Pregnancy and Medical Radiation

International Commission on Radiological Protection

Information abstracted from
ICRP *Publication 84*

Available at **www.icrp.org**

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Use and disclaimer

- This is a PowerPoint file
- It may be downloaded free of charge
- It is intended for teaching and not for commercial purposes
- This slide set is intended to be used with the complete text provided in ICRP *Publication 84*

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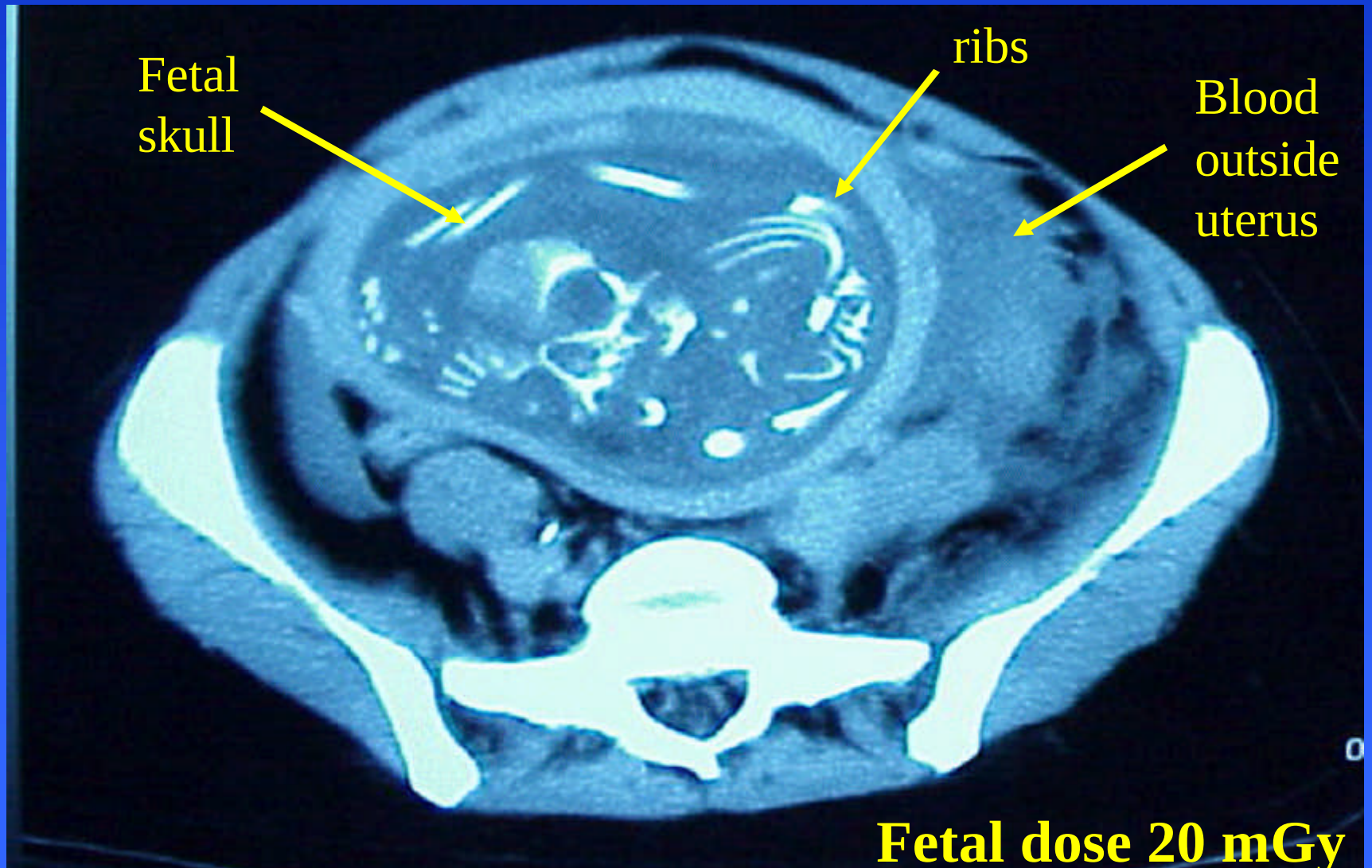
Introduction

