The 2007 Recommendations of ICRP

Dr Jack Valentin, Scientific Secretary, ICRP

- **International Commission on Radiological Protection**
  - *ICRP: Who, why, what?*
- **The 2007 Recommendations**
  - *Justification (political) – optimisation – limits & constraints*
  - *The exposure situation*
  - *Include non-human species*

About ICRP

ICRP, an Independent Registered Charity

Established to advance for the public benefit the science of Radiological Protection,

in particular by providing recommendations and guidance on all aspects of protection against ionising radiation.

Structure of ICRP, 2005 – 2009

Main Commission

Chair: Dr L-E Holm, SE

12 other members

Scientific Secretariat
Dr J Valentin, SE

C1- Radiation Effects *Dr R J Preston, US*

C2- Doses from Radiation Exposure *Dr H Menzel, CH*

C3- Protection in Medicine *Dr C Cousins, UK*

Task Groups

C4- Application of ICRP Recommend:s *Dr A Sugier, FR*

Working Parties

C5-Prot. of the Environment *Prof J Pentreath, UK*

The 2007 Recommendations of ICRP

Why Are We Updating...

- **New biological & physical information**
  - *Validity of the LNT model? (Linear, No Threshold)*
- **Increasing use of radiation in medicine**
  - *Increase professional awareness?*
- **Post-Chernobyl lessons; inclusion of natural exposures**
  - *Coherent, consistent implementation of ICRP Publication 60?*
- **Protection of the environment**
  - *Scientific proof of adequate protection?*

ICRP 1990 Rec's: Logical But Complex

Aims of the Revision

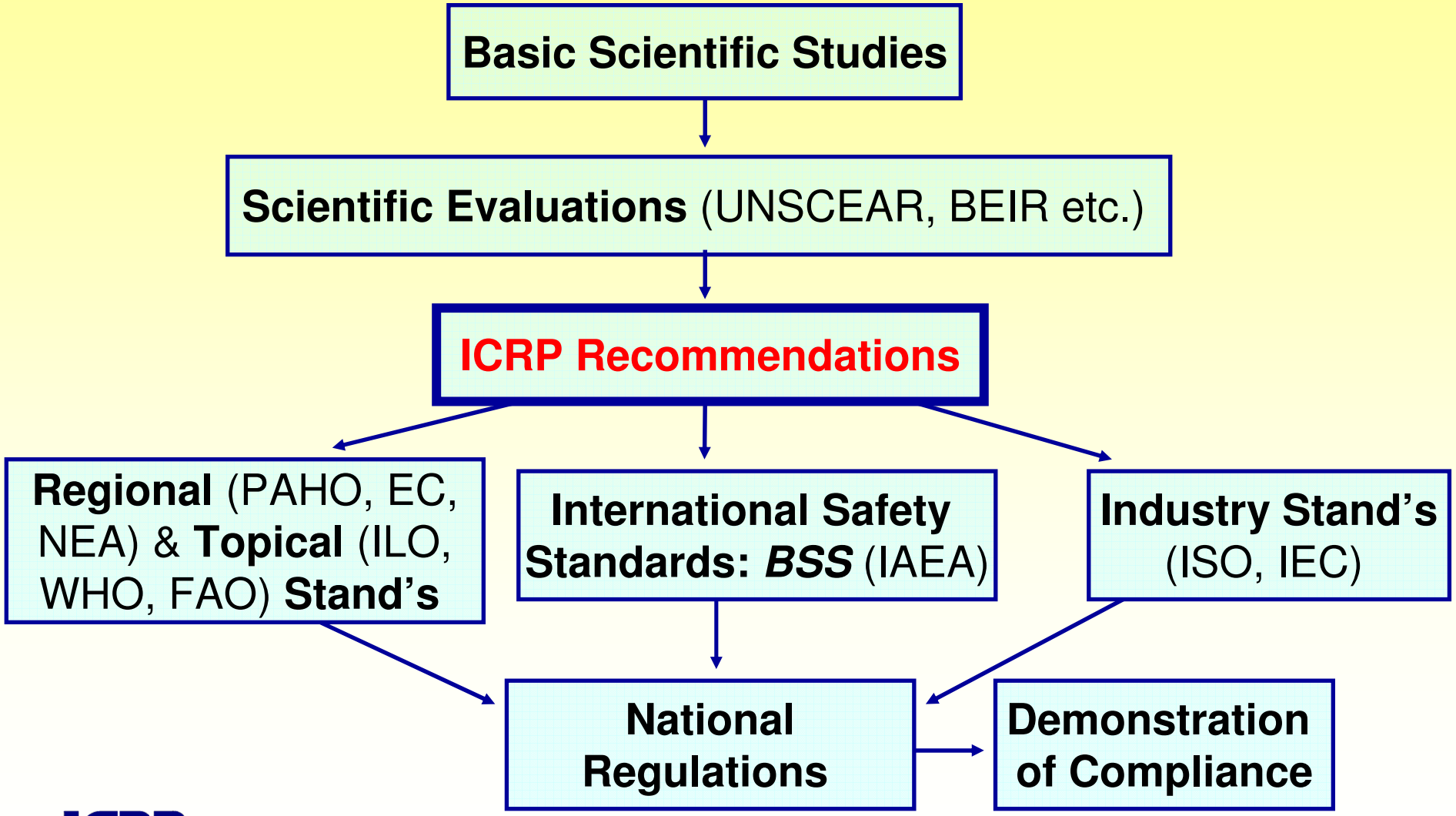
- **Take account of new science**
- **Feed back experience of current radiation safety standards**
- **Improve & streamline the presentation**
- **Use an open, transparent process** (9 years gestation!)
- **Maintain as much stability as is consistent with the new information**

To Get the Recommendations...

