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ABSTRACT

The use of radioisotopes in Australia has been surveyed for the year ending 30 June 1971. Questionnaires were sent to licenced medical, industrial and scientific users of radioisotopes. The results of these questionnaires have been used to gauge the extent of the application of radioisotopes in Australia and to forecast likely future requirements.

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The following descriptors have been selected from the INIS Thesaurus to describe the subject content of this report for information retrieval purposes. For further details please refer to IAEA–INIS–12 (INIS: Manual for Indexing) and IAEA–INIS–13 (INIS: Thesaurus) published in Vienna by the International Atomic Energy Agency.

(0) AUSTRALIA; DATA DISTRIBUTION; ISOTOPE APPLICATIONS; ISOTOPE PRODUCTION; PLANNING; RADIOISOTOPES; TABLES;

(1) DIAGNOSIS; DRUGS; IN VITRO; IN VIVO; LABELLED COMPOUNDS: NUCLEAR MEDICINE; RADIOTHERAPY;

(2) AGRICULTURE; BIOCHEMISTRY; BOTANY; CHEMICAL ANALYSIS; EDUCATION; GEOCHEMISTRY; GEOPHYSICS; INDUSTRY; PHYSIOLOGY; RESEARCH PROGRAMS;

(3) GAMMA RADIOGRAPHY; INDUSTRY; IRRADIATION; RADIOMETRIC GAGES; TRACER TECHNIQUES

CONTENTS

1. INTRODUCTION AND PROCEDURE

In 1962 the Australian Atomic Energy Commission, as part of a study conducted among its members by the International Atomic Energy Agency, carried out an Australia-wide survey on the uses and savings arising from radioisotopes in industry during the year 1962. The results were published in IAEA Technical Report Series No. 40.

This has been the only survey carried out in Australia, and a large increase has taken place in the use of radioisotopes in most fields, particularly medical diagnosis, in recent years. The latter necessitated an expansion of the AAEC radiopharmaceutical production laboratories in 1967 and again in 1972.

This report describes a survey of radioisotope use in Australia during the year 1 July 1970 to 30 June 1971. The survey was concerned only with the extent of application of radioisotopes and not with estimates of savings, as in the earlier survey. The present survey also obtained general forecasts of likely future requirements.

The main objectives of the survey were to:

1. Give a measure of progress to compare with future (and earlier) studies.
2. Assist in future planning of the AAEC radioisotope production program.
3. Provide a base for the AAEC information work in this field by locating the individual user and his interests.
4. Disclose factors in the community which at present inhibit the use of radioisotopes in situations where they might be of value.

A questionnaire together with an explanatory letter (Appendix D), was distributed to each licensed user of radioisotopes in the Australian States and to each user in the Australian Capital Territory and Northern Territory. Three different questionnaires were used to cover the medical, industrial and scientific uses separately. The survey did not cover radioisotopes of sub-licensable quantity, as in school demonstration sources. With the aid of a reminder letter where necessary, a very satisfactory overall response of 79% was obtained. The details of the response in each area are given in Table 1. The figures quoted for 1971-72 and 1972-73 in other tables are the totals of the estimates given by the present users. They do not account for the possibility of new users coming into the particular field or new fields yet to commence.

TABLE 1

RESPONSE TO SURVEY

	Medical	Industrial	Miscell-aneous	Total
No. of forms sent out	413	408	546	1367
No. of forms returned	233	301	374	908
Other replies	81	64	30	175
Total replies	314	365	404	1083
Percentage of form replies	56	74	68	66
Percentage of total replies	76	89	74	79

The statistics and comments reported are as received on the questionnaires. No attempt was made to verify the figures by cross check with AAEC or Commonwealth Radiation Laboratory supply records.

Even though the percentage response was very satisfactory, some allowance must be made for the unanswered questionnaires in the quantitative aspects of the statistics. However, it is likely that a large proportion of these will not still be using radioisotopes or are only marginally interested. Almost all known substantial users of radioisotopes gave useful replies.

A full tabulation of results is given in the Appendix with particular summaries also included in the text.

2. RESULTS

2.1 Medical

As shown, (Questionnaire 1 Appendix D) the medical form was divided into several sub-categories; diagnosis, teletherapy, therapy (other than teletherapy), and research.

The overall results for each category are given in Tables A1, A2a, A2b and A3, while Table 2 shows the totals for each of the sub-categories and gives the expected percentage increase in use of the radioisotopes in each of the sub-categories for the next two years. These tables show the extent to which radioisotopes are being used in medical diagnosis and the great expansion expected to take place. This will be further augmented by new clinics planned to begin in the same period.

Occasional duplication and some ambiguity may appear in the tables because categories, etc., were taken directly from the completed forms.

TABLE 2 USE OF RADIOISOTOPES IN MEDICINE

Diagnosis

No. of shipments (70/71)	No. of patients (70/71)	Delivered activity (mCi) (70/71)	No. of doses or tests			Percentage increases	
			70/71	71/72	72/73	70/71-71/72	71/72-72/73
13,309	148,576	338,605	175,629	228,684	265,241	30	16

Teletherapy

Activity (Ci) of ^{60}Co at 1.1.71	No. of patients (70/71)	No. of irradiations			Percentage increases	
		70/71	71/72	72/73	70/71-71/72	71/72-72/73
16,329	7,729	53,442	56,595	58,695	6	4

Therapy (Other than Teletherapy)

No. of shipments (70/71)	Total Activity (mCi) (70/71)	No. of patients			Percentage increases	
		70/71	71/72	72/73	70/71-71/72	71/72-72/73
1,337	22,216	5,461	6,101	6,512	12	7

Research

No. of shipments (70/71)	Total activity (mCi)			Percentage increases	
	70/71	71/72	72/73	70/71-71/72	71/72-72/73
1,209	16,573	20,756	23,684	25	14

NOTE: Figures for 1970/71 refer to actual use. Figures for 1971/72 and 1972/73 are estimates supplied by users.

The results for medical teletherapy show that only a slight increase is expected (10%) over the next two years in the number of irradiations using cobalt 60.

Diagnostic applications of radioisotopes greatly outnumber therapeutic applications and it is anticipated that the latter will not increase greatly in the future. The use of radioisotopes in medical research is also much less than in diagnosis, but should increase greatly in the next two years.

Table 3 shows the expected percentage increases for some important radioisotopes used for in vivo diagnostic applications, over the next two years; viz., technetium-99m (used for organ scanning), fluorine-18 (bone scanning), ytterbium-169 (cerebro-spinal fluid studies), and iodine-131 (thyroid studies).

Developments since the collection of data for this survey now indicate that a technetium-99m polyphosphate complex (Skeltec) will replace the inconveniently shortlived and less effective fluorine-18 for bone scanning. Therefore, all predictions for future increase of fluorine-18 demand are likely to be invalid. Skeltec is also expected to replace strontium-87m and strontium-85 for bone scans.

Table A1 shows that a very wide variety of radiopharmaceuticals and radioactive preparations is used in medicine. It also shows that an increase is expected in the demand for gallium-67, selenium-75, indium-113m and iodine-132 for in vivo medical diagnosis. However, as the use of these radioisotopes is only a small percentage of the total diagnostic use, the changes predicted will not make a significant impact on the overall scene.

Table A1 indicates a very extensive use of labelled hormones (including T3 and T4) for in vitro medical use. It also shows that for in vitro diagnosis there should be a greatly increased demand for tritium-labelled digoxin and folic acid, and for iodine-131 in the form of iodide.

Radioisotope kits are being used extensively and their use is expected to increase in the next few years (Table A1). These kits include T3 and T4 (iodine-125 labelled tri-iodo-thyronine (liothyronine) and thyroxine respectively) for in vitro diagnosis of thyroid disorders, and Dicopac kits (^{57}Co labelled cyanocobalomin bound to human gastric juice and ^{58}Co labelled cyanocobalomin) for the in vivo diagnosis of vitamin B12 malabsorption.

Other types of radioimmunoassays for various steroids and hormones are also coming into widespread use, and kits may be available for these in the near future.

TABLE 3 EXPECTED PERCENTAGE INCREASES FOR IMPORTANT RADIOISOTOPES, USED IN MEDICAL DIAGNOSIS

Compound	No. of Doses or Tests			Percentage Increase	
	70/71	71/72	72/73	70/71-71/72	71/72-72/73
^{99m}Tc					
Pertechnetate (direct)	10,977	16,057	21,552	46	34
Pertechnetate (generator)	2,802	5,100	7,950	82	56
Technetium sulphide colloid	5,289	8,309	11,672	57	40
Macro aggregated ferrous hydroxide (MAFH)	6,152	9,604	14,199	56	48
+Tc-gluconate - tin complex	8	25	50	212	100
*EDTA	20	50	50	150	-
=DTPA	19	75	150	295	100
Total ^{99m}Tc compounds	25,267	39,220	55,623	55	42
^{18}F	532	512	647	-	26
^{131}I compounds	10,209	11,319	12,755	11	12
^{169}Yb compounds	110	442	534	302	21

NOTE: Figures for 1970/71 refer to actual use.
Figures for 1971/72 and 1972/73 are estimates supplied by users.

\+ This product is still in the development stage and the figures do not necessarily reflect the true potential interest.

* Ethylene diamine tetra acetic acid.

= Diethylene triamine penta acetic acid.

These expected increases are highly significant and reflect a strong belief in the benefits derived from these materials in diagnosis.

The following is a selection of typical comments received concerning kits and radioimmunoassays :

1. Radioimmunoassays of hormones will undoubtedly show a sharp increase over the next few years. This is a greatly expanding field in many clinical laboratories.

2. There are recent advances which will permit isotopes to be used for diagnosis without having very complex and expensive equipment. This has already occurred with diagnosis of hyperthyroidism. (T3 kits).

3. Radioimmunoassay to angiotensin I has been developed for measurement of plasma renin activity. A radioimmunoassay to angiotensin II is at present being developed.

4. These kits (T3 and T4) are much more accurate than chemical methods (e.g. protein-bound iodine), because these latter tests are easily affected by exogenous iodine intake.

5. (T3 and T4 kits) allow us to perform in vitro tests of thyroid function in children with greater ease, greater precision and reliability and with minimum labour and time.

6. Radioisotopes have allowed the routine estimation of hormones which was not feasible before.

7. The high sensitivity and specificity of radioimmunoassay is essential for some pharmacological and endocrinological research.

The most significant application of radioisotopes in medicine is probably their use for organ visualisation or scanning, the most widely-used tracer being ^{99m}Tc (Table A1).

Typical comments on this aspect include :

1. Radioisotopes supply clinical information by producing scans of brain, liver, lungs, bones, thyroid, kidney, blood pool, cerebral cisterns, pancreas.

2. The (scanning) results obtained from the technetium compounds have been most satisfactory.

3. Diagnostic tests using radioisotopes are regarded in this hospital as being an essential part of the proper investigation of patients.

From Table A2b, dealing with medical therapy (other than teletherapy), it is apparent that with two minor exceptions, no significant increase can be expected in the demand for radioisotopes in this field in the period covered by the survey.

The exceptions are :

1. Phosphorus-32 labelled orthophosphate for parenteral injection,

where the demand is expected to more than double in two years, although still remaining small.

2. Iodine-131 labelled hippuran for intralymphatic therapy, where the demand should treble but still remain very small.

The figures for radium and radon therapy are lower than they should be, because some users were in doubt as to whether these materials should be classified as radioisotopes.

Some 47 strontium-90 plaques are in use (Table A2b) mainly to reduce the recurrence of pterygia following surgery, and in the treatment of various skin conditions. A reduced recurrence of the former from 30% to 5% or almost nil is typical.

In the use of radioisotopes for medical research, Table A3 shows that a large variety of labelled compounds is used but mostly in small quantities. With some exceptions, there should be little significant increase in the use of individual radioisotopes in this category in the period of the survey, although Table 2 shows that there should be a significant increase in the total use.

