Gallium isotopes in medicine

$^{68}$Ga is a radioactive isotope that emits positrons, which are used to produce high-resolution imaging with positron emission tomography (PET). Unlike $^{18}$F, which is most commonly used, $^{68}$Ga is more easily produced using a cost-effective generator with the parent radionuclide $^{68}$Ge (Figure 1). Once produced, $^{68}$Ga easily couples to biomolecules (most commonly peptides) that target G-protein coupled receptors, which are over-expressed on human tumor cells. The labeled protein acts as a radiotracer for cancer diagnostics. PET images are often coupled with CT images to get a more complete picture of the body [252-258]. Radiopharmaceutical $^{67}$Ga is a gamma-emitting isotope used in scintigraphy for medical imaging [259-261].
Fig. 1: Gallium-68 generator used to provide those in engaged in medical therapy with the positron-emitting radionuclide $^{68}$Ga. The parent isotope, $^{68}$Ge, has a half-life of 271 days and can be used as the source of $^{68}$Ga, which has a half-life of only 68 minutes. Image kindly provided by Dr. Anatolii Razbash, Cyclotron Co. Ltd., Obninsk, Russia.
Glossary

atomic number (Z) – The number of protons in the nucleus of an atom.

CT scan (X-ray computed tomography or X-ray CT, computerized axial tomography scan or CAT scan) – a computerized tomography (CT) scan combines a series of X-ray images taken from different angles and uses computer processing to create cross-sectional images, or slices, of the bones, blood vessels and soft tissues inside your body [702].

electron – elementary particle of matter with a negative electric charge and a rest mass of about $9.109 \times 10^{-31}$ kg.

element (chemical element) – a species of atoms; all atoms with the same number of protons in the atomic nucleus. A pure chemical substance composed of atoms with the same number of protons in the atomic nucleus [703].

G-protein coupled receptors – the largest and most diverse group of membrane receptors in eukaryotes (living organisms other than bacteria and archaeabacteria). These cell surface receptors act like an inbox for messages in the form of light energy, peptides, lipids, sugars, and proteins [704].

gamma camera (scintillation camera or Anger camera) – instrument used to track the distribution in body tissue of radioactive isotopes (tracers) that emit gamma radiation (high energy photons), a technique known as scintigraphy.

gamma rays (gamma radiation) – a stream of high-energy electromagnetic radiation given off by an atomic nucleus undergoing radioactive decay. The energies of gamma rays are higher than those of X-rays; thus, gamma rays have greater penetrating power.

half-life (radioactive) – the time interval that it takes for the total number of atoms of any radioactive isotope to decay and leave only one-half of the original number of atoms. [return]

isotope – one of two or more species of atoms of a given element (having the same number of protons in the nucleus) with different atomic masses (different number of neutrons in the nucleus). The atom can either be a stable isotope or a radioactive isotope.

neutron – an elementary particle with no net charge and a rest mass of about $1.675 \times 10^{-27}$ kg, slightly more than that of the proton. All atoms contain neutrons in their nucleus except for protium ($^1$H).

over-expressed – to make too many copies of a protein or other substance, which may play a role in cancer development. [return]

parent radionuclide – a radioactive isotope, commonly in a radionuclide generator, that decays to produce a radioactive daughter. For example, the parent radionuclide $^{99}$Mo decays to $^{99m}$Tc, which is used in radionuclide angiography. [return]
peptides – a molecule consisting of 2 or more organic compounds containing a carboxyl (-COOH) and an amino (-NH₂) group [703].

positron – the antimatter counterpart of the electron, with a mass identical to that of the electron and an equal but opposite (positive) charge.

positron emission tomography (PET) scan – an imaging technique that is used to observe metabolic activity within the body. The system detects pairs of gamma rays emitted indirectly by a radioactive isotope used as a tracer, which emits positrons and which is introduced into the body on a biologically-active molecule. Three-dimensional images of the concentration of the radioactive isotope within the body are then constructed by computer analysis. The imaging often is performed with an X-ray CT scan in the same instrument.

proton – an elementary particle having a rest mass of about $1.673 \times 10^{-27}$ kg, slightly less than that of a neutron, and a positive electric charge equal and opposite to that of the electron. The number of protons in the nucleus of an atom is the atomic number.

radioactive decay – the process by which unstable (or radioactive) isotopes lose energy by emitting alpha particles (helium nuclei), beta particles (positive or negative electrons), gamma radiation, neutrons or protons to reach a final stable energy state.

radioactive isotope (radioisotope) – an atom for which radioactive decay has been experimentally measured (also see half-life).

radiolabeled – a mixture of an isotopically unmodified compound with one or more analogous radioactive isotopically substituted compound(s).

radionuclide – a nuclide that is radioactive [703].

radionuclide angiography (also called gated equilibrium blood pool imaging) – a test using the radioactive isotope $^{99m}$Tc to evaluate the function of the right and left ventricles of the heart by measuring radioactivity over the anterior chest as the radioactive blood flows through the large vessels and the heart chambers.

radiopharmaceutical – radiolabeled compound used for diagnostic or therapeutic purposes.

scintigraphy – see gamma camera.

stable isotope – an atom for which no radioactive decay has ever been experimentally measured.

tracer – substance used for tracking purposes.

X-rays – electromagnetic radiation with a wavelength ranging from 0.01 to 10 nanometers—shorter than those of UV rays and typically longer than those of gamma rays.
References

258. J. Fitzsimmons, and Atcher, R. A method for the chemical separation of Ge-68 from its daughter Ga-68 to produce Ga-68 in a suitable form for nuclear medicine. 2007.