- **Buy printed or electronic copies**
  IRPA Associated Societies are eligible for a discount
- **Developing countries: free download at HINARI**
- **Junior staff: coming summary in JRP**
- **For all of this, see www.icrp.org**
- **Or translate them** (an Italian version is ready!)

Chapter 1:
History, development, structure

ICRP In The Cosmic Scheme



Chapter 2:
Aims and scope

Primary Aim of Our Recommendations

To *contribute to* an *appropriate* level of protection for people

and the environment

without *unduly* limiting the *desirable human activities* that may be associated with radiation exposure

The Principles of Protection

Source-related, in all exposure situations:

- **Justification**
  More benefit than detriment

- **Optimisation of protection**
  Dose and risk constraints to
  (a) increase equity,
  (b) consider multiple sources

Individual-related, in planned exposure situations

- **Application of dose limits**
  Except medical exposure of patients

ICRP Value Judgements - Constraints & Equity

Utilitarian ethics *Judge actions by the consequences*	
Justification *Do more good than harm*	
Optimisation *Maximise good > harm*	

ICRP Value Judgements - Constraints & Equity

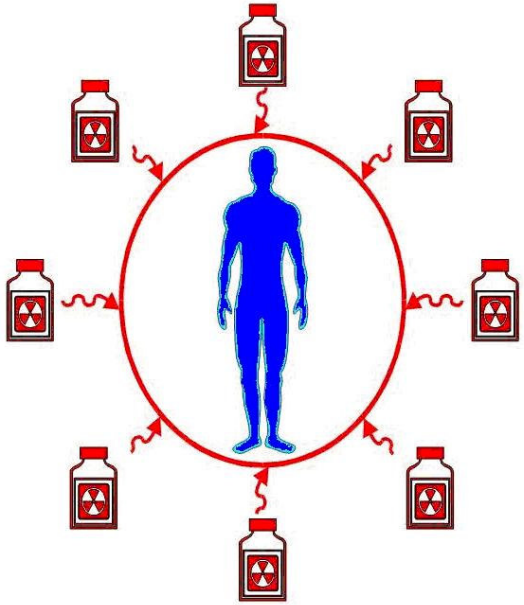
Utilitarian ethics	**Deontological** ethics
Judge actions by the consequences	*Some duties are imperative*
Justification	***Limitation***
Do more good than harm	*No individual unduly harmed*
Optimisation	
Maximise good > harm	

ICRP Value Judgements - Constraints & Equity

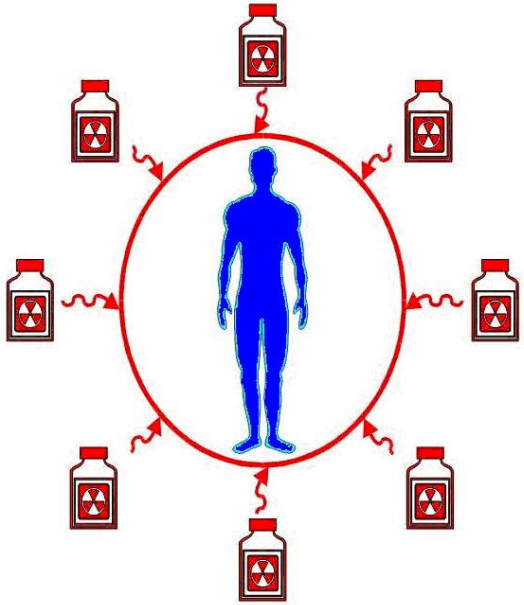
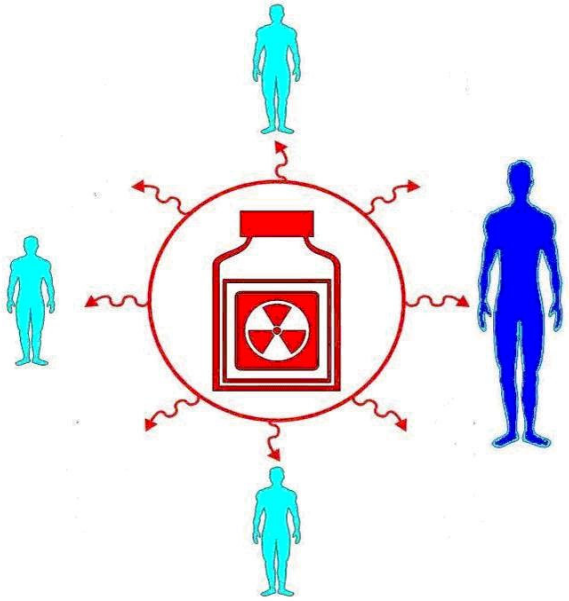
Utilitarian ethics	**Deontological ethics**
Judge actions by the consequences	*Some duties are imperative*
Justification	***Limitation***
Do more good than harm	*No individual unduly harmed*
Optimisation	***Dose constraints***
Maximise good > harm	*Increased equity = emphasise the individual*

ICRP Value Judgements - Constraints & Equity

Limits, Levels – Constraints & Multiple Sources

DOSE LIMITS	DOSE CONSTRAINTS / REFERENCE LEVELS
Protect individuals from PUBLIC and OCCUPATIONAL exposure…	
from ALL regulated sources, in PLANNED exposure situations	
	

Limits, Levels – Constraints & Multiple Sources

DOSE LIMITS	DOSE CONSTRAINTS / REFERENCE LEVELS
Protect individuals from PUBLIC and OCCUPATIONAL exposure…	
from ALL regulated sources, in PLANNED exposure situations	from a source, in ALL exposure situations
	

Chapter 3:
Biology

Deterministic and Stochastic Effects

These words will still be the default terms!