The exceptions are, for clinical research, tritium-labelled adenosine monophosphate and some carbon-14 and iodine-125 labelled compounds, while for laboratory research, they include various tritium-labelled compounds, phosphorus-32 labelled orthophosphate, chromium-51 labelled chromate, strontium-85 labelled microspheres, and iodine-125 labelled insulin and IUDR (iodo uridine deoxy ribotide).

Many comments were received concerning the general use and advantages of radioisotopes in medicine, particularly diagnosis, and also some comments and suggestions concerning the supply of isotopes by CRL and others.

These comments are far too numerous to be reproduced in full, but a representative selection is given :

1. Radioisotopes are used for localisation of abnormally situated placenta in ante partum haemorrhage.

2. Radioisotopes are essential in my research which entails monitoring growth rates of tumours in vitro.

3. It would be of great advantage to many workers if ^{125}I labelled compounds and ^{14}C, ^{3}H and ^{32}P labelled compounds were directly available in Australia.

4. The availability of ^{125}I from a local source and hopefully, cheaper, would be advantageous.

5. We find the service very useful and could not operate these laboratory tests without the co-operation received from the Commonwealth Radiation Laboratory.

6. The provision of AAEC short-lived radiopharmaceuticals has been the most important single factor in the rapid development of Australian diagnostic nuclear medicine. In my opinion, the AAEC provides the best such service in the world.

It is most important that close collaborative development continue between the AAEC and specific departments of nuclear medicine. This is a rapidly changing field and for the AAEC to remain amongst the world leaders as innovators and developers of new radiopharmaceuticals, research and development are essential.

7. Radioisotopes have formed the basis of a study of pulmonary embolic disease in patients at this hospital.

8. Isotopes are absolutely essential for our in vitro enzyme work. We would appreciate either - (i) local availability, or, (ii) better co-ordination between local agents and CRL in handling unstable isotopes such as ^{32}P labelled nucleotides.

9. Radioisotope tracer tests represent an advance in precision and facility of diagnosis over previous chemical methods.

10. In all instances, (the use of isotopes) has provided markedly increased diagnostic accuracy. In many cases (they have) provided screening procedures to determine which patients required more hazardous investigations and in others provided information not obtainable otherwise.

Much of the growth has been the result of the introduction of the new radiopharmaceuticals by the Isotope Division, AAEC, with whom we have enjoyed particularly fruitful co-operation in their imaginative development of compounds, which we have urgently required for diagnostic tests.

2.2 Industrial

This category was divided into several sub-categories; viz. radiography, gauging, massive irradiation, tracing and miscellaneous.

Table B1 shows the results for radiography.

The most frequently used radioisotope for this sub-category is iridium-192, and a steady (though modest) increase in demand is expected, from 165 sources in 1970/71 to 192 in 1971/72 and 228 in 1972/73.

Table B1 also shows that the number of cobalt-60 and caesium-137 sources should not increase, but the total activity of cobalt-60 is expected to increase by about 30% for each of the next two years.

Table B2(i) shows the results for gauging, arranged according to the most important types of gauge. The table shows the maximum, minimum, and total activity for each type of gauge and the number of gauges in use for each of the three years covered by the survey.

There is a widespread use of radioisotopes in Australian industry for gauging, particularly density, level and thickness. Table 4 shows the percentage increase expected for these gauges during the next two years.

TABLE 4 EXPECTED PERCENTAGE INCREASE FOR SOME GAUGES DURING PERIOD OF SURVEY

Gauge	No. in Use			Percentage Increase	
	70/71	71/72	72/73	70/71-71/72	71/72-72/73
Level	444	559	621	26	11
Thickness	125	130	142	4	9
Density	478	530	607	11	15

NOTE: Figures for 1970/71 refer to actual use.
Figures for 1971/72 and 1972/73 are estimates supplied by users.

The number of component analysis gauges is expected to increase from 34 to 49 in the period from 1970/71 to 1972/73. The increase is no doubt due, in part, to the development at Lucas Heights, of on-stream analysis gauges and their application to the mineral industry. Borehole logging (particularly for density) is in fairly widespread use and there will be some increase in the next couple of years.

Table B2(ii) gives the radioisotopes and the activity used in gauging in 1970/71. The most frequently used density gauge sources are strontium-90 and caesium-137. For level gauges, by far the most commonly used source is cobalt-60, and for thickness gauges, strontium-90, thallium-204 and krypton-85 are the most frequently used.

Table B2(iii) gives the number of gauges used for various materials. The most frequently gauged material is tobacco, with 242 cigarette density gauges in use in 1970/71. Then follows fly ash (165 level gauges), various ores (98 level gauges and 55 density gauges), sodium aluminate solution (106 density gauges), paper and paper products (50 thickness gauges), geological formations (43 borehole loggers), paper pulp (28 level gauges) and metal strip and coatings (28 thickness gauges).

Radiation is used to sterilise a wide range of materials, for initiating polymerisation reactions and for agricultural research, as shown by Table B3.

By far the biggest user in 1970/71 was Gamma Sterilisation Pty Ltd of Victoria, but on 1 July 1971 another commercial irradiating company, Tasman Vaccine (Aust.) Pty Ltd opened its plant in Victoria to sterilise medical supplies, with an initial loading of 220,000 curies of cobalt-60.

Another commercial plant is now in operation at Matraville (Sydney) and is sterilising medical equipment.

The AAEC has used the excess capacity of its fuel element pond for commercial sterilisation of medical equipment, radiopharmaceuticals, peat, etc., but the requirement will decrease as private plants come into service.

The number of industrial tracing uses of radioisotopes in 1970/71 was not large, as can be seen from Table B4(i), the total of all types being 328. The table shows that an increase in some applications is expected, e.g., isotope dilution analysis, gas flow measurements, leaks in industrial plants, pipeline pig tracing, and sand, silt and effluent tracing, but there will be a decrease in others.

Table B4(ii) gives the breakdown of tracing uses into the number of tests and the activity used for each radioisotope in each category for 1970/71.

In the industrial - miscellaneous sub-category Tables B5(i) and B5(ii) show that, with two exceptions, no significant increase is expected during the next two years.

The main exception is self-luminous signs (beta-lights) which use tritium. In 1970/71, there were some 3,000 of these devices with an activity of 4,800 curies in use in Australia. This activity is expected to increase to 7,100 Ci in 1971/72 and to 10,150 Ci in 1972/73. These devices include industrial exit and other signs, illuminated meter scales, self-powered emergency signs, panel illumination, etc., and they will be in widespread use in the near future. These signs are fully imported and incorporate tritium.

Another miscellaneous application which should increase is the induction of ionisation in neon lamps, in which a minute trace of the radioactive gas krypton-85 is incorporated into neon lamps to reduce the delay in striking, particularly in the dark. The amount of krypton-85 used for this purpose in 1970/71 was 1,000 mCi and is expected to increase to 2,000 mCi in 1971/72 and to 2,500 mCi in 1972/73. Again, however, krypton-85 is not produced at Lucas Heights and this application is therefore of indirect interest only.

Many comments were received concerning the use of radioisotopes in industry. Typical of those concerning gamma radiography were the following :

1. (Radioisotopes) have been invaluable in carrying out field radiography on sites in remote parts of Australia where an X-ray machine would

either have been too cumbersome or would not even have had access.

2. (Radioisotopes) are mainly used in checking the quality of field butt welds in pressure piping used in boiler construction. This has allowed us to maintain higher quality welds by more stringent quality control.

3. Radioisotopes permit in situ radiographic inspections of jet engine internal structure and components, thus effecting considerable savings in manpower, etc., involved in disassembly of engines to perform visual inspection. Serviceability of engines is also improved, since isotope inspections can be quickly performed to satisfy possible doubts regarding structure integrity as shown by performance monitoring.

A wide range of comments was received on the use of isotope gauges of all kinds, most comments were favourable, but a few were unfavourable. The following is a selection from the substantial number of replies received:

(a) Level

1. Due to the adhesive nature of the material handled (liquid polyethylene), level measurement by any other method is impractical, e.g. material adhering to capacitance probes makes them very unreliable and inaccurate. High pressures in the vessels concerned and the nature of the material handled make visual level measurements impossible.

2. This method of measuring acid levels is advantageous for personnel safety.

3. We are reluctant to use this type of gauge due to the inconvenience to workers in wearing film badges and the significant difficulty in controlling the issue and use of badges to shift operators.

4. There is no other effective way of inspecting filled cans at speeds of 1,000 cans/minute.

5. The use of radioisotopes for level detection in our coal bins has not been successful, due largely to the erratic manner in which the coal flows in the bins. Coal in the bin centre sinks below the level of the coal at the periphery making a hole of constantly varying size. This prevents accurate adjustment of the sensitivity level of the indicators and necessitates the use of more primitive but more reliable means of level detection.

6. Because raw sugar is sticky it is difficult to detect level in a bin using conventional means such as a feeler switch, photo-cell or probe. The use of a radiation switch, because no contact is made with the sugar, has proved most satisfactory.

(b) Thickness

(1) The relative thickness of sheets of asbestos cement is easily

measured without touching or stopping the sheets as they are carried along a conveyor.

2. It would not have been possible to measure on-machine substance (i.e. thickness or density) in any other way with existing technology. Thus radioisotope use will be a valuable contribution to eventual computer control of paper and board machines.

3. The use of radioisotopes has enabled us to have a non-contact, accurate measurement of the thickness of sheet steel travelling at speeds up to 4,500 feet/minute. The output signal from such a thickness gauge is used to control automatically the thickness of the strip being rolled. Coating thickness gauges using beta backscatter and X-ray fluorescence principles have provided a means for obtaining immediate readings of zinc coating weight which leads to better control of coating distribution.

(c) Density

1. Continuous scanning of the tobacco rod has enabled a high degree of control on the weight of individual cigarette production, by giving a fast response to weight correction and also a means of monitoring weight deviation of a number of machines at a centralised point for the purpose of an overriding control of machines that are malfunctioning outside the limits of automatic correction.

2. Generally, the application of gamma-ray density gauges has not been particularly successful. This is partly due to application, e.g. gasification in the liquor passing through the pipe section containing the gauge caused instability and erroneous readings. However, in other cases faults appeared to be in the detector, the instrument calibration tending to drift. Checking calibration is another difficulty which limits effectiveness.

3. Close control of slurry density in wet gravity separation plant by means of radioisotopes enables more efficient separation of valuable heavy minerals (rutile, zircon, monazite, etc.) to be made from sand feed.

4. The fluid density gauge is used to measure the density of a sand-slurry mixture flowing in a 10 inch flex. The density is an indication of the proportion, by weight of sand in the slurry. The output of the gauge is used to control this variable by means of an electro-pneumatic transducer and pneumatic control equipment.

5. The use of a radioisotope gauge leads to closer control of the mass flow of suspended solids, resulting in more uniform operating conditions with consequent potential for higher productivity.

(d) Density/Moisture

1. Radioisotopes have enabled the testing time for density and moisture content to be shortened considerably, thus allowing a far greater number of tests and a more extensive evaluation of the road bases involved.

2. Both instruments (density/moisture gauges) were withdrawn from service in 1969 because of repeated component failure, poor repair facilities and generally inaccurate results.

3. The nuclear meter measures the in-place moisture and wet density of soil quickly and non-destructively. Measurements can be taken before and after each soil compaction and the results are immediately available in the field, so that compactive efforts can be quickly evaluated or modified at the job.

(e) Component Analysis

1. This equipment has provided a rapid, safe and accurate method of determining sulphur and lead (in petroleum products).

2. (Radioisotopes are being used for) on-stream analysis for lead and zinc content of slurries in the mineral concentrating process.

3. Radioisotopes have enabled operators to improve concentrating plant efficiency and control through the almost instantaneous indication of percentage lead and density of the lead flotation feed slurry.

(f) Borehole Logging

1. The radioisotopes used in borehole logging for oil and water search in deep boreholes have been of particular benefit in that they can be used in cased holes.

