Chapter 1　Cell Structure and Function

1. Cells are as fundamental to the living systems of biology as the atom is to chemistry.Many different types of cells are working for you right now.
2. All organisms are made of cells.In the hierarchy of biological organization, the cell is the simplest collection of matter that can be alive.
3. Indeed, many forms of life exist as single-celled organist is.Larger, more complex organisms, including plants and animals, are multicellular; their bodies are cooperatives of many kinds of specialized cells that could not survive for long on their own.
4. Even when cells are arranged into higher levels of organization, such as tissues and organs, the cell remains the organism's basic unit of structure and function.
5. All cells are related by their descent from earlier cells.During the long evolutionary history of life on Earth, cells have been modified in many different ways.
6. But although cells can differ substantially from one another, they share common features.

Ⅰ. Microscopy and the tools of biochemistry

A. Microscopy

1. Biologists use microscopes and the tools of biochemistry to studycells

(1) Microscopes were invented in 1590 and further refined during the 1600s.
(2) Studying the inner workings of cells is often the first step in making exciting biological discoveries.
(3) Cell walls were first seen by Robert Hooke in 1665 as he looked through a microscope at dead cells from the bark of an oak tree.

2. LM (light microscope)

(1) In a light microscope (LM), visible light is passed through the specimen and then through glass lenses.
(2) The lenses refract (bend) the light in such a way that the image of the specimen is magnified as it is projected into the eye or into a camera.

3. Three important parameters in microscopy are magnification, resolution, and contrast.

(1) Magnification:
Magnification is the ratio of an object's image size to its real size. Light microscopes can magnify effectively to about 1,000 times the actual size of the specimen; at greater magnifications, additional details cannot be seen clearly.
(2) Resolution
① Resolution is a measure of the clarity of the image; it is the minimum distance two points can be separated and still be distinguished as separate points.
② For example, what appearg to the unaided eye as one star in the sky may be resolved as twin stars with a telescope, which has a higher resolving ability than the eye.
③ Similarly, using standard techniques, the light microscope cannot resolve detail finer than about 0.2 micrometer (μ m), or 200 nanometers (nm), regardless of the magnification.
(3) Contrast:
The third arameter, contrast, is the difference in brightness between the light and dark areas of an image. Methods for enhancing contrast include staining or labelling cell components to stand out visually, shows some different types of microscopy; study this figure as you read this section.

4. Until recently, the resolution barrier prevented cell biologists from using standard light microscopy when studying organelles, the membrane-enclosed structures within eukaryotic cells. To see these structures in any detail required the development of a new instrument-electron microscope.

B. Light microscopy has been revitalized by major technical advances.

1. Labeling individual cellular molecules or structures with fluorescent markers has made it possible to see such structures with increasing detail.

2. In addition, both confocal and deconvolution microscopy have produced sharper images of three-dimensional tissues and cells.
   (1) Finally, a group of new techniques and labeling molecules developed in recent years have allowed researcherg to "break" the resolution barrier and distinguish subcellular structures as small as 10-20 nm across.
   (2) As this super-resolution microscopy becomes more widespread, the images we see of living cells are proving as awe-inspiring to us as van Leeuwenhoek's were to Robert Hooke 350 years ago.
   (3) Microscopes are the most important tools of cytology, the study of cell structure. Understanding the function of each structure, however, required the integration of cytology and biochemistry, the study of the chemical processes (metabolism) of cells.

C. EM electron microscope

1. In the 1950s, the electron microscope was introduced to biology.Rather than focusing light, the electron microscope (EM) focuses a beam of electrons through the specimen or onto its surface.
   (1) Resolution is inversely related to the wavelength of the light (or electrons) a microscope uses for imaging, and electron beams have much shorter wavelengths than visible light.
   (2) Modern electron microscopes can theoretically achieve a resolution of about 0.002 nm, though in practice they usually cannot resolve structurs smaller than about 2 nm across.
   (3) Still, this is a 100-fold improvement over the standard light microscope.

2. SEM
   (1) The scanning electron microscope (SEM) is especially useful for detailed study of the topography of the topography of a specimen
   (2) The scanning electron microscope (SEM) is especially useful for detailed study of the topography of a specimen. The electron beam scans the surface of the sample, usually coated with a thin film of gold.
   (3) The beam excites electrons on the surface, and these secondary electrons are detected by a device that translates the pattern of electrons into an electronic signal sent to a video screen.
   (4) The result is an image of the specimen's surface that appears three-dimensional.

3. TEM

(1) The transmission electron microscope (TEM) is used to study the internal structure of cells. The TEM aims an electron beam through a very thin section of the specimen, much as a light microscope aims light through a sample on a slide.

(2) For the TEM, the specimen has been stained with atoms of heavy metals, which attach to certain cellular structures, thus enhancing the electron density of some parts of the cell more than others.

