimensional view of the specimen. Dissecting microscopes also have optics that correct the image so that it appears as if being seen by the naked eye and

not as an inverted image. The light illuminating a sample under a dissecting microscope typically comes from above the sample, but may also be directed from below.

In contrast to light microscopes, electron microscopes use a beam of electrons instead of a beam of light as a source of illumination. Not only does this allow for higher magnification and, thus, more detail, it also provides higher resolving power. The method to prepare the specimen for viewing with an electron microscope kills the specimen. Electrons have short wavelengths (shorter than photons) that move best in a vacuum, so it is not possible to view living cells with an electron microscope. The cost of electron microscopes makes them quite an investment, and they are considerably bulkier than light microscopes.

The microscopes we use today are far more complex than those used in the 1600s by Antony van Leeuwenhoek, a Dutch shopkeeper who had great skill in crafting lenses. Despite the limitations of his now-ancient lenses, van Leeuwenhoek observed the movements of protists (a type of single-celled organism) and sperm, which he collectively termed animalcules. In a 1665 publication called Micrographia, experimental scientist Robert Hooke coined the term cell – derived from the Latin cella, meaning small room – for the box-like structures he observed when viewing cork tissue through a lens. In the 1670s, van Leeuwenhoek discovered bacteria and protozoa. Later advances in lenses and microscope construction enabled other scientists to see different components inside cells. By the late 1830s, botanist Matthias Schleiden and zoologist Theodor Schwann were studying tissues and proposed the unified cell theory, which states that all living things are composed of one or more cells, that the cell is the basic unit of life, and that all new cells arise from existing cells. These principles still stand today.