(g) Tracing

1. The radioisotope installation gave progressive patterns of lining wear in the blast furnaces and as this information could be otherwise obtained only by drilling holes around the shell of the furnace during its 4-5 year life, such information would not otherwise be gained. Some changes in operating procedure result from knowledge gained from these installations.

2. Of all the tests undertaken, the pipeline leaks using methyl bromide have been the most impressive as to accuracy against sophisticated sonic and magnetic equipment.

3. The isotope dilution technique allows the determination of the weight of mercury in each individual caustic-chlorine mercury cell, avoiding the necessity to periodically remove mercury from the cell (when shut down) for weighing.

4. Radioisotopes have been used in the area of trouble-shooting and control in industrial chemical plants. The benefits gained are usually in the clarifying and locating of problems such that development and maintenance effort, etc., are directed to the most profitable areas.

(h) Miscellaneous

1. The fire detectors (using radioisotopes) sense products of combustion rather than the more common thermal effect, and therefore provide a very sensitive alarm system.

2. If neon lamps are subjected to an electric current whilst they are in total darkness, they will produce a characteristic delay in emission of a neon negative glow. The use of a radioactive substance eliminates this characteristic completely.

2.3 Scientific, Non-Medical Research and Miscellaneous Uses

Radioisotope users listed many sub categories under this general heading, as seen in Table C1. In this table, only the total activity of each radio-isotope is given - not the activity of each labelled compound of that radio-isotope.

There will be few spectacular increases in this category during the period covered by the survey. Table 5 shows the areas in which a significant increase in demand will occur.

TABLE 5 EXPECTED INCREASES FOR SCIENTIFIC, NON-MEDICAL AND MISCELLANEOUS USES

Category	Isotope	Activity (mCi)		
		70/71	71/72	72/73
Biological Research	^{3}H	12,930	15,658	15,871
	^{14}C	324	392	534
	^{22}Na	1.3	3.7	7.1
	^{36}Cl	2.8	10.2	13.2
	^{75}Se	13	22	47
	^{125}I	144	236	201
Biochemical Research	^{3}H	449	676	687
	^{14}C	88	134	175
	^{32}P	386	491	489
	^{33}P	-	-	100

(Contd.)

TABLE 5 (Contd.)

Category	Isotope	Activity (mCi)		
		70/71	71/72	72/73
Agricultural Research	^{32}P	651	976	1,058
	^{42}K	1	102	451
	^{45}Ca	8	410	415
	^{51}Cr	427	631	635
	^{59}Fe	2	400	401
	^{65}Zn	8.2	415	413
	^{75}Se	-	400	420
	^{86}Rb	66	71	101
	^{125}I	6.6	26	30
Physics Research	^{3}H	20,200	25,200	75,200
	^{46}Sc	20	1,000	-
	^{55}Fe	-	-	20
	^{60}Co	466	2,008	4,010
	^{65}Zn	300	3,000	5,000
	^{75}Se	-	100	-
	^{132}I	-	100	400
	^{153}Gd	20	20	40
	^{238}Pu	60	120	120
Analytical Chemistry	^{125}I	109	122	142
	^{131}I	-	10	30
Veterinary Research & Applications	^{60}Co	-	100	100
	^{198}Au	-	100	100
Tertiary Education and Teaching	^{32}P	66	89	92
	^{57}Co	5.9	17.9	25.9
	^{60}Co	77.9	73.6	5,090
	^{131}I	59.6	85.5	101
	^{241}Am	22.6	32.6	52.7
	^{242}Cm	-	10	10

(Contd.)

TABLE 5 (Contd.)

Category	Isotope	Activity (mCi)		
		70/71	71/72	72/73
Engineering Research	^{24}Na	-	500	500
	^{64}Cu	-	500	500
	^{65}Zn	-	20	20
	^{85}Kr	-	200	200
	^{170}Tm	2	1,000	1,000
	^{182}Ta	-	20	20
	^{192}Ir	-	50	50
Biological Engineering	^{3}H	15,500	1,022,000	1,520,000
Radio-chemical Analysis	^{18}F	-	10	10
	^{131}I	1	20	20
Chemical Research	^{67}Cu	-	10	10
Geochemical/Geophysical Research	^{147}Pm	-	1,000	1,000
	^{210}Po	-	10,000	10,000
	^{238}Pu	-	30	100
	^{241}Am	0.003	10	100
	^{242}Cm	-	400	4,000
	Cm/Be	-	20,000	20,000
Fisheries Research	^{3}H	-	1,010	1,010
	^{46}Sc	-	10	10
	^{51}Cr	-	10	10

NOTE: Figures for 1970/71 refer to actual use.
Figures for 1971/72 and 1972/73 are estimates supplied by users.

As in the other two categories, the comments made on the use of radioisotopes in this category were very numerous. A selection (in various sub-categories) is given below :

(a) Biological Research

1. (Radioisotopes are) essential for virtually all our research work in characterising capacity of whole cells, nuclei or chromosomal material for protein, RNA and DNA synthesis. Also iron isotopes are used as a measure of haem synthesis of red cells in vitro.

2. The ability to trace normal metabolites has led to a much better understanding of sheep physiology. Radioisotopes have enabled us to develop new techniques, e.g. measurement of rate of growth in length of wool fibres by autoradiography, and measurement of mean wool fibre diameter by liquid scintillation counting of wool containing ^{14}C formic acid.

Highly sensitive analytical procedures, e.g. radioimmunoassays, have revolutionised our research on hormones.

The ease of measurement of gamma emitters has speeded up some research by displacing older and slower techniques, e.g. measurement of ^{51}Cr-EDTA in study of digestion in sheep.

3. It is impossible to determine the water requirements of free living animals without radio-labelled water. Animals drinking at a trough containing tritiated water are unaware that they are being marked. Subsequent capture of animals with tritiated body fluids provides movement data on unharassed animals.

4. (Radioisotopes are used) as markers for the characterisation of viral nucleic acids and for the purification and characterisation of animal viruses. The use of radioactive markers has given a new dimension to the scope of our work and has allowed us to obtain readily answers to problems which would otherwise have been impossible.

5. One of the projects of the School of Human Genetics deals with the study of serum transferrin variation in human and non-human primates and in other mammalian populations.

Since transferrin combines specifically with iron, the serum is previously treated with 5-10 μCi/ml ^{59}Fe and subsequently subjected to starch-gel electrophoresis. After electrophoresis, the gel is cut horizontally into two halves, and the cut surface of one half is exposed to Kodirex X-ray film at $-20^{\circ}C$ for 80 to 120 hours.

The film when developed will show only the ^{59}Fe serum transferrin complex. Thus, this procedure provides an excellent means of identifying and confirming various types of serum transferrin.

(b) Biochemical Research

1. Many substances which are important in metabolic reactions are normally present in very small amounts in the cell. The availability of radioisotopes has enabled the labelling of such compounds and has greatly facilitated their identification and estimation. This has been of importance in research problems in the fields of carbohydrate, lipid, nucleic acid and protein biochemistry.

2. Radioisotopes have been used to study metabolism of steroids in the blow fly : Calliphora stygia.

3. (Radioisotopes are used for) rapid elucidation of the pathways of metabolism and excretion of drugs and other xenobiotics in animals, (and they allow) simplification of collection of quantitative data.

(c) Agricultural Research

1. Isotopes are used in a neutron moisture meter to measure soil moisture in irrigation research conducted at this research establishment.

2. Sulphur-35 has enabled estimation of microbial protein synthesis in the complex ecological systèm operating within the paunch of ruminants. Direct estimates of this aspect of metabolism in this situation are virtually impossible without isotopes. Carbon-14 has been used to provide information on the turnover of various pools of metabolites and to assess their importance in the overall metabolic processes occurring in complex natural ecological systems involving bacterial and protozoal populations.

3. Radioisotopes have been used to assist in the assay of circulating hormones in domestic animals either -

(a) in competitive binding assays,
(b) in radioimmunoassays, or
(c) as tracers to measure recoveries.

4. The research program of this laboratory is aimed at understanding the functioning of grazing systems; i.e. the complex relationships between climate, soil, plants, grazing animals, insects, decomposers, etc. Without radioisotopes, much of our program would be impossible.

(d) Physics Research

1. Radioisotopes have been used as a compact source of radiation to excite X-ray fluorescence or to be absorbed preferentially in elements to be analysed. In this way it is possible to use them for on-stream analysis in mineral processing streams.

2. Sources are mainly for Mossbauer and nuclear orientation experiments - which would be impossible without radioisotopes.

(e) Chemical Research

1. We have studied mechanisms of fundamental metal catalysis and surface phenomena by examining rates of exchange in heterogeneous and homogeneous catalysis. We have also developed unique methods for labelling compounds with tritium for biological research.

2. Carbon-14 labelled sucrose has been used in this laboratory to determine accurately sucrose concentration in mill and refinery products using

the isotope dilution technique. This is, at present, the only accurate and precise reference method for these determinations. The method has also been used to measure the effect on the sucrose content of materials of various processes within sugar mills and refineries.

(f) Veterinary Research and Applications

1. The use of radioisotopes has enabled us to study the physiology and pathology of host-parasite relationships, and to gather information not easily obtained by non-isotopic techniques.

2. (Treatment with a ^{90}Sr plaque) is the only satisfactory treatment for squamous cell carcinoma of the bovine orbit. The only other treatment is surgical ablation of the orbit with consequent blindness and deformity. Treatment of some twelve cases (including one very advanced case) so far has been uniformly successful and the sight has always been preserved.

Several users indicated that the supply of a greater range of labelled compounds in Australia would be very useful, e.g. ..."It would be convenient for us if there were a supply of carbon-14 in Australia. All our previous supplies have come from overseas."... ..."The availability of radioiodine labelled bovine serum albumin and gamma globulin would facilitate blood volume work in this species."

Some were highly critical of the cost of imported radioisotopes, e.g., ..."The availability of some ^{35}S labelled inorganic compounds in Australia would be helpful. The handling charges and freight and insurance costs frequently triple the overseas price of these compounds - as they do for ^{14}C labelled biochemicals as well."

One user mentioned the opposition encountered from a health authority to the use of a radioisotope: ..."Krypton-85 was tested as a tracer to measure gas flow in gas distribution mains. Resistance was encountered from local health authorities and a non-radioactive tracer was used instead."

CONCLUSION

The survey has met with a sufficiently good response for the resulting information to be regarded as authoritative and reliable.

It has brought to light a number of applications which are interesting in themselves, and quantitative results which will be valuable in future planning. No serious weaknesses have become apparent in the method followed.

The survey should be repeated at intervals of, say, five years.