- **Deterministic**

  Harmful, mostly late, tissue reactions

- **Stochastic**

  Cancer and heritable disease

  Cancer probability now based on incidence, not mortality

  LNT: Scientifically plausible but not unambiguous (cf. Central Limit Theorem, i.e., valid at the population level)

Heritable Disease

- **Induced mutation rates: based on mouse studies**
  - *Induced genetic effects not demonstrable in man!*
  - *Human spontaneous mutation rates used to estimate Doubling Dose*
- **Probability of heritable risk was over-estimated in 1990**
  - *Particularly for multifactorial diseases*
- **Nominal probability coeff/s: 2 generations only**
  - *Based on UNSCEAR 2001, agrees with BEIR VII*
  - *1990 calculation to equilibrium – assumptions not sustainable*
  - *Risk after 2 generations small, no substantial difference 2 – 10 generations*
  - *Thus, no significant underestimation of genetic risk*

Epigenetic Responses to Radiation

- **Genomic instability: Damage expressed after several cell generations**
  - ***Why and how does it happen?***
  - ***Does it really affect normal cells?***
  - ***If it does, does it change the total risk assessed epidemiologically?***
- **Bystander signalling: Damage to non-irradiated cells in an irradiated cell population**
  - ***Why and how does it happen?***
  - ***Does it change the total risk assessed epidemiologically?***
- **Important for understanding - currently no way to assess effect on risk – major effect unlikely**

Adaptive Response to Radiation

- **A priming dose sometimes confers increased resistance against a second dose**
  - *Not a universal feature*
  - *Considerable variation, usually transient*
  - *Mechanistic knowledge fragmentary*
  - *Not evident at 'protection' doses*
  - *No consistent evidence of reduction of adverse health effects*

- **Thus, scientifically important but at present not relevant for radiological protection**

Females and Males

- **Nominal risk estimates for protection**
  - *Individual retrospective assessments require specific information*
- **The average achieves adequate protection for both sexes**
  - *A value judgement, based on science*
- **Thus, no need for sex-specific protection criteria**
  - *Precludes discrimination*

Nominal Probability Coefficients (% Sv^{-1})

Exposed popula-tion	Cancer		Heritable effects		Total	
	Publ. 60	2007	Publ. 60	2007	Publ. 60	2007
Whole	6.0	5.5	1.3	0.2	7.3	**5.7**
Adult	4.8	4.1	0.8	0.1	5.6	**4.2**

For practical protection purposes, the overall risk coefficient of ~5% is still appropriate

A Reminder:

1 = 2

Does ICRP Over- Or Underestimate Risk?

Chapter 4:
Physical quantities

Radiation Weighting Factors, w_R

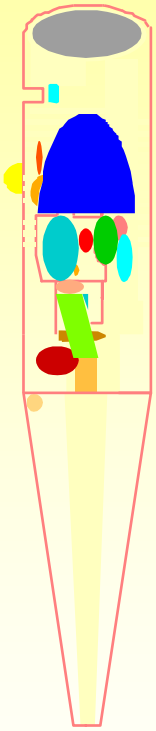
Type and energy range	Publication 60	2007
Photons, all energies	1	1
Electrons and muons, all energies	1	1
Protons	5	2
Alpha particles, fission fragments, heavy nuclei	20	20
Neutrons	Stepwise function	Continuous function <10 keV, 2.5

Tissue Weighting Factors, w_T

Tissue	w_T	$\sum w_T$
Bone-marrow, breast, colon, lung, stomach, remainder tissues *(13/14)*	0.12	0.72
Gonads	0.08	0.08
Bladder, oesophagus, liver, thyroid	0.04	0.16
Bone surface, brain, salivary glands, skin	0.01	0.04

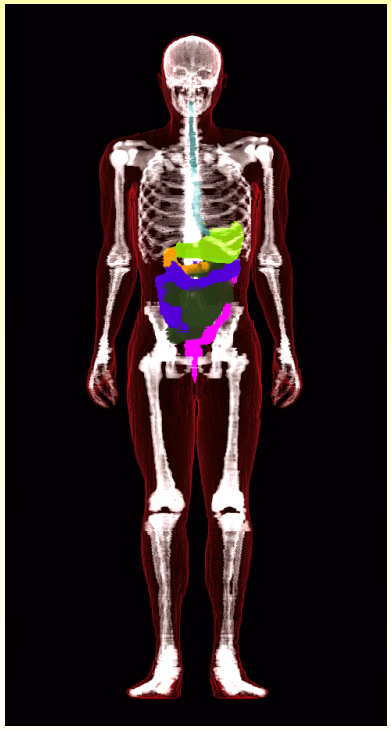
New Reference Phantoms

MIRD Phantom



Voxel Male and Female Phantoms

Fetus; child: in preparation



New dose coefficients in 2008 ☺

The Use of Effective Dose (E)

- **For compliance and prospective planning**
- ***Not* for detailed retrospective dose and risk assessments after exposure of individuals**
  particularly not for patients (old, unhealthy population)
- ***Not* for epidemiological studies** *(at least not for risk assessment)*

The Use of Collective Dose (S)

- **For optimisation**
- **For comparing technologies and protection options**
- ***Not* for epidemiologic risk assessment**
  Inappropriate to use it in risk projections based on epidemiology
- ***Not* for predicting number of cancer deaths due to trivial exposures to large populations**
  An unreasonable, unintended, incorrect use of collective dose

Collective Dose: Logical, But Is It Right?

Equates
many small doses to
few large doses…

Are 500 road traffic
casualties just as bad as
500 plane crash victims?

