Specific binding, useful signals

A selected monoclonal antibody binds a particular epitope. This lets a test recognise a target molecule in a complex mixture, or a treatment act on a chosen molecular target.

1. DETECT A DISEASE-RELATED TARGET

An antibody can detect an antigen from a pathogen in a sample, or identify a marker on cells. The antibody supplies recognition; an attached or indirectly linked label makes that binding detectable.

2. A LABELLED-ANTIBODY TEST: THE PRINCIPLE

Bind	A matching antibody attaches to the target in a prepared sample.
Remove background	In a staining assay, washing removes unbound labelled antibody.
Read the signal	A fluorescent marker emits light under suitable illumination, revealing the labelled target.

3. LOCATE AS WELL AS DETECT

Fluorescent antibody staining can show where a target occurs in a cell or tissue sample. Different tests use different readouts: fluorescence, coloured particles or enzyme-generated colour. The label creates the signal; the binding site supplies specificity.

Interpretation matters: a signal must be compared with suitable controls. Detecting a target supports a conclusion about that target, not an automatic diagnosis of every disease.

Fluorescent labels and target localisation: OpenStax, Microbiology 20.5.
Diagnostic binding and detectable signals: OpenStax, Microbiology 20.4.

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 3, p. 31.

Example: an hCG test

A pregnancy test illustrates the same antigen-detection principle used in some disease tests. Its target is the hormone hCG in urine, not a pathogen.

1. LABELLED ANTIBODY BINDS hCG

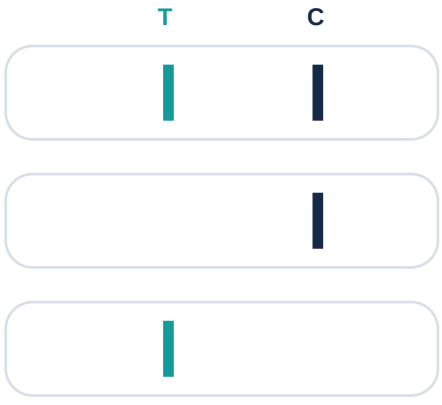
Urine moves along the strip by capillary action. If hCG is present, it binds mobile anti-hCG antibodies attached to coloured particles.

2. CAPTURE AT THE TEST LINE



Fixed antibodies bind another epitope on hCG, trapping the labelled complex. Accumulated coloured particles produce the test line. Boxes show the binding relationship, not molecular shapes.

3. THE CONTROL LINE CHECKS THE TEST



T + C: target detected

C only: target not detected

No C: result invalid

A separate control line captures labelled reagent regardless of hCG. A negative result means no target was detected at the test's sensitivity, not proof that no target exists.

Lateral-flow mechanism and controls: OpenStax, Microbiology 20.4.
Course scope: diagnostic principles; pregnancy is an illustrative application.

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 3, p. 31.

Targeting treatment

Therapeutic antibodies use specific binding to interfere with disease processes or direct an immune response. The mechanism depends on the chosen antibody and target.

1. BLOCK A SIGNAL

Binding to a receptor or signalling molecule can stop a growth-promoting interaction. Some cancer therapies use this principle to reduce uncontrolled cell division. Binding is the targeting step; blocking the signal is the biological effect.

2. MARK CELLS FOR IMMUNE ATTACK

Some antibodies bind surface markers on cancer cells and help immune cells recognise and destroy them. For example, rituximab targets CD20 on B cells, including certain cancerous B cells. CD20 is not found only on cancer cells.

3. DELIVER A CELL-KILLING SUBSTANCE

An antibody can be linked to a drug, toxin or radioactive material. Binding concentrates the linked agent at cells carrying the target. In many antibody-drug conjugates, the complex is taken into the cell and the drug is released.

4. SPECIFIC DOES NOT MEAN RISK-FREE

The target must be present and accessible. Healthy cells may share it, tumours may differ in target expression, and resistance can develop. Treatment can cause side effects; a targeted antibody is not a universal cure.

Diagnosis asks: where is the target, or is it present? Treatment asks: what happens when the antibody binds? Both depend on molecular recognition.

Blocking signals, linked agents and limitations: National Cancer Institute, Targeted Therapy.
Immune targeting and CD20 example: National Cancer Institute, Monoclonal Antibodies.

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 3, p. 31.