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# Alternatives to Caesium Irradiators for Biological Sciences and Blood Transfusion Services

To access the report:

<https://www.phe-protectionservices.org.uk/radiationeffects/publications/>

Stephen Barnard, Liz Ainsbury, Simon Bouffler

# Introduction of report authors & areas of work

Stephen Barnard, Liz Ainsbury and Simon Bouffler work in PHE's Radiation Effects Department, carrying out research on cell and animal models of radiation associated diseases and biological dosimetry. Includes work on cataract, leukaemia, radiation cancer mechanisms. – ***we are users ourselves***  
See <https://www.phe-protectionservices.org.uk/services/radiationeffects> and <https://www.phe-protectionservices.org.uk/services/cds>



# Introduction of report authors & areas of work

Tim Daniels, Jon Eakins and Rick Tanner work in PHE's Radiation Metrology Group and bring expertise on radiation sources, including x-,  $\gamma$ - and neutron fields, instrumentation for assessing radiation fields.

See <https://www.phe-protectionservices.org.uk/services/radmet>



# Motivation for producing the report

- Global effort to reduce the number of High Activity Sealed Sources (HASS)
  - reduce threat of inappropriate disposal, theft and malicious use.
- A number of countries have made reductions, notably France, Japan, Norway and parts of the USA.
- JSaRC/Home Office commissioned PHE to write a report to consider specifically the use of  $^{137}\text{Cs}$  irradiators in the biological sciences and in blood transfusion services, and where possible identify reported alternatives.
- A number of current users were consulted with the aim of ensuring a comprehensive coverage of current uses and identification of practical alternatives.

# Structure of the report

1. Introduction
2. Current uses – blood transfusion services, irradiation of experimental animals and cells, botanical uses etc.
3. Characteristics of Cs- and x-ray fields
4. Alternatives for specific purposes
5. Discussion
6. Decision tree to guide selection of an appropriate alternative

# Current uses in the UK

## Blood Transfusion

- Irradiation of blood/blood components to avoid TA-GvHD – about 10% of blood is irradiated prior to use.

## Biological Sciences

- Irradiation and ablation of experimental animals (e.g. rodents) for basic radiobiology, bone marrow and hematopoietic stem and progenitor cell (HSPC) transplantation.
- Irradiation of cells in culture – basic radiobiology, DNA damage response studies, production of feeder cells.
- Sterilisation of reagents, equipment, tissues.
- Botanical uses – insect sterilisation, clearance of pests from seed, generation of new varieties of crop etc.

# Alternatives for Blood transfusion applications

- X-irradiators demonstrated to be suitable alternatives for blood irradiation for the avoidance of TA-GvHD in US, UK and elsewhere.
- Study on blood component irradiation (Meli et al, unpublished) has found x-irradiation to be an acceptable alternative to  $\gamma$ -irradiation for red cell storage.
- UV alternatives increasingly under development but yet to be adopted in the UK.

# Alternatives for animal irradiation - I

- *Generally*, x-rays can be used as a suitable alternative, attention to the x-ray field characteristics is very important – 320 or 220 KeVp irradiators provide the most suitable alternative.
- Guidance on selection of an x-ray alternative is provided in the report and elsewhere (e.g. Zoetelief et al., 2001, Int J Radiat Biol, 77:817-835).
- Purpose-designed x-irradiators for small mammals are commercially available.
- Investigators are encouraged to carry out work to ensure that the selected alternative does perform as well as  $^{137}\text{Cs}$  – *comparison studies*.
- X-ray can act as a reference radiation for RBE studies, occasional access to  $^{137}\text{Cs}$  may be required for a limited range of specific studies (e.g. as a comparator in development of novel radiotherapy modalities).