Chapter 5:
System of protection, man

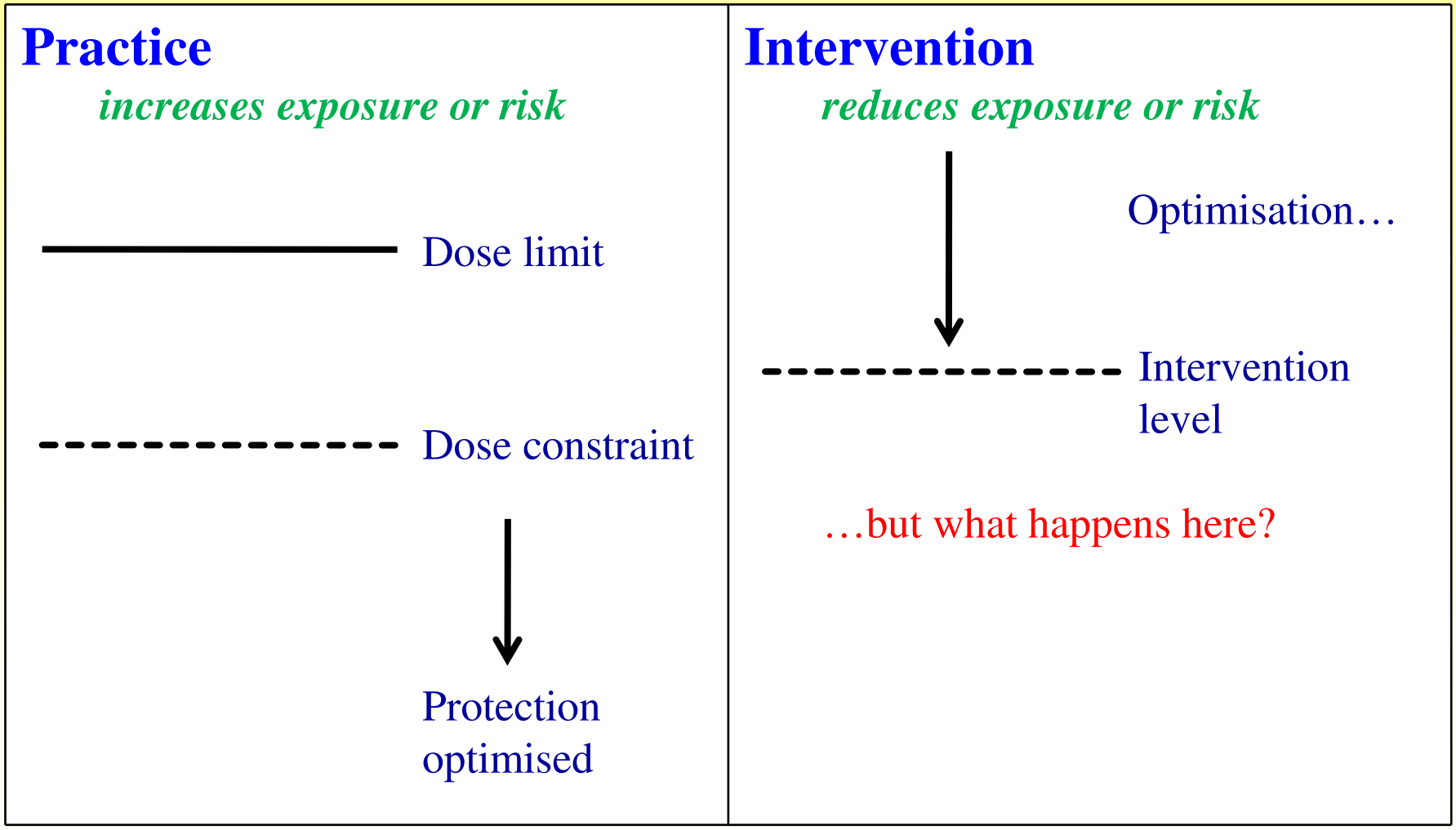
In 1990, a Process-Based Approach

Practice	Intervention
increases exposure or risk	*reduces exposure or risk*

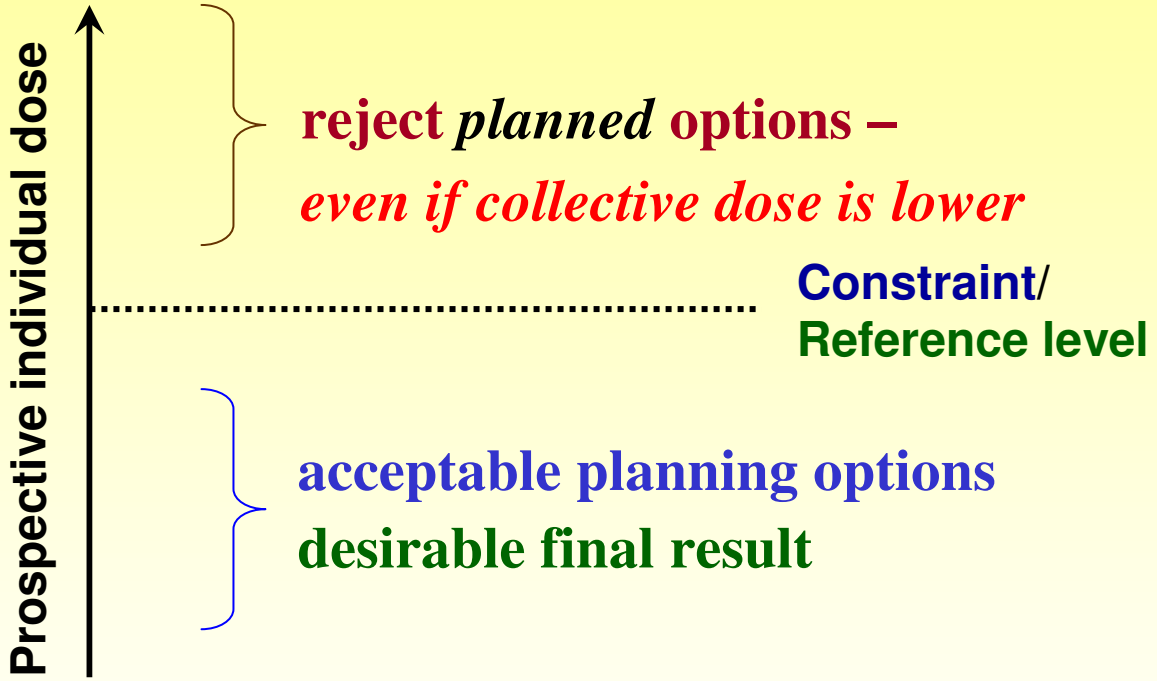
In 1990, a Process-Based Approach

Practice	Intervention
increases exposure or risk	*reduces exposure or risk*
Dose limit	
Dose constraint	
↓	
Protection optimised	

In 1990, a Process-Based Approach



2007, Exposure Situation: Planned / Emergency / Existing



Inappropriate to *plan to allow* higher exposures

How to Select Constraints / Reference Levels

- **100 – 20 mSv**

  Direct benefit. Information, training, dose monitoring.

  Example: Radiological emergencies

- **20 – 1 mSv**

  Direct or indirect benefit. Information, training, dose monitoring or assessment.

  Examples: Occupational exposures in planned situations, radon in dwellings

- **Less than 1 mSv**

  Societal benefit. Dose assessment.

  Example: Public exposures in planned situations

The Collective Dose in Optimisation

- **A key parameter (at least in occupational protection), but we usually also need to know**
  - *average dose, number exposed, range, etc*
  - *…*
- ***Perhaps* give more weight to**
  - *a few large doses than to many small doses*
  - *doses now than to doses in the far future*

Dose Limits for Planned Exposure Situations

- **They remain the same as in 1990!**

PUBLIC	OCCUPATIONAL
1 mSv in a year	**20 mSv per year,** averaged over defined 5-year periods
In special circumstances, an average of 1 mSv per year averaged over defined 5-year periods	**100 mSv in 5 years,** and less than 50 mSv in one year