APPENDIX A

Results are tabulated of Questionnaire 1 :

Medical Uses

The categories are

1. Medical Diagnosis
2a. Medical Teletherapy
2b. Medical Therapy (other than teletherapy)
3. Medical Research.

TABLE A1 MEDICAL DIAGNOSIS

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vivo	^{3}H	water	4	47	59.5	47	44	48
		pyridoxine	3	40	20	40	40	40
		digoxin	3	68	0.0003	68	200	200
		hormonal	2	22	1.2	22	75	125
	^{14}C	folic acid	1	-	0.05	-	-	-
	^{18}F	fluoride *	391	541	2,230	532	512	647
	^{24}Na	solution *	26	26	26	26	10	10
	^{32}P	phosphate *	33	33	21	33	37	47
	^{35}S	thiamine	3	40	4	40	40	40
	^{35}S	sulphur injection	2	4	2	4	-	-
		sulphate	12	80	120	80	80	80
	^{42}K	solution *	10	10	10	10	10	10
	^{47}Ca	chloride	7	10	0.14	10	13	17
	^{51}Cr	chromate	597	1,096	664	1,173	1,519	1,866
		chloride	57	89	22.3	97	98	128
		albumin	4	4	0.2	4	8	16
	^{57}Co	vitamin B12	102	1,141	14.7	1,387	2,925	3,068
	^{58}Co	vitamin B12	104	149	12.46	180	177	294
	^{57}Co ^{58}Co	vitamin B12 and I.F. (Dicopac kits)	55	174	0.22	174	236	286

* Normally available from Isotope Division, AAEC

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vivo	^{59}Fe	chloride (Fe^{3+})	11	15	0.34	15	20	43
		citrate (Fe^{3+})	77	160	2.82	195	235	280
		hydroxide (Fe^{3+})	12	12	0.24	12	13	14
	^{64}Cu	chloride *	3	2	20	3	3	4
	^{67}Ga	citrate	4	4	12	14	90	170
	^{75}Se	selenomethionine	148	244	68.4	235	508	815
	^{82}Br	bromide *	10	10	10	10	-	-
	^{87m}Sr	citrate	188	206	1,199	207	320	436
	^{99m}Tc	pertech. (direct)*	2,227	10,932	240,866	10,977	16,057	21,552
		pertech. (generator) *	154	2,763	7,112	2,802	5,100	7,950
		sulphide colloid *	2,619	5,541	35,108	5,289	8,309	11,672
		macro aggregated ferrous hydroxide *	2,411	6,030	31,045	6,152	9,604	14,199
		+gluconate - tin complex*	-	6	-	8	25	50
		ethylene diamine tetra acetic acid	2	10	-	20	50	50
		diethylene triamine penta acetic acid *	10	19	314	19	75	150
	^{109}Cd	chloride	1	1	0.5	1	1	2
	^{111}In	chloride	20	20	120	20	45	90

\+ This is still in the stage of clinical evaluation. Its potential for renal studies is very good and the future use should be larger than indicated here when it becomes generally known and available.

* Normally available from Isotope Division, AAEC.

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vivo	^{113m}In	acid (eluate)	232	312	2,186	312	425	3,250
		chloride	101	1,011	1,906	867	1,326	1,596
		^{113m}In particles	2	51	50	51	50	100
	^{125}I	iodide	32	215	113.3	259	312	362
		insulin	20	3,029	0.29	3,029	3,040	3,050
		human serum albumin	55	213	5.19	256	298	328
		fibrinogen	70	319	61.4	319	415	432
		human growth hormone	12	3,600	0.04	3,600	3,600	3,600
		hippuran	4	20	2	20	40	60
	^{131}I	fibrinogen	29	61	28.75	62	20	50
		macro aggregated albumin	95	83	98	84	10	10
		iodide *	1,078	8,037	5,794	8,637	9,545	10,613
		thiosulphate	38	50	20.2	42	50	50
		human serum albumin	283	420	139.1	490	420	428
		Rose Bengal	10	12	9.6	12	69	124
		hippuran	233	560	170	573	875	1,115
		iodide in saline	55	301	8.7	305	330	360
		insulin	1	5	0.5	4	-	5
	^{131}Cs	chloride	55	205	262	125	275	350
	^{132}I	iodide	12	20	250	20	50	250

* Normally available from Isotope Division, AAEC

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vivo	^{133}Xe	-	44	-	1,197	-	-	-
	^{169}Yb	diethylene triamine penta acetic acid	38	90	181	89	401	473
		chloride	11	11	11	11	11	11
		ethylene diamine tetra acetic acid	36	30	36	10	30	50
	^{197}Hg	chlormerodrin	276	417	2,200	418	449	524
		bromo mercuric hydroxy propane	5	4	4.4	4	-	-
	^{198}Au	colloid	109	262	509	262	356	407
In vitro	^{3}H	digoxin	3	20	0.5	20	510	750
		nucleotides	3	10	2	12	22	7
		testosterone	7	345	6.5	375	760	910
		aldosterone	1	-	0.1	350	500	650
		androstene-dione	3	-	2.5	-	70	130
		acetic anhydride	9	136	3.8	410	700	800
		epinephrine	3	12	0.08	12	50	75
		norepinephrine	2	12	0.005	12	50	75
		estradiol	3	50	4	52	62	62
		hormone labelled cortisol	8	2,000	3.5	4,010	5,010	9,520
		progesterone	3	50	2.25	50	70	120

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vitro	^{3}H	corticosterone	2	2,000	2	2,000	2,005	2,505
		pregnanediol	1	-	1	-	10	10
		prednisone	1	-	1	-	10	10
		prednosolone	1	-	1	-	10	10
		folic acid	-	-	-	-	200	1,000
		inorganic chemical	1	-	100	-	-	-
		organic chemical	3	-	5	-	-	-
		hormonal	3	50	5	200	300	400
	^{14}C	progesterone	1	50	0.1	50	50	100
		aldosterone	4	136	0.003	410	700	800
		norepinephrine	2	3	0.001	3	-	-
		hypoxanthine	2	80	0.2	110	100	100
		guanine	1	40	0.1	55	50	50
		adenine	1	40	0.1	55	50	50
		hormone labelled	7	800	4.04	1,600	2,500	4,600
		estradiol	1	50	0.05	50	50	50
		testosterone	2	100	0.15	100	110	120
		androstene-dione	1	-	0.25	-	10	20
		glyceryl trioleate	1	-	0.5	-	100	100
		leucine	10	400	4	400	600	600

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vitro	^{14}C	acetic anhydride	1	-	2	300	500	800
		organic chemical	4	-	1	-	-	-
	^{35}S	-	-	150	24	150	150	150
	^{51}Cr	sodium chromate	16	36	1.06	7	10	10
		chromic chloride	1	1	0.26	1	1	1
	^{57}Co	vitamin B12	42	5,025	0.54	4,394	3,992	5,297
	^{58}Co	vitamin B12	21	27	0.029	27	130	235
	^{59}Fe	ferric chloride	35	530	5.6	740	760	860
		"Ferronex"	6	100	0.002	150	250	300
	^{64}Cu	acetate	6	8	60	80	-	-
	^{125}I	T3 kits	354	42,294	-	53,909	67,840	80,146
		T4 kits	217	24,832	-	31,344	42,370	50,626
		sodium iodide	52	10,360	3,086	3,650	3,936	4,042
		insulin	55	2,294	-	4,990	4,190	4,400
		angiotensin	15	100	0.08	300	370	450
		human serum albumin	2	-	0.01	2	5	5
		renin	4	64	0.04	210	300	400
		human growth hormone	17	264	-	644	844	944
		thyroxine binding globulin	-	50	0.03	100	120	120
		hormone labelled	79	1,792	86	12,360	15,200	18,400

TABLE A1 MEDICAL DIAGNOSIS (Contd.)

Type	Radio-isotopes	Chemical Form	No. of shipments (1970-71)	No. of patients (1970-71)	Delivered Activity (1970-71) (mCi)	No. of doses or tests		
						1970-71	71-72	72-73
In vitro	^{131}I	human serum albumin	5	2	0.05	2	5	8
		sodium iodide *	18	5,000	376	376	2,476	3,376
		hormone labelled	24	400	480	2,000	2,000	2,000
Total for diagnosis, in vivo plus in vitro			13,309	148,576	338,605	175,629	228,684	265,241

NOTE: Figures for 1970/71 refer to actual use.
Figures for 1971/72 and 1972/73 are estimates supplied by users.

* Normally available from Isotope Division, AAEC

TABLE A2a MEDICAL TELETHERAPY

Activity (Ci) of ^{60}Co at 1.1.71	No. of patients (70-71)	No. of irradiations		
		70-71	71-72	72-73
16,329	7,729	53,442	56,595	58,695

TABLE A2b MEDICAL THERAPY (OTHER THAN TELETHERAPY)

Type	Radio-Isotope	Chemical Form	1970-71		No. of patients		
			No. of shipments	Total activity (mCi)	70-71	71-72	72-73
Plaque	^{90}Sr	-	(no. of plaques) 47	1,144	3,414	3,686	4,022
	Radium	-	1	20	-	-	-
Parenteral Injection	^{32}P	orthophosphate *	30	157	30	41	71
	^{131}I	sodium iodide *	44	586	59	59	34
Oral	^{125}I	sodium iodide	23	185	15	20	25
	^{131}I	sodium iodide *	390	8,288	648	800	869
	^{131}I	sodium thiosulphate*	94	1,662	172	159	160
Implant	^{90}Y	Y_2O_3 seeds *	14	463	4	5	6
	^{90}Y	microspheres	2	20	2	5	5
	^{192}Ir	rods *	-	-	-	10	20
	^{198}Au	grains, seeds *	6	435	6	8	10
	Radon	Gold capillary, needles brass tubes	52	1,743	71	81	95
	Radium	tubes, needles	12	1,033	64	82	93
Clinical	^{32}P	orthophosphate *	64	290	62	72	79
	^{131}I	sodium iodide *	316	1,592	306	333	353

* Normally available from Isotope Division, AAEC

TABLE A2b MEDICAL THERAPY (OTHER THAN TELETHERAPY) (Contd.)

Type	Radio-Isotope	Chemical Form	1970-71		No. of patients		
			No. of shipments	Total activity (mCi)	70-71	71-72	72-73
Intravenous Injection	^{32}P	Orthophosphate *	88	403	94	103	114
	^{131}I	sodium iodide *	12	315	13	14	15
Intracavitory	^{32}P	chromic phosphate	6	55	6	7	9
		sodium orhtophosphate colloid	20	120	20	20	20
	^{60}Co	-	70	-	57	57	57
	^{137}Cs	-	58	-	57	57	57
	^{222}Rn	-	-	1,500	211	211	211
Insertion	^{60}Co	-	-	40	3	3	3
	^{137}Cs	tubes	-	-	11	14	18
Intralym-phatic	^{131}I	hippuran	3	120	3	6	9
Interstitial	^{32}P	phosphate	16	100	16	20	20
Afterloading	^{198}Au	seeds *	3	260	3	3	3
	^{222}Rn	seeds	5	175	5	5	5
Mould	Radon	-	3	1,230	103	114	125
Surface Mould	^{60}Co	-	5	200	5	5	3

* Normally available from Isotope Division, AAEC

TABLE A2b MEDICAL THERAPY (OTHER THAN TELETHERAPY) (Contd.)

Type	Radio-Isotope	Chemical Form	1970-71		No. of patients		
			No. of shipments	Total activity (mCi)	70-71	71-72	72-73
Intrapleural	^{198}Au	-	1	80	1	1	1
Total for Therapy			1,337	22,216	5,461	6,101	6,512

TABLE A3 MEDICAL RESEARCH

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Clinical	^{3}H	cholesterol	2	2	2	2
		sitosterol	2	0.5	0.5	0.5
		palmitic acid	8	7	7	7
		mevalonic acid	1	2	1	1
		AMP (hormone labelled)	3	10.5	25	27
		aldosterone	-	-	0.25	-
		prostaglandins	3	3	12	15
		hormone labelled	3	0.77	1.55	3.1
		thymidine	6	70	70	70
	^{14}C	glucose	8	2.6	1	1
		cholic acid	1	0.05	0.25	0.25
		cholesterol	2	0.5	0.5	0.5
		palmitic acid	8	4	4	4
		mevalonic acid	1	0.1	0.2	0.2
		(di) phenylalanine	1	250	500	500
		glycine	3	0.8	0.8	0.8
		hormone labelled	2	0.02	0.03	0.04
		aldosterone	-	-	0.25	-
	^{14}C & ^{3}H	miscellaneous	16	16	16.1	16.5
	^{22}Na	-	2	10	10	10
	^{32}P	dyflos (di-isopropyl fluorophosphonate)	12	24	36	36