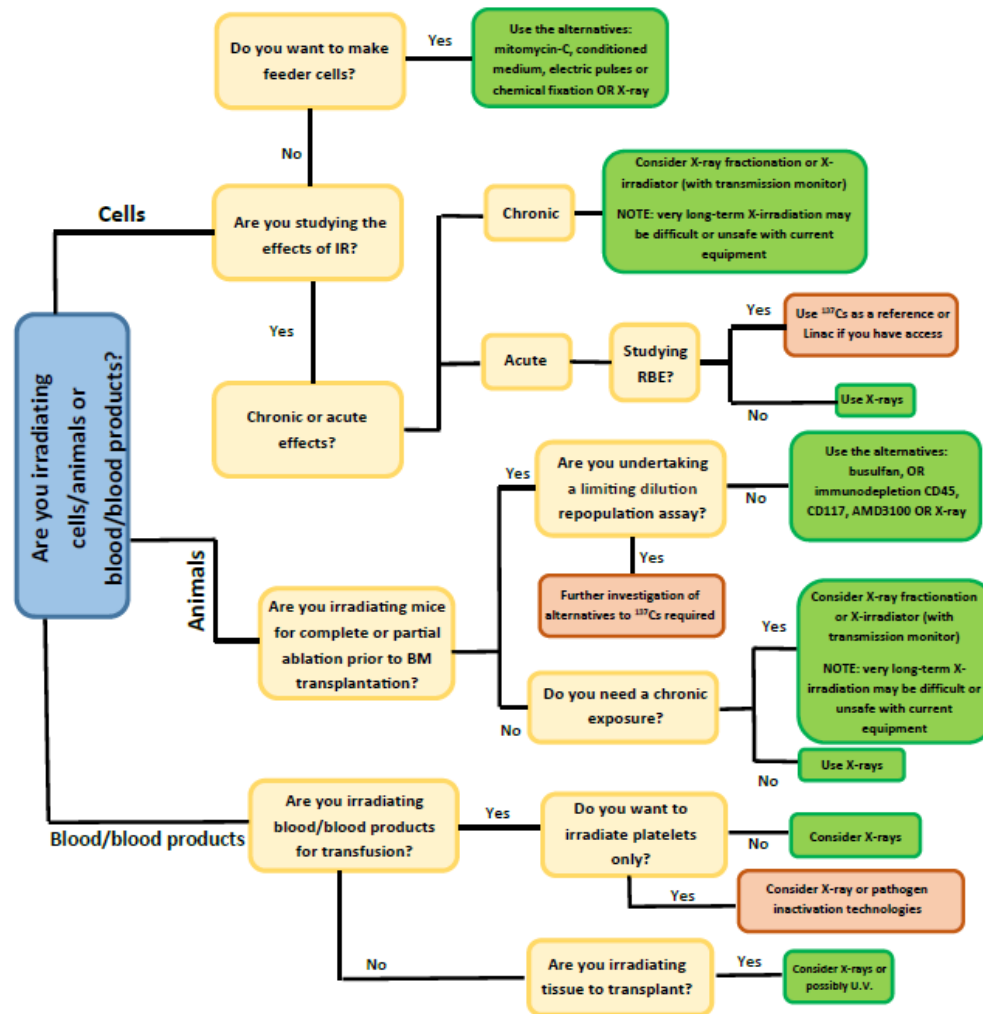
# Alternatives for animal irradiation - II

- *For bone marrow ablation/transplantation, x-ray can be used as an alternative (e.g. Gibson et al. 2015, Comp Med, 651:65-172).*
- Busulfan treatment has shown to be an effective non-radiation ablating agent.
- Immuno-ablation protocols are under development, and are used clinically.
- Where very low numbers of bone marrow/HSPCs are transplanted, most investigators rely on  $^{137}\text{Cs}/^{60}\text{Co}$ , in principle x-ray *should* provide a suitable alternative but further work to establish this is still required.
- Note the caveat on use of x-ray sources for protracted irradiations, the performance of the x-ray alternative in terms of stability, potential overheating, electrical safety etc. must be kept in mind, manufacturers are aware and some are carrying out checks on their machines.