- Thousands of pregnant women are exposed to ionising radiation each year
- Lack of knowledge is responsible for great anxiety and probably unnecessary termination of pregnancies
- For most patients, radiation exposure is medically appropriate and the radiation risk to the fetus is minimal

Example: justified use of CT

Pregnant female, was in motor vehicle accident



3 minute CT exam and taken to the operating room. She and the child survived

Fetal radiation risk

- There are radiation-related **risks** throughout pregnancy that are **related to the stage of pregnancy and absorbed dose**
- Radiation risks are most significant during organogenesis and in the early fetal period, somewhat less in the 2nd trimester, and least in the 3rd trimester

Most risk

Less

Least

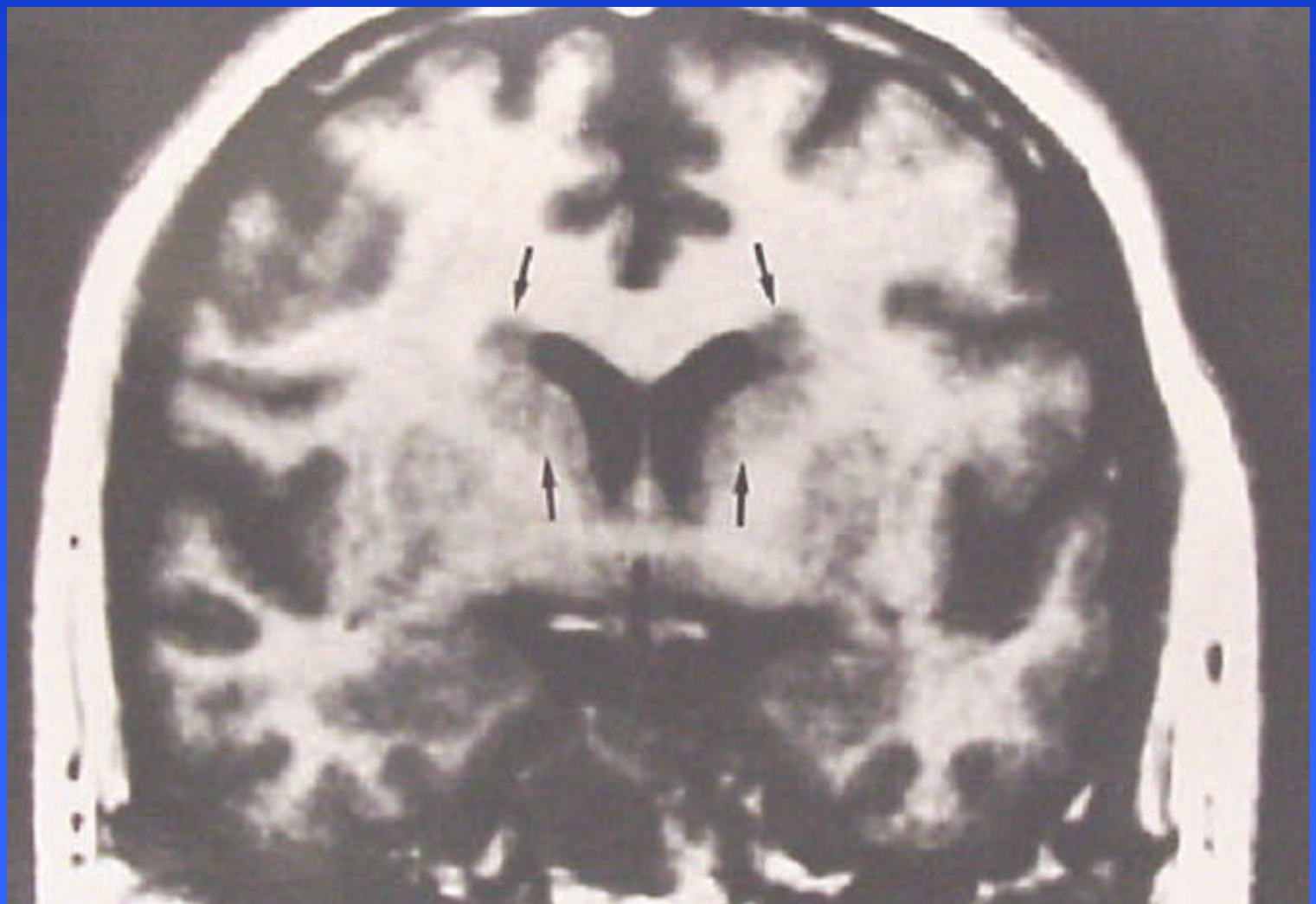
Radiation-induced malformations

- Malformations have a **threshold of 100-200 mGy or higher** and are typically associated with central nervous system problems
- Fetal doses of 100 mGy are not reached even with 3 pelvic CT scans or 20 conventional diagnostic x-ray examinations
- These levels **can** be reached with fluoroscopically guided interventional procedures of the pelvis and with radiotherapy