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Clinical	^{32}P	adenosine triphosphate	-	-	6	8
		phosphate	2	1	-	-
	^{35}S	bromosulphophthalein	2	4	4	4
	^{47}Ca	$Ca\ Cl_2$	-	-	1	2
	^{51}Cr	labelled erythrocytes	-	-	2	3
		chromate	40	544	522	522
		chloride	2	350	500	500
	^{59}Fe	citrate	13	2.3	2.3	2.3
		chloride	31	491	401	401
	^{63}Ni	chloride	2	2	2	3
	^{68}Ga	ethylene diamine tetra acetic acid	1	2	-	-
	^{75}Se	selenomethionine	1	1	1	1
	^{125}I	fibrinogen	4	2	-	-
		Rose Bengal	1	1	1	1
		bromosulphophthalein	2	2	2	2
		human serum albumin	11	2.5	5.5	5.5
		hippuran	2	2	-	-
		thyroxine binding globulin	12	10	20	30
		liothyronine	12	10	20	30
		uridine	4	5	5	5
		hormone labelled	47	77	127	427

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Clinical	^{125}I	urinary chorionic gonadotrophin	12	24	72	72
		iodide	13	49	49	49
	^{131}I	albumin	25	250	250	250
		hormone labelled	25	250	250	250
		fibrinogen	-	-	50	100
	^{133}Xe	in saline	20	20	-	-
Animal	^{3}H	thymidine	1	5	10	10
		cyclic adenosine monophosphate	1	0.25	1	-
	^{14}C	carbohydrate	2	100	100	100
	^{59}Fe	salt	-	-	10	10
	^{125}I	insulin	1	5	5	-
	^{169}Yb	diethylene triamine penta acetic acid	5	10	10	10
Laboratory	^{3}H	3,4 dihydroxyphenyl ethylamine	-	1	1	-
		choline	2	2	1	1
		cholesterol	-	-	10	10
		toluene	-	1	1	1
		folic acid	4	4	8	20
		aminoacids	19	27	38	41
		steroids	15	7.25	9.25	12.25
		adenosine monophosphate	4	1	2.5	2.5
		thymidine	80	338.8	673	598

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^3H	nucleotides	11	23.3	31	31
		metabolites	2	10	10	10
		5 hydroxy tyramine	1	5	20	20
		ethanolamine	1	1,000	1,000	1,000
		5 hydroxy tryptamine	-	-	10	10
		nucleic acid	-	-	10	10
		adenosine triphosphate	2	1,000	2,000	3,000
		uridine	11	119	177	177
		purine bases	1	2	4	4
		phenylalanine	3	1.5	2.5	3
		isonicotinic acid	2	2	4	4
		adrenaline compounds	2	5.5	7.3	14.3
		5 - adenosyl methionine	-	0.25	0.5	-
		labelled hormones	12	11.1	15.1	26
		urethane	2	45	45	45
		acetylcholine chloride	-	-	1	1
		lysine	3	15	20	20
		aspartic acid	4	7.5	7.5	7.5
		digitoxin	-	-	1	-
		digoxin	-	-	-	1
		water	14	364	367	372

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{3}H	isoprenaline	1	-	1	-
		hexadecane	1	-	0.8	-
		purines	-	-	-	20
		element	-	2,600	2,600	2,600
		puromycin	-	1	1	1
		acetic anhydride	-	25	25	25
		cortisol	1	1	1.5	2
		lipids and precursors	-	-	3	3
		testosterone	2	1.25	1.75	2.25
		glucose	2	26	25	30
		leucine	9	11	11	11
		uracil	11	25	25	25
		sorbitol	2	2	3	4
		sodium borohydride	1	100	150	200
		proline	2	7	3	3
		adenine	2	10	10	10
		acetate	-	-	25	25
		fluorodinitrobenzene	1	0.25	0.25	0.25
		p-aminobenzoic acid	1	5	5	5
		glycerol trioleate	2	30	30	30
		guanosine triphosphate	2	2	2	2

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{3}H	uridine triphosphate	1	0.25	0.25	0.25
		ℓ - glutamic acid	1	0.25	0.25	0.25
		ℓ - arginine	1	5	5	5
		glycine	1	1	1	1
		N-acetylglucosamine	1	1	1	1
		α-aminobutyric acid	1	0.25	0.25	0.25
		dimethyl sulphate	1	1	1	1
		estradiol	1	0.25	0.25	0.25
		progesterone	1	0.25	0.25	0.25
		corticosterone	1	0.25	0.25	0.25
		cortisone	1	0.25	0.25	0.25
	^{14}C	protein	1	0.1	-	-
		fatty acids	-	-	5	5
		amino acids	36	12.5	21.3	54.3
		nucleotides	1	1.4	2.4	2.4
		steroids	7	3	4	4
		metabolites	11	1.5	1	1
		uridine	3	6.1	102.2	102.2
		adenosine triphosphate	4	0.46	0.16	0.60
		adenosine monophosphate	2	0.04	0.03	0.05
		andrenaline compounds	-	0.2	0.2	0.1

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{14}C	tyramine HCl	-	0.1	0.2	0.2
		toluene	-	0.2	0.2	0.2
		choline chloride	-	0.2	0.2	0.2
		lactate	1	0.1	0.1	0.1
		acetyl choline chloride	-	-	0.1	0.1
		thymidine	3	1.6	2.6	4.1
		urethane	1	2	2	2
		D-glucosamine	2	0.2	0.3	0.3
		aspartic acid	3	0.35	0.35	0.35
		ethanol	2	40	40	40
		methanol	1	2	2	2
		butanol	1	10	10	10
		propanol	1	10	10	10
		bicarbonate	1	5	5	5
		methionine	7	0.65	5	10
		leucine	14	7.9	8	8
		orotic acid	-	-	0.1	0.2
		glyceric acid	2	0.07	0.05	0.05
		glycerol	1	0.02	-	-
		fructose	1	0.02	-	-
		glucose	11	12.2	2.6	14

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{14}C	purines	1	0.06	0.2	0.2
		guanine	2	0.2	-	-
		labelled hormone	6	6	10	15
		acetic acid	2	1.1	-	-
		lipids and precursors	1	0.15	5	10
		putrescine	-	0.05	0.2	0.2
		barium carbonate	-	-	3	3
		adenosine diphosphate	3	600	1,200	1,200
		ethanolamine	2	1,000	1,000	1,000
		uracil	10	20	20	20
		ℓ-proline	1	0.3	0.4	0.7
		adenine	3	0.25	0.25	0.3
		glycine	3	0.3	0.4	0.5
		adenosine	3	0.5	0.5	0.5
		protein hydrolysate	2	0.35	0.6	0.6
		xylose	2	0.25	0.25	0.3
		pyruvic acid	6	1	0.5	1
		sorbitol	1	0.1	0.1	0.2
		nicotinamide	1	0.01	0.01	0.01
		glutamic acid	2	0.1	0.1	0.1
		succinic acid	1	0.05	0.05	0.05

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{14}C	citric acid	1	0.05	0.05	0.05
		malic acid	1	0.05	0.05	0.05
		1-valine	1	0.25	0.25	0.25
		p-aminobenzoic acid	1	0.5	0.5	0.5
		sodium glyoxalate	1	0.1	0.1	0.1
		phosphatidylcholine	1	0.005	0.005	0.005
		1-tyrosine	2	0.15	0.15	0.15
		naphthalene	1	0.1	0.1	0.1
		methyl iodide	1	0.1	0.1	0.1
		β-sitosterol	1	0.05	0.05	0.05
		iodoacetamide	2	0.15	0.15	0.15
		guanosine triphosphate	1	0.01	0.01	0.01
		phthalic anhydride	1	0.1	0.1	0.1
		uridine diphospho galactose	1	0.01	0.01	0.01
		iodo acetic acid	1	0.1	0.1	0.1
		n-ethylmaleimide	1	0.05	0.05	0.05
		sodium pyruvate	1	0.25	0.25	0.25
		citric acid	1	0.25	0.25	0.25
		alanine	1	0.3	0.3	0.5
		inulin	1	0.1	0.2	0.2
		mannitol	1	0.1	0.1	0.1

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{14}C	ornithine	1	0.1	0.1	0.1
		tryptophan	1	0.1	0.1	0.2
		shikimic acid	5	1.05	1.05	0.05
		lysine	7	0.85	11.5	12
		kidney clearance measurement	1	2	-	-
	^{22}Na	chloride	2	0.7	1	1
	^{24}Na	chloride *	-	-	400	400
	^{32}P	phosphate *	31	1,407	1,668	2,278
		nucleotides	2	1.25	0.25	0.25
		dyflos (di isopropyl fluorophosphonate)	-	0.6	0.6	0.6
		adenosine triphosphate	1	1	2	4
		lipids and precursors	-	-	1	1
		bacteria	10	120	150	150
	^{35}S	sulphate	8	220	221	231
	^{36}Cl	chloride	2	0.13	0.15	0.2
	^{42}K	chloride *	-	-	40	40
	^{45}Ca	chloride	3	42	22	22
		element	2	2,000	2,000	2,000
	^{47}Ca	-	2	0.05	-	-
	^{51}Cr	chromate	35	149	208	684
		chloride	-	15	30	30

* Normally available from Isotope Division, AAEC

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{51}Cr	live cells	-	-	30	30
	^{57}Co	vitamin B12	6	60.2	60.3	60.3
	^{59}Fe	citrate	16	4.46	4.46	6.46
		chloride	4	3.7	3.6	4.0
		ferrous ascorbate	2	100	-	-
	^{64}Cu	chloride *	1	10	10	10
	^{74}As	arsenate	1	1	1	1
	^{75}Se	selenomethionine	3	3	3.5	3.5
	^{85}Sr	microspheres	1	1	5	5
		chloride	1	0.5	-	-
	^{86}Rb	inorganic	1	10	15	15
	^{123}I	iodide	8	400	500	600
	^{125}I	hormone labelled	22	110	110	110
		proteins	18	82	115	160
		angiotensin I	-	10	24	24
		iodide	90	694	783	886
		iodine	6	73	95	85
		human serum albumin	2	2.3	4.3	4.3
		insulin	5	0.081	0.001	10
		iodo uridine deoxy ribotide	-	-	50	50
		thyroxine	3	0.6	0.6	0.6

* Normally available from Isotope Division, AAEC

TABLE A3 MEDICAL RESEARCH (Contd.)

Type	Radio-isotope	Chemical Form	No. of shipments (70-71)	Total activity (mCi)		
				1970-71	71-72	72-73
Laboratory	^{131}I	labelled antibody or labelled protein antigen	14	73	75	110
		iodide *	55	595	891	958
		serum albumin	4	4	8	8
		iodine	-	45	10	10
	^{195}Au	chlorauric acid	1	1	2	2
	^{198}Au	colloidal gold	4	100	200	200
		Totals for Research	1,209	16,573	20,756	23,684

* Normally available from Isotope Division, AAEC

APPENDIX B

Results are tabulated of Questionnaire 2 :
Industrial Uses

The categories are

1. Radiography
2. Gauging
3. Massive Irradiation
4. Tracing
5. Miscellaneous

TABLE B1 GAMMA RADIOGRAPHY

	^{60}Co			^{192}Ir			^{137}Cs			Totals		
	70/71	71/72	72/73	70/71	71/72	72/73	70/71	71/72	72/73	70/71	71/72	72/73
No. of sources	23	21	23	165*	192	228	4	4	4	192	217	255
Min.source activity (Ci)	0.20			3.0			0.25					
Max. source activity (Ci)	15.0			30.0			4.0					
Total activity (Ci)	79.4	101	134	3,103	3,817	4,493	7.0	6.8	6.5	3,189	3,925	4.633
No. of radiographs	28,385			144,440			2,164			174,989		
No. of radiography units	20			85			4			109		

* 83 sources were of activity 20 - 29 Ci
42 " " " " 10 - 19 Ci
30 " " " " 0 - 9 Ci
10 " " " " >29 Ci

Note: Figures for 70/71 refer to actual use.

Figures for 71/72 and 72/73 are estimates supplied by users.