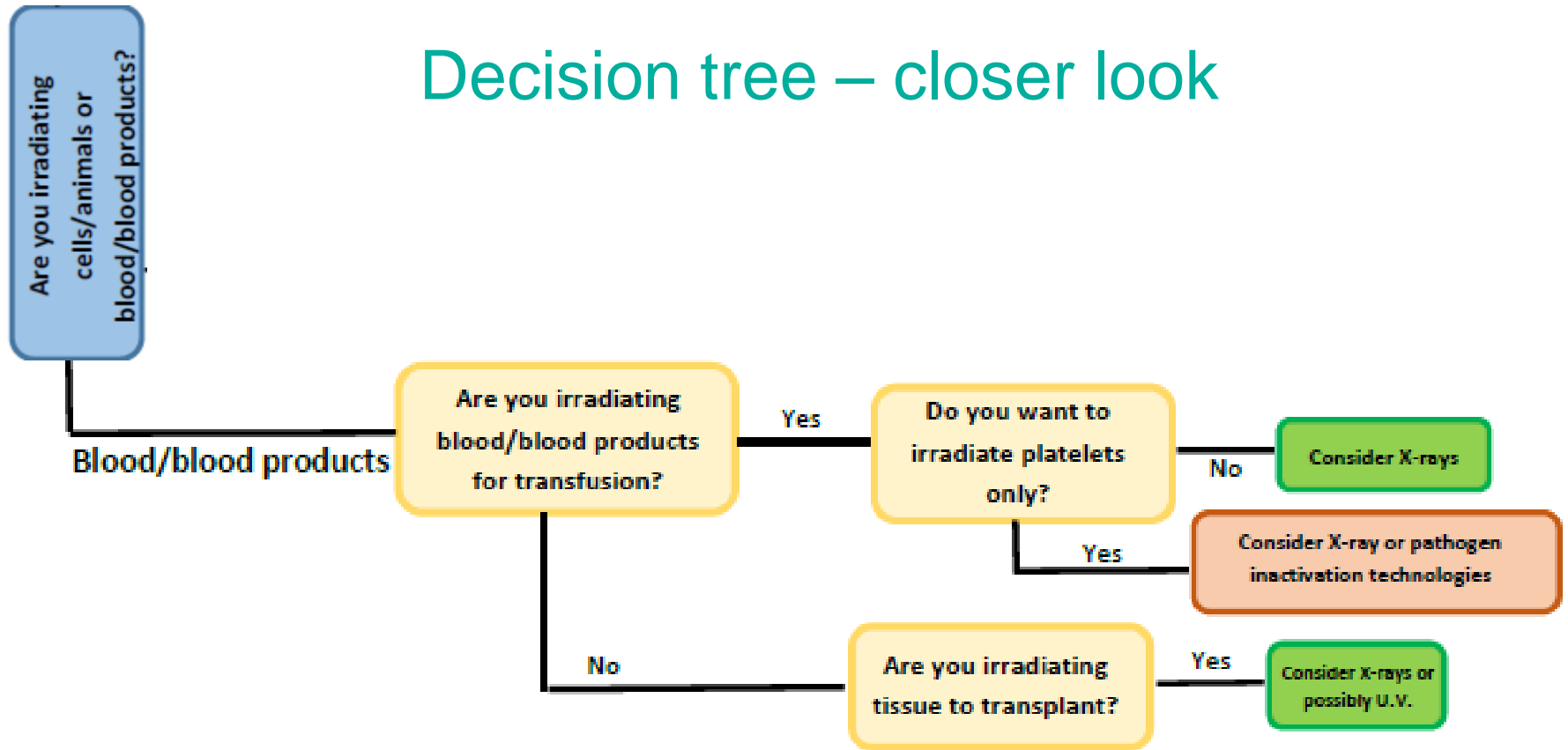
# Alternatives for cell irradiation

- *For production of feeder cells* (during co-culture of stem cells) x-ray has been successfully used. Mitomycin C treatment is an additional validated non-radiation alternative. Less well developed alternatives; ultrashort electrical pulses; fixation with glutaraldehyde etc. reported to prepare good quality feeder cells – inducing intracellular response without affecting cell viability.
- *Generally* x-ray provides a suitable alternative for other applications, again field characteristics are important (as in animal irradiations), particularly where 3D cell culture is used where the degree of penetration of the beam is an important consideration.
- As with animal irradiation studies, RBE determinations may be carried out using an x-ray reference source but for certain limited applications access to  $^{137}\text{Cs}$  remains desirable.

# Decision tree



# Decision tree – closer look



# The report can be accessed:

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**Thank you for your attention**

Questions, comments etc.?

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