Challenge Title: Radioactivity in our environment	**Duration:** 10-20 minutes
Venue: *Suitable for a classroom. Follow-up work to be carried out at UoM, unless school has Geiger counter available.*	
Number of Participants: Groups of 5 max. Numerous groups to run simultaneously	**Year Group:** Year 9/10
Resources: • Kidney beans • Salt (low sodium) • Banana • Brazil nuts • Water • Coffee • Dishes to put above items in • Descriptions on A4 sheets (included at end of instructions) – need to be cut out. • Geiger counter (if available; or follow-up to be conducted at UoM)	**Health and safety guidance:** • Gloves not required • Potential for Nut/food stuff allergies (See adjacent). Ask students to be aware and disclose any allergies to the session leader. Consult with school/accompanying teacher.

Challenge context: *(what background knowledge do participants need?)*

- Radioactivity describes the processes of radioactive decay.
- Radioactive decay occurs when an unstable 'parent' atom of a particular element (or "radioactive isotope"; e.g. Carbon-14) emits energy or charged particles from the nucleus, allowing it to reach a more stable state known as the 'daughter' atom, which may even be a different element.
- (An isotope is an atom of the same element that has a different number of neutrons.)
- It is these invisible charged particles or energy that form "radiation".
- People are often concerned about radiation because in large doses in can be cause diseases such as cancer or even be fatal. This concern is often made worse because humans cannot see or feel radiation.

- It is a common misconception that radioactivity is artificial.
- All things are made up of atoms, some of which may be atoms of an element which has a radioactive isotope.
- Therefore, we can expect that a proportion of these atoms of a particular element will be radioactive.
- Hence, it is possible that everything is slightly radioactive…even food!

Instructions:

1. **Ask the students to put the items in order of most radioactive to least radioactive**

Tell the students how many are in the correct position and give them a chance to change

*If a Geiger counter is available, allow students to check their answer by measuring the radiation coming off each food.

Answer (NB for Geiger counter, this is usually the correct order though results can be variable!):

Brazil nuts – **most radioactive**

Salt (low sodium)

bananas

Kidney beans

Coffee beans

Water – **least radioactive**

2. **Now ask students to match up the statement to the type of food to describe its radioactivity**

Tell the students how many are in the correct position and give them a chance to change

Answer:

Brazil nuts – can be 1000 times more radioactive than any other food - radioactivity comes from radium which is accumulated by the extensive root system of the tree/plant

Salt - The sodium in this food has been substituted with potassium, some of which is radioactive

Bananas – This food has a unit of radiation dose named after it

Kidney Beans – Rich in the radioactive isotope potassium-40

Coffee beans – Up to 1000 atoms in 1 Kg of this food decay every second.

Water – Radioactive elements in this item are sometimes used as a selling point!

Follow-up task

1. **Calculate the total number of atoms of radioactive potassium in your body.**

Useful information:

The human body typically contains 160 grams of potassium

Atomic mass of potassium = 39 grams

0.017 atoms out of every 100 atoms of potassium in the world are of the radioactive isotope potassium-40

In other words, the 'natural abundance' of radioactive potassium-40 = 0.017 / 100 = 0.000117

The same proportion of all the potassium in the human body is going to be of the radioactive potassium-40.

Hint:

Moles = mass / atomic mass

Number of atoms = Moles X Avagadro's constant 6.022×10^{23}

Number of radioactive potassium atoms = Number of atoms of potassium X natural abundance of radioactive potassium

2. **Now calculate the number of disintegrations of radioactive potassium atoms every second in your body.**

Useful information:

a single atom of potassium-40 undergoes 2.5×10^{-17} decays per second

Hint:

Total number of decays of radioactive potassium atoms every second = Total number of radioactive potassium atoms (from previous question) X number of decays a single atom undergoes per second

Plenary: *(Summary of what students have learnt)*

- Radioactivity is everywhere in the environment
- Even our food is radioactive
- Potassium-40 is the most common radioactive isotope in our food
- Bananas are a rich source of potassium
- Hence bananas are one of the most radioactive foods

- There has even been a unit of dose named after them – "Banana Equivalent Dose"
- Ask the students how many bananas they think you would have to eat to receive the same dose of radiation as:

Tooth x-ray = 40 bananas
Chest x-ray = 100 bananas
Transatlantic flight = 400 bananas

Further reading: (useful websites and information)

http://www.rsc.org/images/number6_tcm18-17768.pdf

Background radiation activity:

http://www.iop.org/education/teacher/resources/radioactivity/file_41559.pdf

Biological effects of radiation

http://www.peep.ac.uk/content/1291.0.html

Ionizing radiation and their properties

http://www.nuffieldfoundation.org/practical-physics/ionising-radiations-and-their-properties

http://www.nuffieldfoundation.org/practical-physics/counting-ions-and-ionisation

About the Author

My name is Ashley Brown and I'm a postgraduate student at the University of Manchester. I graduated from the University with a BSc in Environmental Science and I am now doing a PhD in Radiation Biology. I love how practical my degree is, I get to play with bacteria everyday and zap them with deadly radiation! The fact that this has so many practical applications to how we deal with our nuclear waste makes it all the more interesting!

In my spare time I am a passionate cyclist; both with and without an engine! I love a good challenge, so I am currently preparing to cycle from Lands End to John O'Groats.

Up to 1000 times more radioactive than any other food - radioactivity comes from radium which is accumulated by the extensive root system of the tree/plant

The sodium in this food/drink has been substituted with potassium, some of which is radioactive

This food/drink has a unit of radiation dose named after it

Rich in the radioactive isotope potassium-40

Up to 1000 atoms in 1 Kg of this food decay every second.

Radioactive elements in this item are sometimes used as a selling point!