TABLE B2(i) GAUGING

Type of Gauge	Activity (70/71) (mCi)			Number of Gauges		
	Max.	Min.	Total	70/71	71/72	72/73
Level	5,000	0.3	34,009	444	559	621
Thickness	1,200	2.5	16,151	125	130	142
Density	5,000	0.1	61,094	478	530	607
Moisture	300	5	1,028	7	9	9
Borehole logging	5,000	1.7	128,495	49	52	58
Component analysis	30,000	0.1 μCi	56,300	34	42	49
Portable isotope fluorescence	1,000	1	2,678	13	13	13
Gamma switch	28	2	99	6	8	8
Other	4,000	0.5	8,028	17	18	18

Note: Figures for 70/71 refer to actual use.
Figures for 71/72 and 72/73 are estimates supplied by users.

TABLE B2(ii) GAUGING

Type of Gauge		Radioisotope (No. in use and total activity) (mCi) (70/71)											
		^{3}H	^{60}Co	^{85}Kr	^{90}Sr	^{109}Cd	^{137}Cs	^{147}Pm	^{204}Tl	Radium (or Ra/Be)	^{238}Pu	^{241}Am (or Am/Be)	Other
Level	T.A.		13,446		10		15,036	5,000		17		500	
	No.		407		1		24	1		4		7	
Thickness	T.A.		20	1,869	8,562		40	50	570			5,040	
	No.		2	23	55		2	1	36			6	
Density	T.A.		1,712		4,629		54,713				30		10
	No.		27		244		205				1		1 (Tm170)
Moisture	T.A.									28		1,000	
	No.									4		3	
Borehole logging	T.A.		600				28,870					99,025	
	No.		1				24					24	
Component analysis	T.A.	450	4			35	7,000	47,905			320	300	286
	No.	2	1			2	1	14			6	2	6 (^{55}Fe, ^{63}Ni, ^{125}I, ^{153}Gd (2) ^{210}Pb)
Portable isotope Fluorescence gauge	T.A.					2		2,501			150	20	
	No.					1		4			5	2	
Gamma switch	T.A.		99										
	No.		6										

TABLE B2(ii) GAUGING (Contd.)

Type of Gauge		Radioisotope (No. in use and total activity (mCi)) (70/71)											
		^{3}H	^{60}Co	^{85}Kr	^{90}Sr	^{109}Cd	^{137}Cs	^{147}Pm	^{204}Tl	Radium (or Ra/Be)	^{238}Pu	^{241}Am (or Am/Be)	Other
Other (Dens/Moist 10, Thick/Level 1, Weighing 3, Lab gauge 2, Ash content 1)	T.A.	4,000					374			3,524		130	
	No.	1					6			8		2	

TABLE B2(iii) GAUGING

Type of Gauge	Material Gauged	No. of Gauges 1970/71	
Level	Fly ash	165	
	Various ores	98	
	Paper pulp	28	
	Petroleum products	24	
	Coal	23	
	Caustic liquor	19	
	Cement	19	
	Fertiliser	14	
	Liquid carbon dioxide	11	
	Beverages	9	
	Catalyst	5	
	Molten steel	5	
	Copper flue dust	4	
	Miscellaneous	20	
			444
Thickness	Paper and paper products	50	
	Metal strip and coatings	28	
	Plastic film and sheet	22	
	Glass	11	
	Asbestos cement sheeting	5	
	Wax coating	4	
	Miscellaneous	5	
			125
Density	Tobacco	242	
	Sodium aluminate solution	106	
	Mineral ores and slurries	55	
	Coal	19	
	Sand slurry	18	
	Petroleum products	9	
	Sewage	7	
	Asbestos cement slurry	3	
	Miscellaneous	19	
			478
Moisture	Miscellaneous	7	
Borehole Logging	Geological formations	43	
	Formations in oilwells	6	
			49

TABLE B2(iii) GAUGING (Cont.)

Type of Gauge	Material Gauged	No. of Gauges 1970/71	
Component analysis	Minerals	7	
	Rock samples	7	
	Sulphur in fuel oil	5	
	Compounds by absorption	3	
	Tin in ore	3	
	Miscellaneous	9	
			34
P.I.F. gauge	Minerals	13	
Gamma switch	Ores	6	
Other	Miscellaneous	17	
			1,173

TABLE B3 MASSIVE IRRADIATION

Application	^{60}Co or spent fuel elements	Activity (if ^{60}Co) on 1.1.71	Material Irradiated	Total megarad - cubic ft. irradiated		
				1970/71	1971/72	1972/73
Sterilisation	F.E.	-	sutures antibiotics saline solution radio-pharmaceuticals	3,027	2,000	1,000
	F.E.	-	peat	2,018	2,000	1,000
Sterilisation	^{60}Co	nil (220,000 Ci on 1.7.71)	plastic syringes petri dishes medical dressing packs	-	80,000	100,000
Polymerisation	^{60}Co	8,000	organic compounds	5,200	7,800	10,400
Polymerisation	^{60}Co	10,700	wood-plastic composites	10	-	-
Sterilisation	^{60}Co	10,700	monkey nerves	1.5	2.5	-
Sterilisation & polymerisation	^{60}Co	700,000	medical supplies fibre, wood-plastic composites	-	-	-

NOTE: Figures for 70/71 refer to actual use.

Figures for 71/72 and 72/73 are estimates supplied by users.

TABLE B4(i) TRACING

Type	No. of uses	Total Activity (mCi)		
	70/71	70/71	71/72	72/73
Isotope dilution analysis	11	16,520	21,520	21,520
Furnace lining wear	6	914	550	700
Leaks in pipelines	4	150	150	200
Gas flow measurements	6	70	210	210
Water flow measurements	108	271	220	185
Leaks in industrial plant	3	40	1,100	120
Process evaluation	130	35	35	35
Pipeline pig tracing	23	79	136	186
Sand, silt and effluent tracing	-	-	20,000	120,000
Tracing migration of fluids	32	99	40	20
Other	5	250	205	225
(Pipeline location 1. blockages 2. chemical analysis check 1. location of material 1.)				

Note: Figures for 70/71 refer to actual use.

Figures for 71/72 and 72/73 are estimates supplied by users.

TABLE B4(ii) TRACING

Type		Radioisotope (No. of uses & total activity (mCi)) (70/71)								
		^{24}Na	^{60}Co	^{82}Br	^{85}Kr	^{131}I	^{192}Ir	^{197}Hg ^{203}Hg	Radium	Other
Isotope dilution analysis	No	4						7		
	TA	20						16500		
Furnace lining wear	No		6							
	TA		914							
Leaks in pipelines	No			4						
	TA			150						
Gas flow measurement	No				6					
	TA				70					
Water flow measurement	No	1				107				
	TA	1				270				
Leaks in industrial plants	No	1								2{^{64}Cu, ^{198}Au}
	TA	10								30
Process evaluation	No	7	123							
	TA	25	10							
Pig tracing	No		17							
	TA		75							
Tracing migration of fluids	No						32			
	TA						99			
Other *	No	1	2					1		1(^{110m}Ag)
	TA	20	205					20		5

* Pipe location 1, blockages 2, chemical analysis check 1, location of material 1.

TABLE B5(i) MISCELLANEOUS

Type	No. of devices in use (70/71)	Total Activity (mCi)		
		70/71	71/72	72/73
Luminous dial painting	many	2,560	2,560	2,560
Static charge measurement	6	1,200	1,200	1,200
Static elimination	61	1,941	2,020	2,141
Ionisation in neon lamps	many	1,000	2,000	2,500
X-ray fluorescence source	2	7	17	17
Neutron production	1	2,000	2,000	2,000
Gas chromatography detector	20	2,263	2,633	2,635
Fire alarm	1,056	124	141	84
Self luminous signs	3,002	4,802,000	7,100,000	10,150,000
Other *	8	229	63	69

* voltage measurement, 1. test apparatus, 2.
atmospheric charge measurement, 3. gas dewpoint measurement, 1.
power source, 1.

Note: Figures for 70/71 refer to actual use.
Figures for 71/72 and 72/73 are estimates supplied by users.

TABLE B5(ii) MISCELLANEOUS

Type		Radioisotope (No. of uses and total activity (mCi)) (70/71)								
		^{3}H	^{60}Co	^{63}Ni	^{85}Kr	^{90}Sr	^{210}Po	Radium	^{241}Am	Other
Luminous dial painting	No.	many								
	T.A.	2,560								
Static charge measurement	No.	6								
	T.A.	1,200								
Static elimination	No.					9	46	5	1	
	T.A.					430	1,510	0.2	0.5	
Ionisation in neon lamps	No.				many					
	T.A.				1,000					
X-ray fluorescence source	No.	1								^{57}Co, (1)
	T.A.	2								5
Neutron production	No.	1								
	T.A.	2,000								
Gas chromatography detector	No.	13		4		3				
	T.A.	2,210		22		31				
Fire alarm	No.							100	956	
	T.A.							3.6	120	
Self luminous signs	No.	3,002								
	T.A.	4,800,000								
Other	No.		1 (voltage meas.)			2 (test app.)	1 (atmos. charge meas.)		4 (all ^{241}Am) (atmos. charge meas. 2.	
	T.A.		0.3			225	1.44		2.72 gas dewpoint meas. 1. power source 1)	

APPENDIX C

Results are tabulated of Questionnaire 3 :
Scientific, Non-Medical and Miscellaneous Uses.

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Biological Research	^{3}H	12,930	15,658	15,871
	^{14}C	324	392	534
	^{22}Na	1.3	3.7	7.1
	^{24}Na	0.05	1.1	1.1
	^{28}Mg	0.2	0.6	0.5
	^{32}P	2,154	2,140	2,134
	^{33}P	10	-	-
	^{35}S	196	137	136
	^{36}Cl	2.8	10.2	13.2
	^{42}K	74	79	41
	^{45}Ca	7.1	5.6	5.1
	^{46}Sc	3	5	5
	^{47}Ca	0.05	-	-
	^{51}Cr	89.5	89.5	89.5
	^{55}Fe	0.1	0.1	0.1
	^{59}Fe	9.6	10.7	10.5
	^{60}Co	2	-	-
	^{65}Zn	2	2	2
	^{75}Se	13	22	47
	^{82}Br	-	0.5	0.5
	^{85}Sr	6	4	4
	^{86}Rb	59	62	53
	^{103}Ru	25	25	25
	^{125}I	144	236	201
	^{131}I	174	165	170
	^{134}Cs	-	1	-
	^{141}Ce	4	3	3
	^{147}Pm	1.2	-	-
	^{169}Yb	-	2	4
	^{198}Au	150	100	100
Biochemical Research	^{3}H	449	676	688
	^{14}C	88	135	176
	^{32}P	386	491	489
	^{33}P	-	-	100

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Biochemical Research	^{35}S	111	103	103
	^{36}Cl	0.1	0.1	0.1
	^{45}Ca	15	16	20
	^{55}Fe	0.5	0.5	0.5
	^{59}Fe	1	4	4
	^{90}Sr	1	1	1
	^{125}I	2	2	2
	^{241}Am	0.3	-	-
Botanical Research	^{3}H	-	1	-
	^{14}C	2	3.1	3.1
	^{22}Na	0.5	0.5	0.5
	^{24}Na	-	-	1
	^{32}P	5	5	5
	^{36}Cl	0.5	0.5	0.5
	^{42}K	-	-	1
	^{45}Ca	2	2.5	0.5
	^{56}Mn	20	20	20
	^{82}Br	-	-	0.5
Physiological Research	^{3}H	8	7	1.5
	^{14}C	0.5	0.35	0.2
	^{22}Na	-	0.5	-
	^{32}P	-	5	-
	^{35}S	-	0.005	0.02
	^{36}Cl	-	1	1
	^{42}K	-	0.5	0.5
	^{51}Cr	20	40	40
	^{59}Fe	1.5	1	0.5
	^{125}I	0.3	0.21	0.21
Agricultural Research	^{3}H	5,631	4,611	5,116
	^{14}C	15,121	15,621	16,134
	^{22}Na	1.9	2.4	3.4
	^{24}Na	2	2.7	2.7
	^{32}P	651	976	1,058
	^{33}P	-	11	1