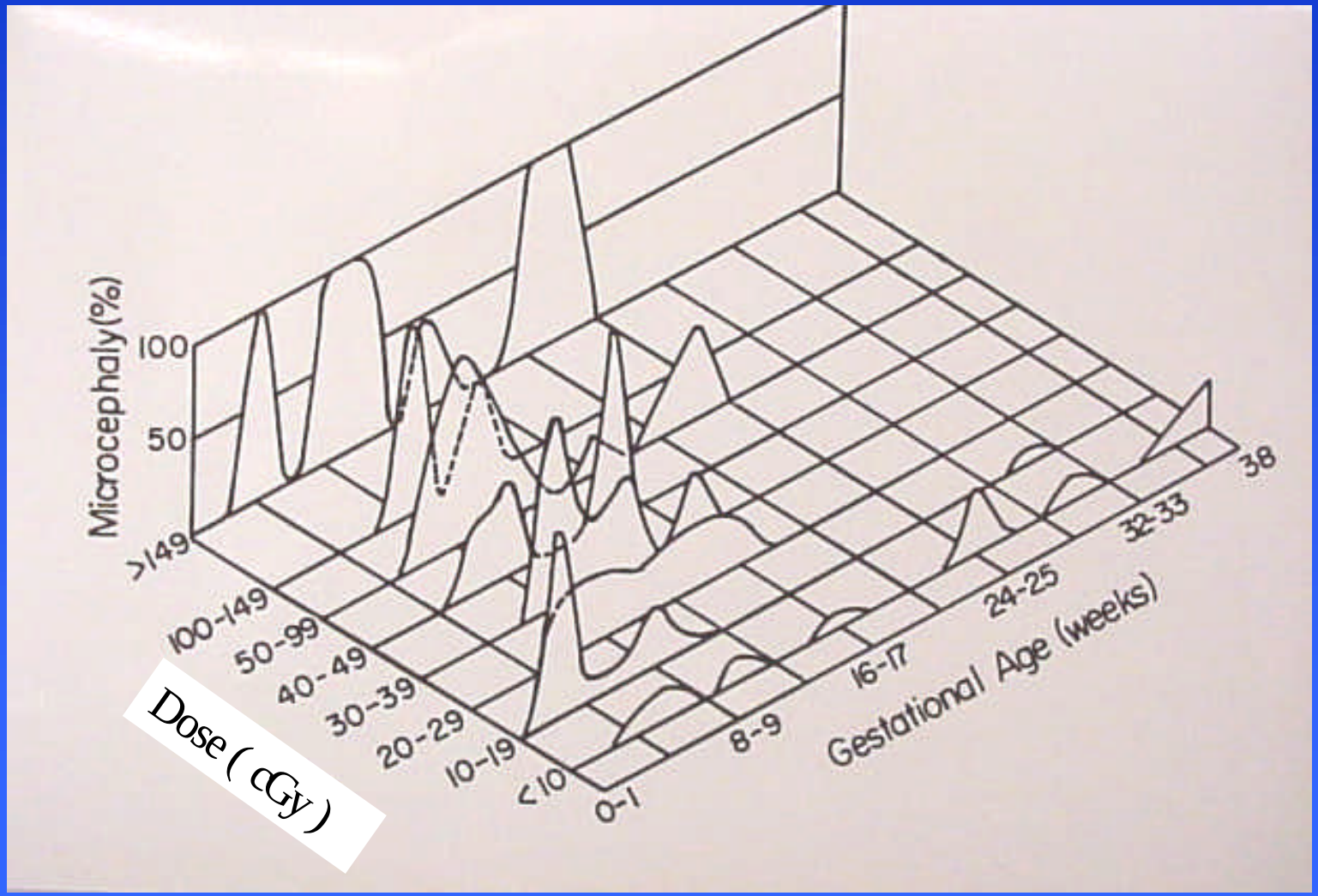
Central nervous system effects

- During 8-25 weeks post-conception the CNS is particularly sensitive to radiation
- Fetal doses in excess of 100 mGy can result in some reduction of IQ (intelligence quotient)
- Fetal doses in the range of 1000 mGy can result in severe mental retardation and microcephaly, particularly during 8-15 weeks and to a lesser extent at 16-25 weeks

Heterotopic gray matter (*arrows*) near the ventricles in a mentally retarded individual occurring as a result of high dose in-utero radiation exposure



Frequency of microcephaly as a function of dose and gestational age occurring as a result of in-utero exposure in atomic bomb survivors (Miller 1976)



Leukaemia and cancer…

- Radiation has been shown to increase the risk for leukaemia and many types of cancer in adults and children
- Throughout most of pregnancy, the embryo/fetus is assumed to be at about the same risk for carcinogenic effects as children

Leukaemia and cancer (cont'd)

- The relative risk may be as high as 1.4 (40% increase over normal incidence) due to a fetal dose of 10 mGy

- For an individual exposed in utero to 10 mGy, the absolute risk of cancer at ages 0-15 is about 1 excess cancer death per 1,700

Probability of bearing healthy children as a function of radiation dose

Dose to conceptus (mGy) above natural background	Probability of no malformation	Probability of no cancer (0-19 years)
0	**97**	**99.7**
1	**97**	**99.7**
5	**97**	**99.7**
10	**97**	**99.6**
50	**97**	**99.4**
100	**97**	**99.1**
>100	**Possible, see text**	**Higher**

Pre-conception irradiation

- Pre-conception irradiation of either parent's gonads has **not** been shown to result in increased risk of cancer or malformations in children

- This statement is from comprehensive studies of atomic bomb survivors as well as studies of patients who had been treated with radiotherapy when they were children

Informed consent and understanding

