

**Radioactive labels**

Tracers (which bind to tumour cells or heart tissue, for example) are linked to a radioactive isotope. They are given a radioactive label, as it were, that is detectable within the body.

**Gamma detector**

A gamma detector consists of a large crystal that emits light when it is hit by gamma rays. An array of photo-detectors at the back records the location of each flash of light in the crystal. If gamma detectors are placed around the patient (or rotated), a computer can construct a three-dimensional image of the radioactive substance's distribution throughout the body.

**Injecting a radioactive label**

The patient (or a mouse) is injected **1** with a small amount of radioactive substance (or this is administered with the food). The substance disperses throughout the body. A scan can be made about one hour later.

Radioactive label

Tracers

**Detecting radiation**

Radioactive substances decay, emitting ionising radiation in the process. This radiation can be measured using special scanners, known as isotope scanners. The radiation reveals where the radioactive labels, hence also the tracers, are concentrated in the body. Cells (for example) at these sites in tissues or organs are taking up more nutrients from the blood than normal healthy cells. This may indicate the presence of tumour cells. Isotope scans can reveal metastases that are not visible on a traditional CT scan.

**Collimator plate**

The radioactive isotope inside the body emits radiation in all directions, so this will intersect with a large area of the detector **2**. This makes it impossible to localise the source of the radiation. For this reason, a collimator (a perforated lead plate) **3** is placed just in front of the detector crystal. Only radiation travelling on a path perpendicular to the surface of this plate can pass through the apertures. A flash of light in the crystal can only be generated by a radioactive source in the patient perpendicularly below that spot in the detector. A single detector cannot measure the depth of the gamma source in the body.

**SPECT-SCANNER**

Scanner used to examine patients

Spect (Single Photon Emission Computerised Tomography) scanners are designed to measure a single gamma photon. Isotopes that are suitable for use in Spect (e.g. technetium or iodine) decay with the emission of a single photon. Spect isotopes have half-lives ranging from a few hours to several days. This technique has a measurement uncertainty of approximately 10 mm.

**U-SPECT**

Special scanner for small animals

Spect scan images have an uncertainty of about 10 mm. While this uncertainty permits effective scans to be made of humans, it is too large for studies of tumours in the brains or livers of mice. U-Spect was developed to produce pin-sharp scans of even very small animals.

