Resolution and magnification

Making an image larger and distinguishing nearby structures are different achievements. A useful microscope image needs sufficient magnification and resolution.

1. MAGNIFICATION: HOW MUCH BIGGER?

Magnification is the ratio of image size to actual size, using the same length unit. It describes enlargement, not the amount of detail. Doubling the size of a photograph doubles its magnification.

2. RESOLUTION: CAN TWO POINTS BE SEPARATED?

Resolution is the ability to distinguish two close points as separate. Better resolving power allows closer points to remain distinguishable. It is not simply a larger image or a darker image.

THE SAME PAIR OF POINTS, THREE IMAGE CONDITIONS

UNRESOLVED



Two points merge into one patch.

ENLARGED ONLY



The patch is bigger; two points are still not distinguishable.

BETTER RESOLUTION



Two separate points are distinguishable.

Conceptual images, not to scale. The underlying pair of points has not changed.

3. EMPTY MAGNIFICATION

Enlarging an image beyond its captured detail makes existing blur larger. It cannot recover two points that were not resolved. A higher-resolution imaging system can reveal detail that simple enlargement cannot.

Cambridge Biology 9700 syllabus: section 1.1, learning outcome 5, p. 15.

Choose the microscope

Electrons used in electron microscopy have a much shorter wavelength than visible light. This permits finer resolution and reveals cell ultrastructure.

1. LIGHT MICROSCOPE

Visible light and glass lenses

Useful for whole cells and larger cell structures. Suitable preparations can be observed alive. Conventional light microscopy resolves detail down to about 0.2 μm (200 nm), under good conditions.

2. TRANSMISSION EM (TEM)

Electrons pass through a very thin specimen

Reveals internal ultrastructure in a thin section, such as membrane arrangements. A conventional TEM image is a two-dimensional projection through the section.

3. SCANNING EM (SEM)

An electron beam scans the specimen surface

Reveals surface shape and texture, producing a three-dimensional-looking view. It does not show internal cell structures in the same way as a thin-section TEM image.

Conventional biological electron microscopy requires a vacuum and prepared, non-living specimens. Electron micrographs are originally grayscale; displayed colours may be added later. Achievable resolution depends on the instrument and preparation.

Choose the method for the question: living activity, internal ultrastructure, or surface features.

Further reading: OpenStax Biology 2e, 4.1 Studying Cells.

Interpret a resolution limit

A resolution limit is a minimum separable distance. A smaller distance means better resolving power. Always compare distances in the same unit.

WORKED COMPARISON: TWO POINTS 100 nm APART

Illustrative limits: microscope A = 200 nm; microscope B = 2 nm.

A: 200 nm	100 nm is below the limit. The pair is not resolved.
B: 2 nm	100 nm is above the limit. The pair can be resolved under suitable conditions.

B has the smaller resolution limit: 200 ÷ 2 = 100 times finer in this example. This compares resolving distance, not image magnification.

1. CONVERT BEFORE COMPARING

0.2 µm = 200 nm. Two points 0.1 µm apart are only 100 nm apart, so they are closer than a 200 nm limit. Enlarging the captured image cannot supply their missing separation.

2. CONTRAST IS A DIFFERENT PROPERTY

Contrast is the difference in brightness or colour between a structure and its surroundings. Staining may make a structure easier to see, but it does not by itself improve the optical resolving limit.

3. CONNECT THE CLAIM TO THE EVIDENCE

To claim improved resolution, look for close features becoming distinguishable, not merely a larger image. To compare magnification, use measured image size and actual size or a scale bar, not image sharpness.

Key distinction: a structure can be detectable without its fine internal details being resolved. More visible does not always mean more finely resolved.

Cambridge Biology 9700 syllabus: outcome 1.1.5. Numerical comparison by Jimlaoshi.