Chapter 6: Implementation

Planned Exposure Situations

- **Occupational exposure**
  - *Constraint usually set by operator*
    - *(small operators may need guidance)*
  - *Transient/itinerant workers need special attention*

- **Public exposure**
  - *Constraints usually set by regulator*
    - *About 0.3 mSv in a year appropriate*
      - *0.1 mSv in a year if prolonged exposure*

Potential Exposures

- **Workplace accidents**
  - *Number of people affected is small*
  - *Detriment = health risk to those directly exposed*
- **Large disasters**
  - *Number of people affected can be large*
  - *Detriment also includes contaminated land, food restrictions, etc*
- **Exposures in the far future, e.g. from waste repositories**
  - *Considerable uncertainties*
  - *Dose calculations useful to compare protection options but not to project detriment*

Assessment of Potential Exposures

- **Everybody is responsible for safety, incl. security**
  Particularly important to remember outside the nuclear fuel cycle

- **Risk constraints: guide optimisation of protection against risk (probability of death) =**
  *Prob (accident) * Prob (death | accident dose)*

- **ICRP continues to recommend established generic constraints:**
  Potential exposure of workers: 2 10^{-4} per year
  Potential exposure of the public: 1 10^{-5} per year

Existing Exposure Situations: Radon

- **Upper level of dose: 10 mSv** (radon/progeny equilibrium)

  Upper level of activity conc. retained for continuity

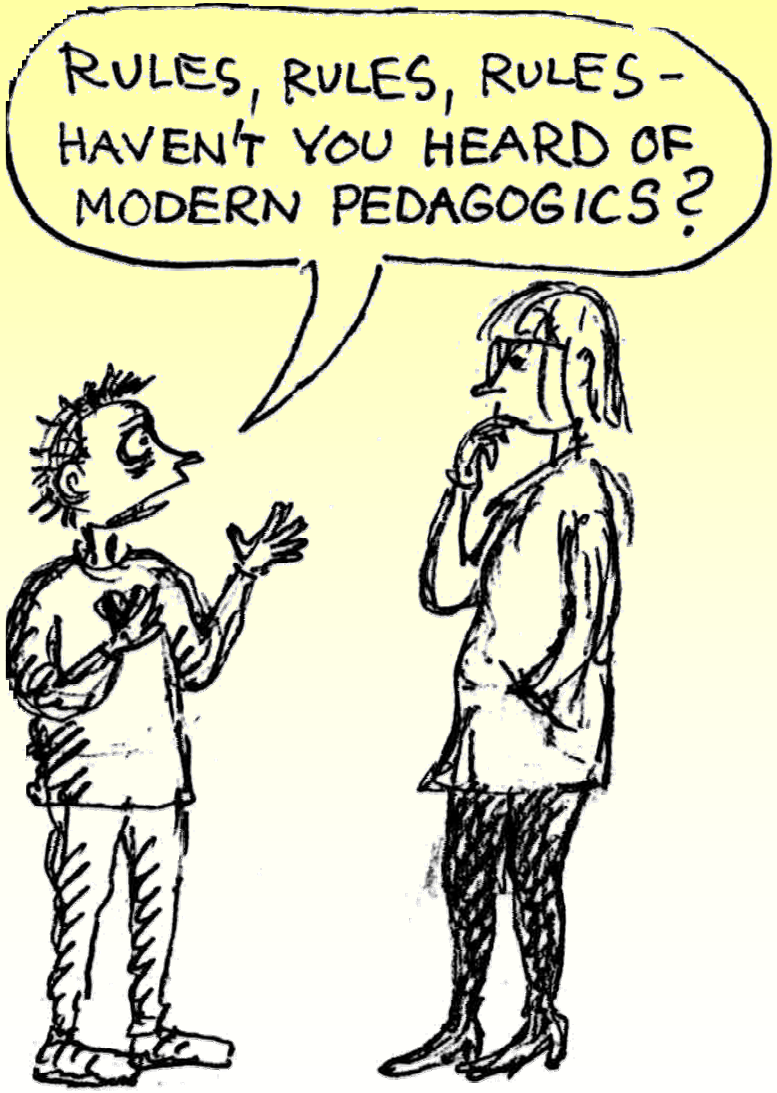
  National regulators can [should] set lower constraints