(3) The electrons passing through the specimen are scattered more in the denser regions, so fewer are transmitted. The image displays the pattern of transmitted electrons.

(4) Instead of using glass lenses, both the SEM and TEM use electromagnets as lenses to bend the paths of the electrons, ultimately focusing the image onto a monitor for viewing.

(5) Electron microscopes have revealed many subcellular structures that were impossible to resolve with the light microscope. But the light microscope offers advantages, especially in studying living cells.

(6) A disadvantage of electron microscopy is that the methods used to prepare the specimen kill the cells. Specimen preparation for any type of microscopy can introduce artifacts, structural features seen in micrographs that do not exist in the living cell.

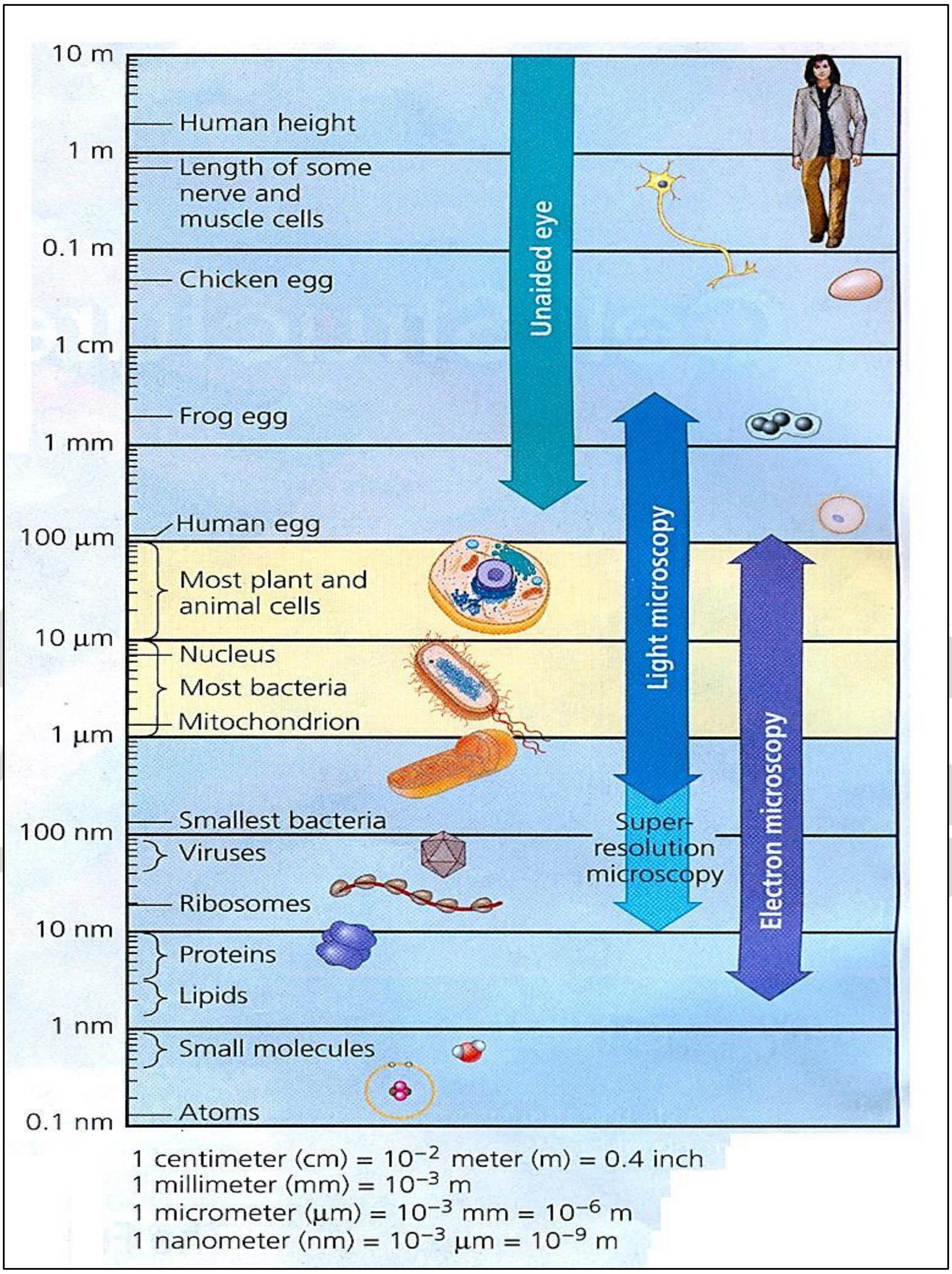

Figure 2

The size range of ceils.Most cells are between 1 and 100 Hm in diameter (yellow region of chart) and their components are even smaller, as are viruses.Notice that the scale along the left side is logarithmic, to accommodate the range of sizes shown.Starting at the top of the scale with 10 m and going down, each reference measurement marks a tenfold decrease in diameter or length.