- The pregnant patient or worker has a right to know the magnitude and type of potential radiation effects that might result from in-utero exposure
- Communication should be related to the level of risk. Communication that risk is negligible is adequate for very low dose procedures (<1 mGy to the fetus)
- If fetal doses are above 1 mGy, a more detailed explanation should be given

Exposure of pregnant patients

- In some circumstances, the exposure is inappropriate and the unborn child may be at increased risk of harm to health
- Prenatal doses from most properly performed **diagnostic** procedures present **no** measurably increased risk of prenatal death, malformation, or mental impairment
- **Higher doses** such as those from therapeutic procedures **can result in significant fetal harm**

Medical radiation procedures

- All medical practices (occupational and patient-related) should be justified (more benefit than risk)
- Medical exposures should be justified for each patient before they are performed
- After it is decided to do a medical radiation procedure, the fetal radiation dose should be reduced while still obtaining the required diagnostic information

Evaluation of potentially pregnant patients

In females of child-bearing age, an attempt should be made to determine who is, or could be, pregnant, prior to radiation exposure

Notices

- A missed period in a regularly menstruating woman should be considered due to pregnancy, until proven otherwise
- Notices regarding pregnancy should be posted in patient waiting areas, such as

  If it is possible that you might be pregnant, notify the physician or other staff before your x-ray examination, treatment, or before being injected with a radioactive material

Approximate fetal doses from conventional x-ray examinations

Data from the UK, 1998

Examination \ Dose	Mean (mGy)	Maximum (mGy)
Abdomen	**1.4**	**4.2**
Chest	**<0.01**	**<0.01**
Intravenous urogram; lumbar spine	**1.7**	**10**
Pelvis	**1.1**	**4**
Skull; thoracic spine	**<0.01**	**<0.01**