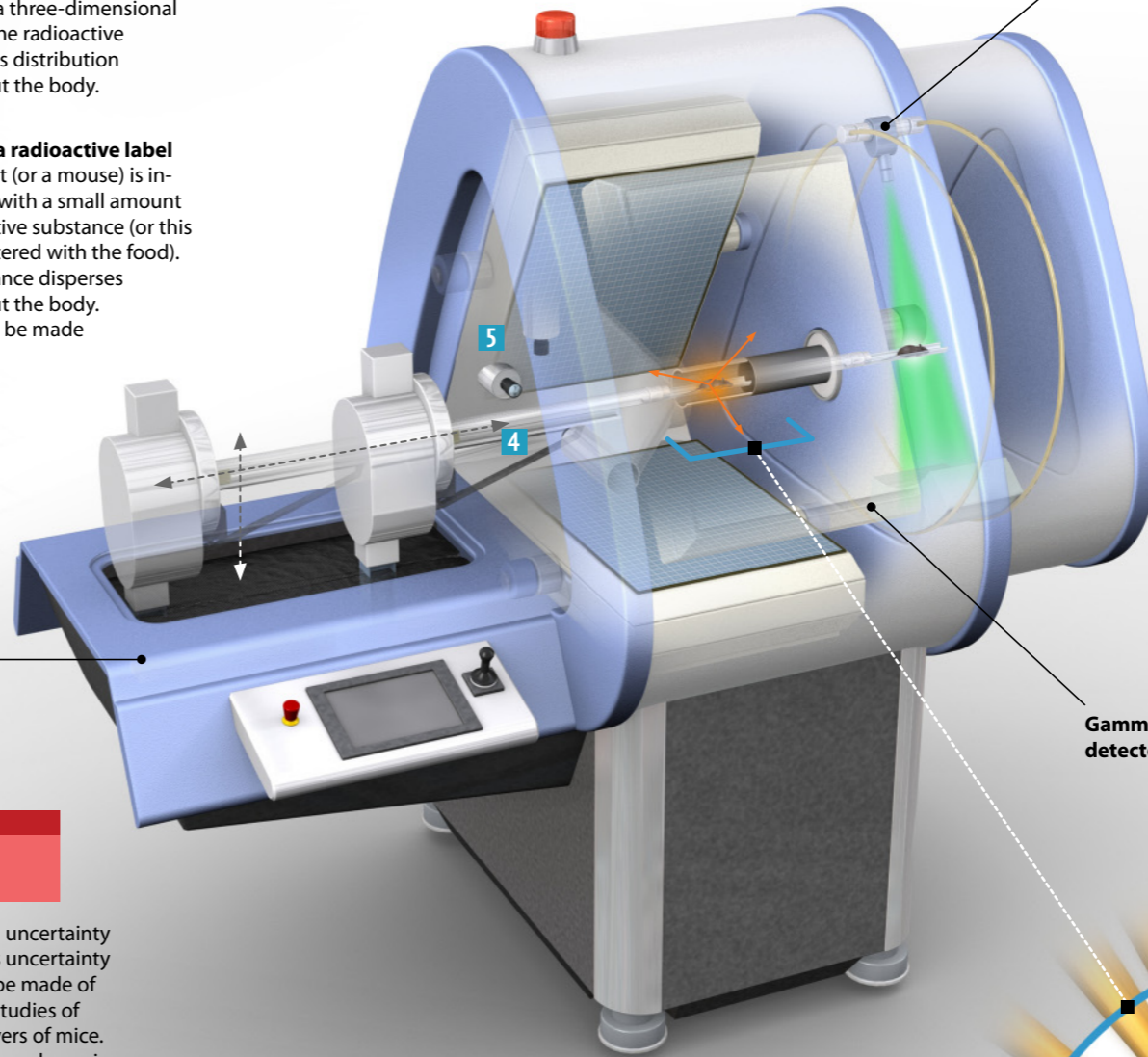
**a Measuring U-Spect: Animal**

A mouse is first injected with a radioactive substance and then anaesthetised. The animal is laid on a heated bed in a container, which is then inserted into the scanner using a mechanical arm **4**.

**b Measuring U-Spect: Measurement area**

The attendant uses three cameras **5** to determine which part of the animal is to be scanned. Each measurement focuses on a cylindrical space measuring 12 mm (diameter) by 8 mm.