  'There is now evidence for what we thought all the time'

  No real difference UNSCEAR-ICRP; an ICRP TG statement in preparation

Situation	Reference level
Domestic dwellings	600 Bq m^{-3}
Workplaces	1500 Bq m^{-3}

Regulatory Philosophy



Chapter 7:
Medical exposure of patients

Special Features of the System of Protection

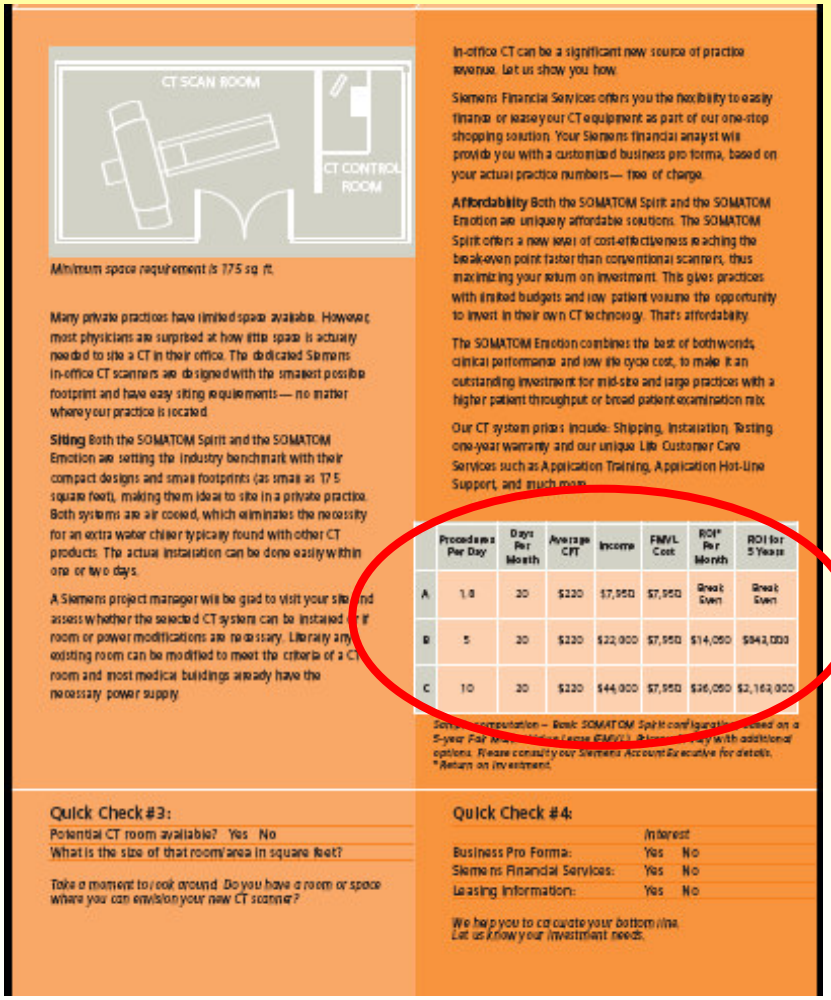
- **Justification in medicine**
  Benefit and risk apply to the same person (patient)

- **Optimisation in medicine**
  Diagnostic Reference Levels, not constraints
  Radiation therapy, maximise PTV but minimise other dose