Approximate fetal doses from fluoroscopic and computed tomography procedures

Data from the UK, 1998

Examination / Dose	Mean (mGy)	Maximum (mGy)
Barium meal (UGI)	**1.1**	**5.8**
Barium enema	**6.8**	**24**
Head CT	**<0.005**	**<0.005**
Chest CT	**0.06**	**1.0**
Abdomen CT	**8.0**	**49**
Pelvis CT	**25**	**80**

Higher dose procedures

- Radiation therapy and interventional fluoroscopically-guided procedures may give fetal doses in the range of 10-100 mGy or more depending on the specifics of the procedure
- After such higher dose medical procedures have been performed on pregnant patients, fetal dose and potential fetal risk should be estimated by a knowledgeable person

Nuclear medicine and pregnant patients…

- Most diagnostic procedures are done with short-lived radionuclides (such as technetium-99^{m}) that do not cause large fetal doses
- Often, fetal dose can be reduced through maternal hydration and encouraging voiding of urine
- Some radionuclides do cross the placenta and can pose fetal risks (such as iodine-131)

Nuclear medicine and pregnant patient (cont'd)

- The fetal thyroid accumulates iodine after about 10 weeks gestational age
- High fetal thyroid doses from radioiodine can result in permanent hypothyroidism
- If pregnancy is discovered within 12 h of radio-iodine administration, prompt oral administration of stable potassium iodine (60-130 mg) to the mother can reduce fetal thyroid dose. This may need to be repeated several times

Approximate whole body fetal dose (mGy) from common nuclear medicine procedures

Procedure	Activity (MBq)	Early pregnancy	9 months
Tc-99^{m}			
Bone scan	**750**	**4.7**	**1.8**
Lung scan	**240**	**0.9**	**0.9**
Liver colloid scan	**300**	**0.6**	**1.1**
Thyroid scan	**400**	**4.4**	**3.7**
Renal DTPA	**300**	**9.0**	**3.5**
Red blood cell	**930**	**6.0**	**2.5**
I-123 thyroid uptake	**30**	**0.6**	**0.3**
I-131 thyroid uptake	**0.55**	**0.04**	**0.15**

Nuclear medicine and breast feeding

A number of radionuclides are excreted in breast milk. It is recommended that breast feeding is suspended as follows:

- Completely after ^{131}I therapy
- 3 weeks after ^{131}I, ^{125}I, ^{67}Ga, ^{22}Na, and ^{201}Tl
- 12 h after ^{131}I hippurate and all ^{99m}Tc compounds except as below
- 4 h after ^{99m}Tc red cells, DTPA, and phosphonates

Research on pregnant patients

Research involving radiation exposure of pregnant patients should be discouraged

Radiation exposure of pregnant workers

- Pregnant medical radiation workers **may work in a radiation environment** as long as there is reasonable assurance that the fetal dose can be kept below 1 mGy during the pregnancy
- 1 mGy is approximately the dose that all persons receive annually from penetrating natural background radiation

Termination of pregnancy…

- High fetal doses (100-1000 mGy) during late pregnancy are not likely to result in malformations or birth defects since all the organs have been formed
- A fetal dose of 100 mGy has a small individual risk of radiation-induced cancer. There is over a 99% chance that the exposed fetus will **NOT** develop childhood cancer or leukaemia

Termination of pregnancy (cont'd)

- Termination of pregnancy at fetal doses of less than 100 mGy is **NOT** justified based upon radiation risk
- At fetal doses in excess of 500 mGy, there can be significant fetal damage, the magnitude and type of which is a function of dose and stage of pregnancy
- At fetal doses between 100 and 500 mGy, decisions should be based upon individual circumstances

Risks in a pregnant population *not* exposed to radiation

Risks:

- Spontaneous abortion	> 15%
- Incidence of genetic abnormalities	4-10%
- Intrauterine growth retardation	4%
- Incidence of major malformation	2-4%

Web sites for additional information on radiation sources and effects

European Commission (radiological protection pages):
europa.eu.int/comm/environment/radprot

International Atomic Energy Agency:
www.iaea.org

International Commission on Radiological Protection:
www.icrp.org

United Nations Scientific Committee on the Effects of Atomic Radiation:
www.unscear.org

World Health Organization:
www.who.int