X-ray tube



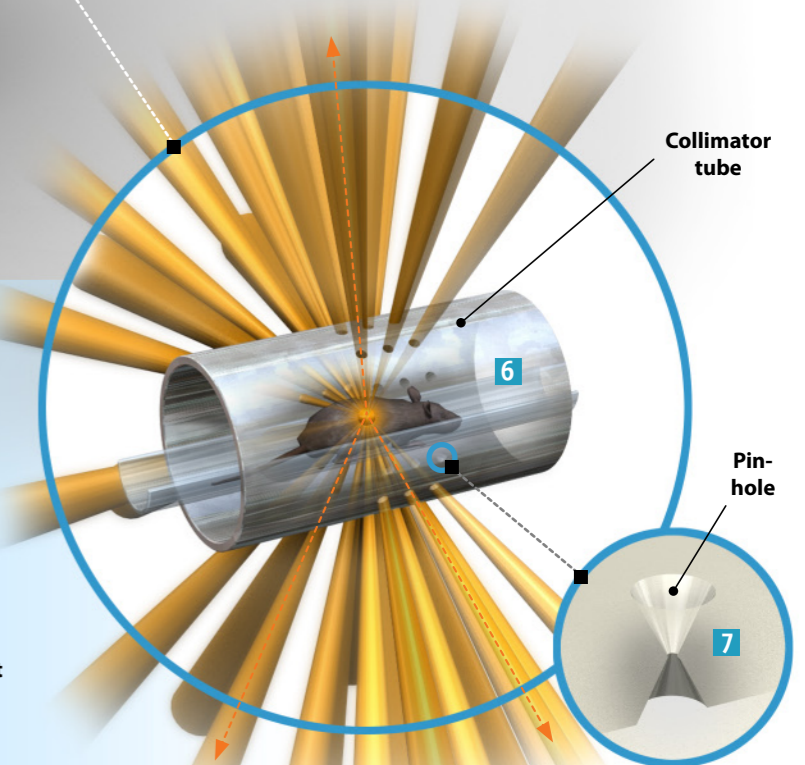
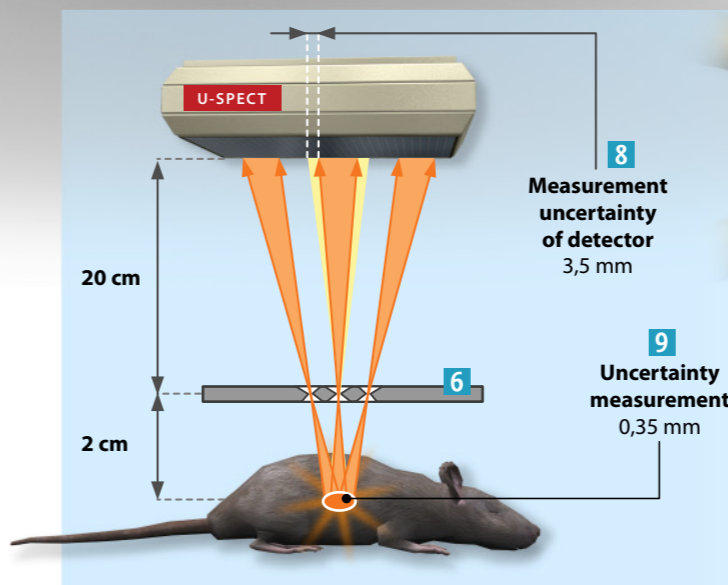
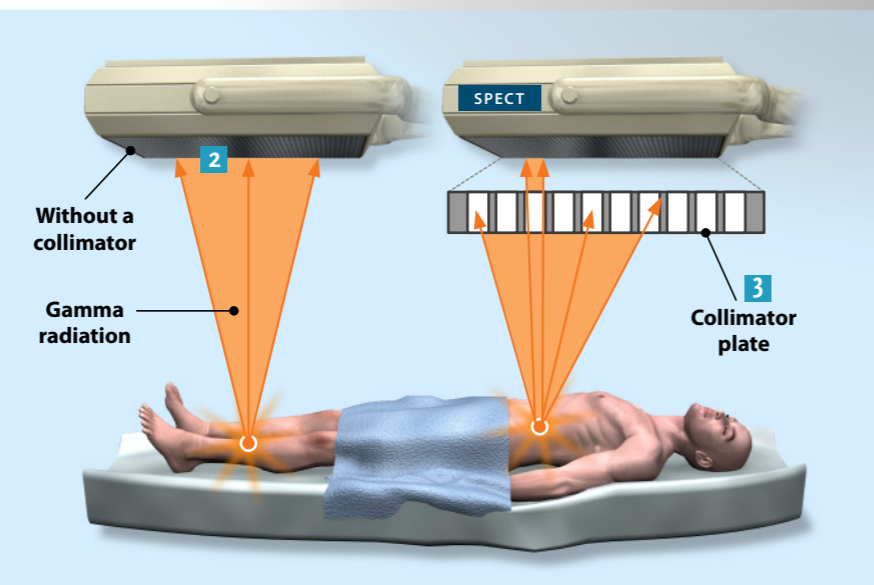
Gamma detector

**c Measuring U-spect: Collimator acts like a magnifier**

In order to increase measurement certainty, the flat collimator plate is replaced by a cylindrical collimator **6** with holes in the sides. Only radiation emitted from a specific area can pass through these pinholes **7**. Each hole functions as a camera obscura, projecting the radiation onto one of three fixed detectors with a measurement uncertainty of 3.5 mm. The magnification factor (about 10) is determined by the ratio of the distances between the animal, the wall of the collimator, and the detector. In this way, the resolution of the U-Spect has improved from 3.5 mm **8** to 0.35 mm **9**. If the position of the mouse is changed relative to the collimator, the radiation in a larger measurement area can be determined.

**d Measuring U-SPECT: CT-scan**

The U-Spect has a built-in CT scanner (a rotating X-ray tube that produces 3D X-ray images), to create a 3D anatomical image showing the Spect (Single Photon Emission) location of the radiation.



**Tumours**

The efficacy of new drugs is tested using mice. For example, the mechanism by which medications bind to tumour cells while ignoring healthy tissue. In order to study this linkage, tumour cells are injected into mice. These animals are later injected with radiolabelled antibodies, which bind to the tumour. An isotope scan will then show whether the antibodies have actually concentrated at the tumour's location (which is known).