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Agricultural Research	^{35}S	1,091	236	370
	^{36}Cl	0.2	0.4	1.8
	^{42}K	1	102	451
	^{45}Ca	8	410	415
	^{46}Sc	1	2	2
	^{51}Cr	427	631	635
	^{54}Mn	2.3	-	0.1
	^{55}Fe	0.5	0.5	-
	^{57}Co	11	1	1
	^{59}Fe	2	400	401
	^{60}Co	5	5	5
	^{65}Zn	8.2	415	413
	^{73}As	-	0.02	-
	^{75}Se	-	400	420
	^{85}Sr	0.2	-	-
	^{86}Rb	66	71	101
	^{103}Ru	60	60	60
	^{115}Cd	-	2	3
	^{125}I	6.6	26	30
	^{131}I	48	52	52
	^{133}Ba	-	-	1
	^{137}Cs	1	1	2
	^{144}Ce	3	3	3
	^{203}Hg	-	2	3
	^{210}Pb	-	2	3
	^{226}Ra	5	5	5
	Ra/Be	27	27	27
	Am/Be	445	445	475
Industrial Research	^{3}H	0.1	0.1	0.1
	^{14}C	0.1	0.1	0.1
	^{24}Na	10	10	10
	^{42}K	2	5	5
	^{51}Cr	1	1	1
	^{60}Co	17	14	12

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Industrial Research	^{63}Ni	10	10	10
	^{85}Kr	10	10	10
	^{110m}Ag	1	1	1
	^{137}Cs	5	5	-
	^{153}Gd	20	20	-
	^{238}Pu	90	90	30
	^{241}Am	100	100	100
	^{242}Cm	-	150	150
Physics Research	^{3}H	20,200	25,200	75,200
	^{7}Be	0.15	0.15	0.15
	^{14}C	1.5	1.5	1.5
	^{22}Na	0.2	0.3	0.4
	^{24}Na	1,000	-	-
	^{46}Sc	20	1,000	-
	^{51}Cr	1	1	1
	^{55}Fe	-	-	20
	^{57}Co	136	105	114
	^{57}Fe	5	5	10
	^{60}Co	466	2,008	4,010
	^{65}Zn	300	3,000	5,000
	^{75}Se	-	100	-
	^{85}Kr	-	-	1
	^{88}Y	0.005	0.005	0.005
	^{119m}Sn	14	15	16
	^{131}I	210	280	110
	^{132}I	-	100	400
	^{137}Cs	10.1	15.1	15.1
	^{140}Ba	-	1	-
	^{144}Ce	0.3	0.2	0.1
	^{153}Gd	20	20	40
	^{155}Eu	6	12	13
	^{169}Er	10	10	10
	^{198}Au	400	-	-
	^{210}Po	2.2	-	-

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Physics Research	^{233}U	0.05	0.05	0.05
	^{238}Pu	60	120	120
	^{239}Pu	0.5	3	3
	^{241}Am	60	80	60
	^{252}Cf	0.003	0.002	0.01
	Radium	0.21	0.21	0.21
	Am/Be	1,033	1,033	1,033
	Ra/Be	6	6	6
Chemical Research	^{3}H	23,112	24,429	10,924
	^{14}C	27.6	28.6	29.5
	^{22}Na	0.4	1	1
	^{32}P	15.1	15.2	15.5
	^{35}S	10	12.6	12.6
	^{136}C	0.1	0.2	0.2
	^{45}Ca	-	0.5	0.5
	^{51}Cr	100.1	101.1	101.1
	^{55}Fe	1	5	5
	^{57}Co	25	31	31
	^{58}Co	1	1	1
	^{59}Fe	12	11	11
	^{60}Co	201.2	101.2	101.2
	^{63}Ni	2	5	5
	^{64}Cu	0.05	4.05	2.05
	^{65}Zn	-	-	1
	^{67}Cu	-	10	10
	^{74}As	-	1	1
	^{82}Br	0.6	0.2	0.2
	^{85}Kr	20	20	20
	^{85}Sr	-	1	1
	^{95}Nb	5	5	-
	^{95}Zr	-	1	1
	^{99m}Tc	8	8	5
	^{103}Ru	-	-	5
	^{109}Cd	0.2	1.2	1.2

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Chemical Research	^{110m}Ag	6	6	6
	^{114m}In	0.6	0.7	0.2
	^{125}Sb	-	5	5
	^{134}Cs	5	-	5
	^{137}Cs	0.63	0.73	0.73
	^{144}Ce	11	12	11
	^{147}Pm	5	6	1
	^{152}Eu	6	6	2
	^{182}Ta	2	5	-
	^{183}Re	-	-	0.05
	^{185}W	5	-	-
	^{198}Au	0.05	0.05	0.05
	^{203}Hg	10	10	10
	^{207}Bi	10	-	-
	^{231}Pa	2	-	-
	^{239}Pu	61.3	61.3	61.3
	^{241}Am	5	5	5
	^{244}Cm	83.3	83.3	83.3
Analytical Chemistry	^{3}H	1.5	2	2.5
	^{14}C	5.1	5	5
	^{22}Na	10	10	10
	^{36}Cl	0.005	-	-
	^{46}Sc	10	5	5
	^{59}Fe	-	0.1	0.1
	^{60}Co	10.5	10.5	10.5
	^{82}Br	0.005	-	-
	^{88}Y	10	10	10
	^{125}I	109	122	142
	^{131}I	-	10	30
	^{197}Hg	0.01	-	-
	^{203}Hg	2	5	5
Veterinary Research & Applications	^{3}H	85	81	81
	^{14}C	3.1	3.3	3.3
	^{32}P	109	110	110

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Veterinary Research & Applications	^{35}S	15	13	18
	^{51}Cr	27	19	19
	^{59}Fe	0.3	0.5	1
	^{60}Co	-	100	100
	^{75}Se	0.75	0.5	0.5
	^{90}Sr	270	270	270
	^{125}I	2.5	9.0	11.5
	^{131}I	35.5	42.5	22.5
	^{198}Au	-	100	100
	Radon	1,590	2,000	2,000
	Radium	147	152	152
	^{241}Am	10	10	10
Radiochemical Analysis	^{3}H	0.01	0.01	0.01
	^{14}C	0.01	0.01	0.01
	^{18}F	-	10	10
	^{32}P	-	1	5
	^{44}Ce	-	1	1
	^{63}Ni	-	1	1
	^{65}Zn	-	1	5
	^{89}Sr	-	0.1	1
	^{90}Sr	0.1	0.1	0.2
	^{106}Ru	-	1	1
	^{131}I	1	20	20
	^{137}Cs	0.1	0.1	0.2
	Radium	-	0.01	-
Fisheries Research	^{3}H	-	1,010	1,010
	^{14}C	-	1	1
	^{22}Na	-	5	5
	^{136}C	-	5	5
	^{46}Sc	-	10	10
	^{51}Cr	-	10	10
Tertiary Education and Teaching	^{3}H	218.1	234.1	297.1
	^{14}C	42.5	42.9	49.3
	^{22}Na	2.36	6.59	6.59

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Tertiary Education and Teaching	^{24}Na	23.6	31.5	31.5
	^{32}P	66.0	89.0	92.0
	^{35}S	30.3	26.1	37.8
	^{36}Cl	0.15	0.15	0.20
	^{42}K	9.02	19.0	13.0
	^{44}Ti	-	0.005	0.005
	^{45}Ca	7.4	6.5	7.5
	^{46}Sc	10.6	5.56	5.56
	^{51}Cr	1	1	2
	^{54}Mn	0.15	0.20	0.30
	^{56}Mn	1	1	1
	^{57}Co	5.86	17.9	25.9
	^{59}Fe	10.1	10.1	10.1
	^{60}Co	77.9	73.6	5,090
	^{64}Cu	2	2	2
	^{65}Zn	2	7.1	2.1
	^{80}Br	0.02	0.02	0.02
	^{82}Br	3.02	3.02	3.02
	^{90}Sr	8.29	8.27	8.39
	^{110}Ag	10	3.6	-
	^{113}Sn	0.001	0.001	0.001
	^{125}I	21	27	27
	^{128}I	2.5	2.5	2.5
	^{131}I	59.6	85.5	101
	^{137}Cs	2,069	2,069	2,069
	^{137m}Ba	0.009	0.009	0.009
	^{139}Ba	1.25	1.25	1.25
	^{144}Ce	6	3	1
	^{147}Pm	7	1	1
	^{192}Ir	0.01	0.01	0.01
	^{198}Au	8.1	8.1	8.1
	^{204}Tl	0.41	0.41	0.41
	^{207}Bi	0.01	0.01	0.01
	^{210}Pb	2	2	2

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Tertiary Education and Teaching	^{210}Po	2	2	2
	Radium	0.12	0.12	0.22
	^{228}Th	0.02	0.02	0.02
	Ra/Be	20	20	21
	^{238}U	-	0.01	0.01
	^{241}Am	22.6	32.6	52.7
	Am/Be	1,330	1,330	1,430
	^{242}Cm	-	10	10
Engineering Research	^{24}Na	-	500	500
	^{60}Co	46.8	46.8	46.8
	^{64}Cu	-	500	500
	^{65}Zn	-	20	20
	^{85}Kr	-	200	200
	^{110}Ag	10	10	10
	^{137}Cs	140	140	140
	^{170}Tm	2	1,000	1,000
	^{182}Ta	-	20	20
	^{192}Ir	-	50	50
	^{198}Au	20	20	20
	^{241}Am	200	200	200
	Radium	0.05	0.05	0.05
	Ra/Be	10	10	10
	Am/Be	70	70	70
Forestry Research	^{3}H	25	25	-
	^{14}C	2.05	3.45	3.45
	^{32}P	0.5	0.55	5.55
	^{65}Zn	-	-	20
	Am/Be	80	80	80
Food Research	^{3}H	108	108	-
	^{14}C	9.9	8.9	6.5
	^{28}Mg	-	1	1
	^{45}Ca	-	1	1
	^{55}Fe	-	1	1
	^{65}Zn	-	1	1

TABLE C1 NON-MEDICAL RESEARCH AND MISCELLANEOUS USES (Contd.)

Type	Radio-isotope	Activity (mCi)		
		1970-71	71-72	72-73
Geochemical/ Geophysical Research	^{55}Fe	-	5	5
	^{60}Co	8	8	8
	^{88}Y	0.003	0.003	0.003
	^{109}Cd	-	5	5
	^{137}Cs	0.003	0.003	0.003
	^{147}Pm	-	1,000	1,000
	^{210}Po	-	10,000	10,000
	^{238}Pu	-	30	100
	^{241}Am	0.003	10	100
	^{242}Cm	-	400	4,000
	Pu/Be	4,000	4,000	4,000
	Am/Be	10	10	10
	Cm/Be	-	20,000	20,000
Gas Chromatography	^{3}H	7,000	6,650	7,010
	^{63}Ni	148	148	148
	^{90}Sr	50	40	40
Biological Engineering	^{3}H	15,500	1,022,000	1,520,000
Miscellaneous Research, (Parasitology, Metallurgy, Road, Zoology, Pharmacology Dental).	^{3}H	1,108	348	143
	^{14}C	1.60	27.4	27.1
	^{32}P	-	6.2	6.2
	^{35}S	-	0.1	0.1
	^{45}Ca	0.5	-	-
	^{64}Cu	-	0.5	1
Miscellaneous Applications, (Civil Defence Training, Photographic, Instrument Calibration, Alphatron Gauge.)	^{14}C	0.013	0.016	0.021
	^{136}C	0.001	0.002	0.003
	^{60}Co	2.01	2.01	52
	^{99m}Tc	0.14	0.14	0.14
	^{210}Po	0.9	0.9	1
	Radium	4.1	4.2	4.2

Note: Figures for 70/71 refer to actual use.

Figures for 71/72 and 72/73 are estimates supplied by users.

APPENDIX D

Questionnaires and accompanying letter from The Secretary.

Australian Atomic Energy Commission

Cliffbrook, 45 Beach Street, Coogee, N.S.W.