- **Dose limits**
  Do not apply to patients

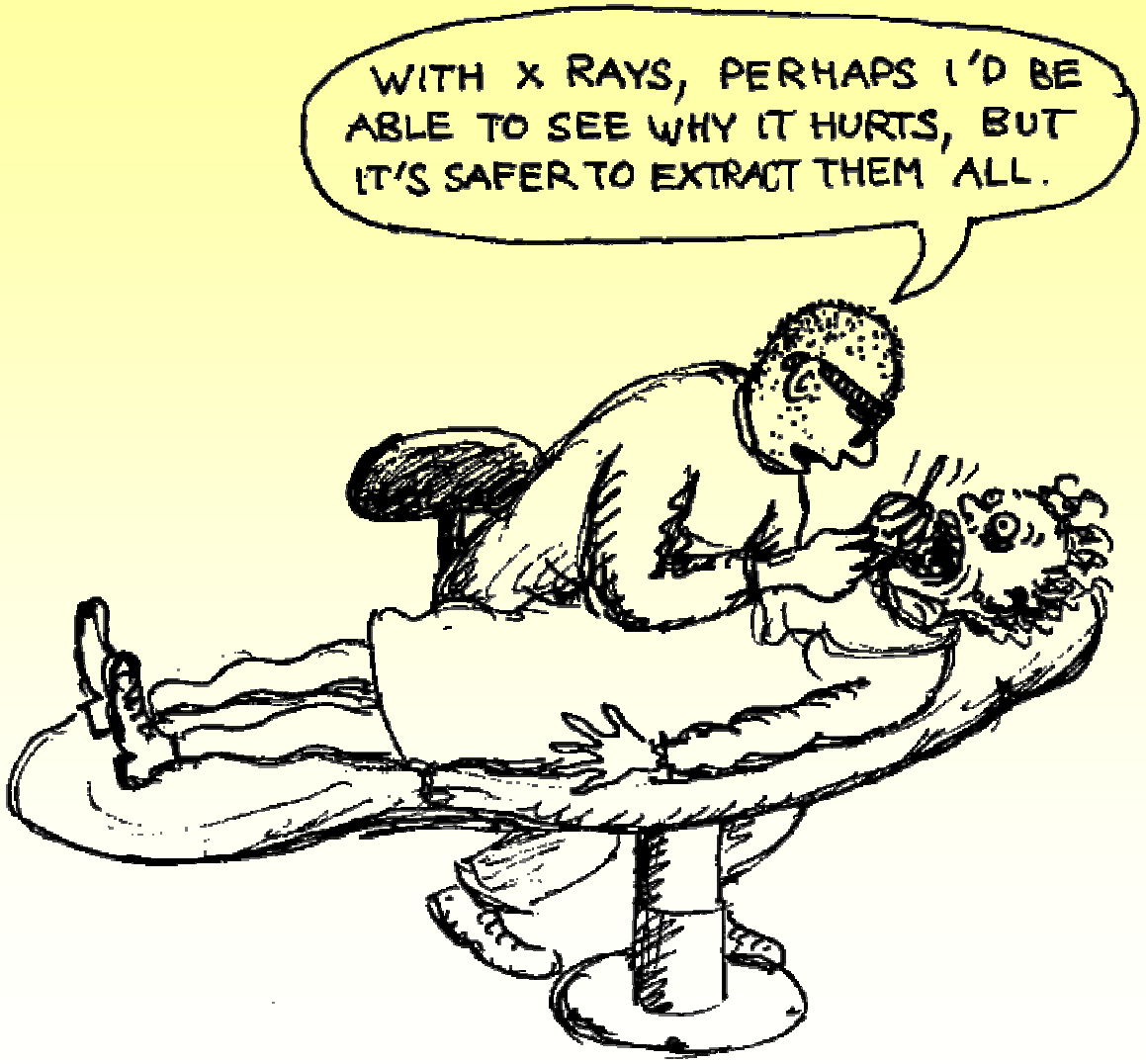
Justification or Indiscriminate Referral

'Buy Our CT, Earn $ 2,163,000 in 5 Years'