AAEC

BOX 41. POST OFFICE, COOGEE, N.S.W., AUSTRALIA, 2034
CABLES: ATOMCOM, SYDNEY — TELEPHONE: 665-1221

OUR REFERENCE G.71/3822 YOUR REFERENCE

12 August 1971

Dear Sir,

The Australian Atomic Energy Commission is conducting a survey of all aspects of the use of radioisotopes in Australia for the financial year 1 July 1970 to 30 June 1971, with some information pertaining to earlier years.

Within the last three or four years there has been a great increase in the demand for radioisotopes in Australia, particularly in the medical field. This has led to the development of special preparations for specific purposes and has generally necessitated expansion of the A.A.E.C.'s production capacity.

Current use of radioisotopes, as indicated by the survey, will be measured against former years and the potential for future years will be gauged. This will enable requirements and demands in the use of radioisotopes to be predicted more accurately.

Your name, or the name of your organisation, as the user of specified radioisotopes, was supplied to us by the Health Department in your State, or the Commonwealth X-Ray and Radium Laboratory, or was available from our own records.

We would greatly appreciate your assistance in helping us to carry out the survey and would be most grateful if you would complete and return one copy of the enclosed questionnaire to the above address by 10 September 1971, the spare copy being for your records.

We have prepared three separate questionnaires covering the following categories of radioisotope use:-

1. Medical[1] (including medical research)[2]
2. Industrial
3. Scientific, non medical research and miscellaneous,

and have sent you the questionnaire we consider to be appropriate to your use of radioisotopes. If this questionnaire is not appropriate, please let us know and we will forward the correct form to you.

You are assured that, if you so indicate on the questionnaire, the information you supply therein will remain confidential and will not be disclosed to any outside body without your permission. However, we may wish to quote and publish the bulk figures for each category, and general conclusions, etc., in the survey.

If you have any questions concerning the questionnaire or the survey, we would be very pleased to answer them for you.

Yours faithfully,

W. B. Lynch

W. B. Lynch
Secretary

1. Medical use is here defined as "use on humans or for research, the results of which may ultimately be applied to humans".

2. Medical research is here defined as "research using human subjects or other in vivo or in vitro research, the results of which may ultimately be applied to humans".

AUSTRALIAN ATOMIC ENERGY COMMISSION

SURVEY ON THE USE OF RADIOISOTOPES IN AUSTRALIA IN 1970-71†

Questionnaire 1 : Medical Uses

Instructions & Explanation

Please complete and return one copy of this form by the date shown in the accompanying letter.

The various medical uses* of radioisotopes have been divided into several categories as shown, and a table prepared for each category.

At the head of each table is a typical example. Please model your answer on this example.

In the columns marked 1971-72 and 1972-73†, please enter your estimates for these years under the appropriate category. Please include radioisotopes you expect to use in the future, even though you have not hitherto used them. We realise that in most cases, it will be difficult to make an accurate forecast, but some indication would be most useful for our future planning.

The categories are:-

1.1. Diagnosis (*in vivo*, *in vitro*).

1.2. Therapy (teletherapy, implant, afterloading, other (please specify)).

1.3. Research (clinical, laboratory).

† Year refers to financial year (1 July - 30 June)

* Medical use is here defined as "use on humans or for research, the results of which may ultimately be applied to humans".

Category 1.1. MEDICAL – DIAGNOSIS

Type*	Radio-isotope	Chemical form	1970-71 No. of shipments	1970-71 No. of patients	1970-71 Total delivered activity (mCi)	No. of doses or tests 1970-71	No. of doses or tests 71-72†	No. of doses or tests 72-73†
In vivo	*Tc 99m*	*Pertech-netate*	*60*	*70*	*150*	*80*	*110*	*190*

* *In vivo, in vitro*

† Please estimate, as explained on page 1.

Category 1.2.A. MEDICAL – TELETHERAPY

Activity (Ci) of cobalt 60 as at 1.1.1971	Number of patients in 1970-71	Number of irradiations 1970-71	Number of irradiations 71-72†	Number of irradiations 72-73†
3,500	*300*	*450*	*500*	*600*

† Please estimate, as explained on page 1.

Do you expect to purchase cobalt 60 within the next two years? YES/NO.
If so, please state expected year of purchase and quantity of cobalt-60.

Category 1.2.B. **MEDICAL – THERAPY (other than Teletherapy)**

Type*	Radio-isotope	Chemical form	1970-71		Number of patients		
			No. of shipments	Total activity (mCi)	1970-71	71-72†	72-73†
Implant	*Y90*	Y_2O_3	*15*	*60*	*15*	*25*	*15*

* Implant, afterloading, other (please state).

† Please estimate, as explained on page 1.

Category 1.3. **MEDICAL – RESEARCH**°

Type*	Radio-isotope	Chemical form	Number of shipments	Total activity (mCi)		
			1970-71	1970-71	71-72†	72-73†
Clinical	*I131*	*Hormone labelled*	*25*	*200*	*400*	*1800*

° Medical research is defined as research using human subjects or other *in vivo* or *in vitro* research, the results of which may ultimately be applied to humans.

* Clinical, laboratory, other (please state).

† Please estimate, as explained on page 1.

P.T.O.

Would you please also supply the following information:

1. In what year did you first use radioisotopes in the categories listed?

Category	1.1	1.2.A.	1.2.B.	1.3.
Year				

2. Please give a more detailed description of the ways in which radioisotopes have been of benefit to your work.

3. Additional information and general comments.

4. Do you wish the information given in this questionnaire to remain confidential? YES/NO.

Individual's or Organisation's name, and address of the location where radioisotopes are used.

....

....

....

....

Name & Designation | Signature | Date

....

....

AUSTRALIAN ATOMIC ENERGY COMMISSION

SURVEY ON THE USE OF RADIOISOTOPES IN AUSTRALIA IN 1970-71†

Questionnaire 2 : Industrial Uses.

Instructions & Explanation

Please complete and return one copy of this form by the date shown in the accompanying letter.

The various industrial uses of radioisotopes have been divided into several categories as shown, and a table prepared for each category.

At the head of each table is a typical example. Please model your answers on this example.

In the columns marked 1971-72 and 1972-73† , please enter your estimates for these years, under the appropriate category. Please include radioisotopes you expect to use in the future, even though you have not hitherto used them. We realise that in most cases it will be difficult to make an accurate forecast, but some indication would be most useful for our future planning.

The categories are:-

2.1. Radiography.

2.2. Gauging (thickness, density, level, gamma switch, moisture, component analysis, other (please specify)).

2.3. Massive irradiation (sterilisation of medical supplies or other materials (please specify material), initiation of chemical reactions, other (please specify)).

2.4. Tracing (leak detection, pipe line location, mixing studies, flow measurement, isotope dilution analysis, wear studies, sand, silt or effluent tracing, process evaluation, other (please specify)).

2.5. Miscellaneous (static elimination, fire alarms, safety devices, self luminous signs, power sources, other (please specify).

\+ Year refers to financial year (1 July - 30 June).

Category 2.1. INDUSTRIAL – RADIOGRAPHY

Radioisotope	No. of radiographs 1970-71	No. of sources* purchased or used			No. of radiography units in use 1970-71	Total activity (mCi)		
		70-71	71-72	72-73		70-71	71-72†	72-73†
Ir 192	*200*	*4*	*4*	*9*	*2*	*12,000*	*15,000*	*30,000*

* Include sources purchased previously, but used in year specified.
† Please indicate, as explained on page 1.

Category 2.2. INDUSTRIAL – GAUGING

Type*	Radio-isotope	Total activity 1970-71	Material gauged.	Number of gauges		
				1970-71	71-72†	72-73†
Continuous level	*Cobalt 60*	*10 mCi*	*Caustic liquor in steel tank*	*2*	*4*	*4*

* Thickness, density, level, gamma switch, moisture, component analysis, other (please specify).

† Please indicate, as explained on page 1.

Category 2.3. INDUSTRIAL – MASSIVE IRRADIATION

Type*	Cobalt 60 or spent fuel elements	Activity (if Co60)as at 1.1.1971	Material irradiated	Total megarad cubic ft irradiated		
				1970-71	71-72†	72-73†
Sterilisation of medical supplies	*Cobalt 60*	*100,000 Ci*	*sutures etc*	*1,500*	*2,000*	*2,500*

* Sterilisation of medical supplies or other materials (please specify material), initiation of chemical reactions, other (please specify).

† Please indicate, as explained on page 1.

Category 2.4. **INDUSTRIAL – TRACING**

Type *	Radio-isotope	Form	Number of uses 1970-71	Total activity (mCi)		
				1970-71	71-72 †	72-73 †
Leak detection in heat exchanger	*Krypton 85*	*Gas, with nitrogen*	*8*	*20*	*35*	*5*

* Leak detection, pipe line location, mixing studies, flow measurement, isotope dilution analysis, wear studies, sand, silt or effluent tracing, process evaluation, other (please specify).

† Please indicate, as explained on page 1.

Category 2.5. **INDUSTRIAL – MISCELLANEOUS**

Type *	Radioisotope	No. of devices in use 1970 - 71	Total activity (mCi)		
			1970-71	71-72 †	72-73 †
Static elimination	*Strontium 90*	*4*	*100*	*200*	*200*

* Static elimination, fire alarms, safety devices, self luminous signs, power sources, other (please specify).

† Please indicate, as explained on page 1.

P.T.O.

Would you please also supply the following information:

1. In what year did you first use radioisotopes in the categories listed?

Category	2.1	2.2	2.3	2.4	2.5
Year					

2. Please give a more detailed description of the ways in which radioisotopes have been of benefit to your work.

3. Additional information and general comments.

4. Do you wish the information given in this questionnaire to remain confidential? YES/NO.

Individual's or Organisation's name, and address of the location where radioisotopes are used.

Name & Designation   Signature   Date

AUSTRALIAN ATOMIC ENERGY COMMISSION

SURVEY ON THE USE OF RADIOISOTOPES IN AUSTRALIA IN 1970-71†

Questionnaire 3 : Scientific, Non-Medical Research and Miscellaneous Uses

Instructions & Explanation

Please complete and return one copy of this form by the date shown on the accompanying letter.

The various sub-categories covered by this Category 3 include scientific, non-medical research*, (agricultural, analytical, biological, chemical, engineering, industrial, physical, etc.) education and teaching, veterinary, other (please specify).

On page 2 of this form, there is a table covering these applications of radioisotopes. At the head of this table are two typical examples. Please model your answers on these examples.

In the columns marked 1971-72 and 1972-73†, please enter your estimates for these years. Please include radioisotopes you expect to use in the future, even though you have not hitherto used them. We realise that in most cases it will be difficult to make an accurate forecast, but some indication would be most useful for our future planning.

† Year refers to financial year (1 July - 30 June)

* Medical research is defined as research using human subjects or other *in vivo* or *in vitro* research, the results of which may ultimately be applied to humans.

Category 3. SCIENTIFIC, NON-MEDICAL RESEARCH and MISCELLANEOUS USES

Type of application*	Radio-isotope	Chemical form	Activity (mCi)		
			1970-71	71-72 †	72-73 †
Agricultural research	*Phosphorus 32*	*Orthophosphate*	*0.1*	*0.5*	*1.0*
Chemical research	*Tritium*	*Water*	*1.0*	*5.0*	*1.0*

* Scientific, non-medical research (agricultural, analytical, biological, chemical, engineering, industrial, physical, etc.), education and teaching, veterinary, other (please specify).

† Please indicate, as explained on page 1.

Would you please also supply the following information:

1. In what year did you first use radioisotopes in the sub-categories listed?

Sub-category			
Year			

2. Please give a more detailed description of the ways in which radioisotopes have been of benefit to your work.

3. Additional information and general comments.

4. Do you wish the information given in this questionnaire to remain confidential? YES/NO.

Individual's or Organisation's name, and address of the location where radioisotopes are used.

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Name & Designation Signature Date

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