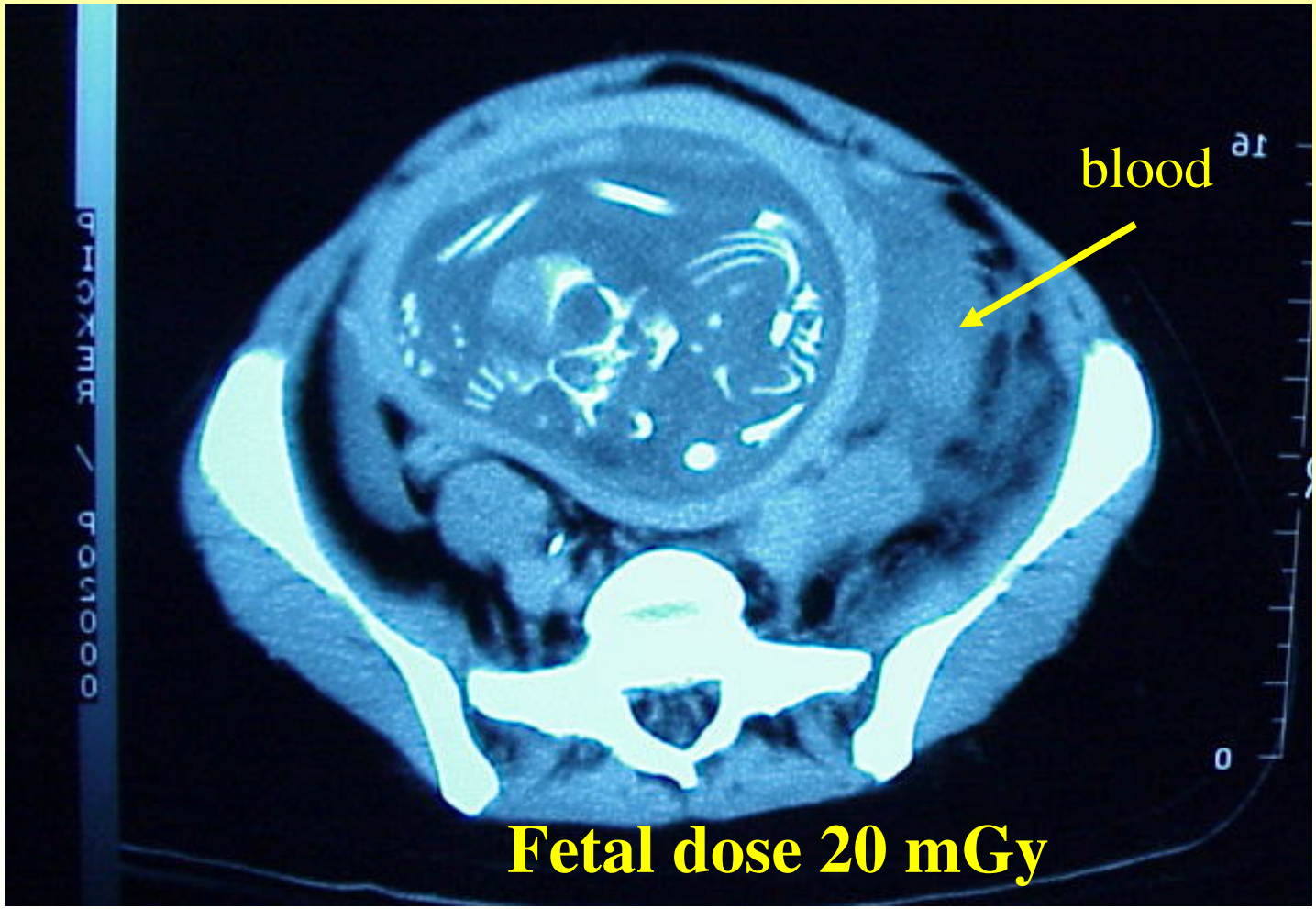


	Procedures Per Day	Days Per Month	Average CPT	Income	FMVL Cost	ROI* Per Month	ROI for 5 Years
A	1.8	20	$220	$7,950	$7,950	Break Even	Break Even
B	5	20	$220	$22,000	$7,950	$14,050	$843,000
C	10	20	$220	$44,000	$7,950	$36,050	$2,163,000

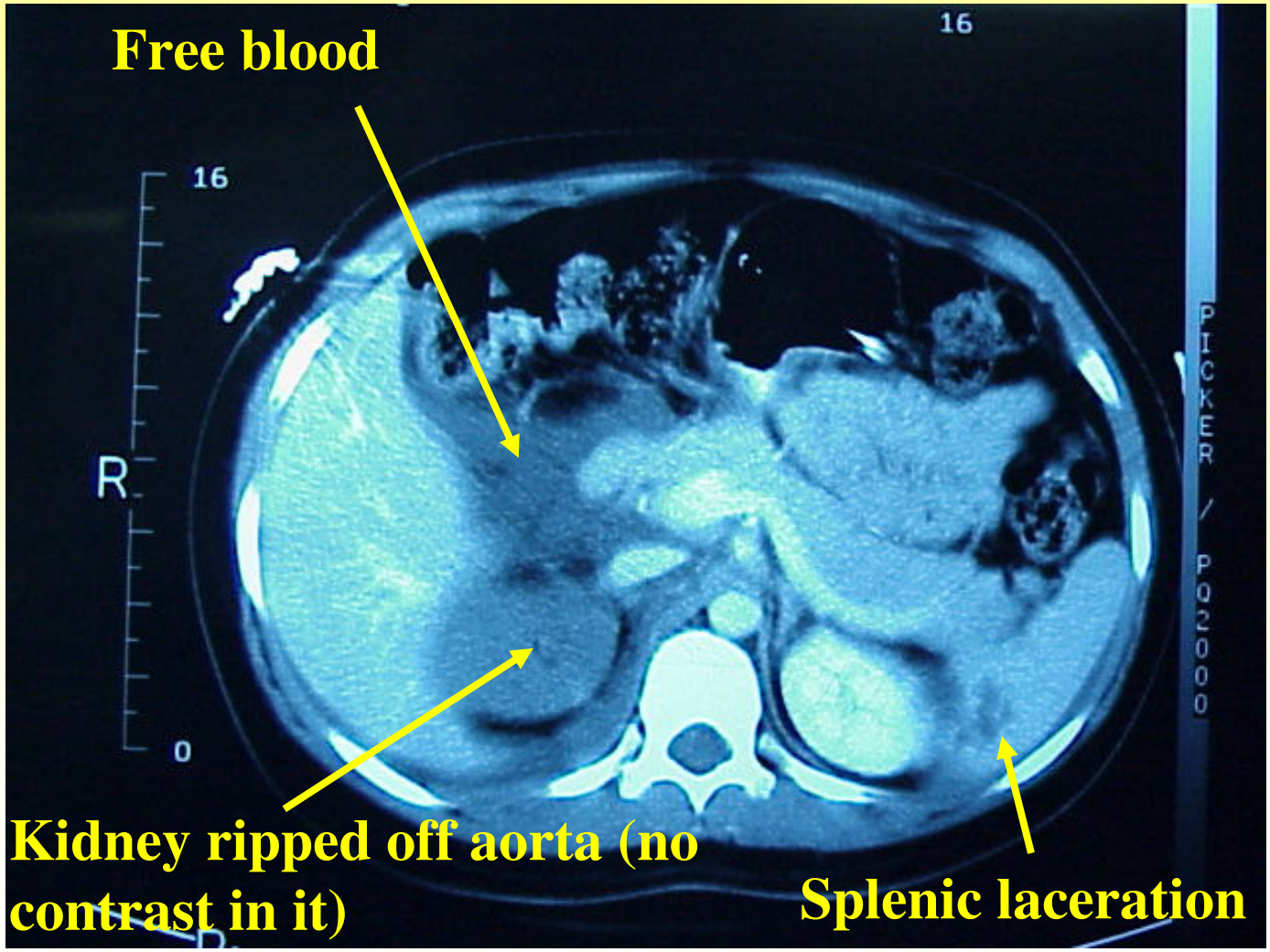
Is It Justified?



Justification in Medicine...



...3 Min. Exam, Then OR (both survived!)



Some Medical Is Justified – But...

ICRP

Chapter 8:
Protection of the environment

Why Protect Other Species?

Why Protect Other Species?

- ***NOT*** **driven by concerns of existing radiation hazards**

- **Fills a conceptual gap**

  Science to show if the environment is adequately protected
  - and methods to improve protection if required

- **Further guidance will be provided**

To Summarise, ICRP is...

- **Retaining the fundamental principles of protection**
- **Clarifying how they apply to sources and the individual**
- **Changing focus from process** *(practice/intervention)* **to exposure situation** *(planned/emergency/ existing)*
- **Extending the concept of source-related constraints to all situations**
- **Updating weighting factors and detriment**
- **Maintaining the current dose limits**

2007 Recommendations