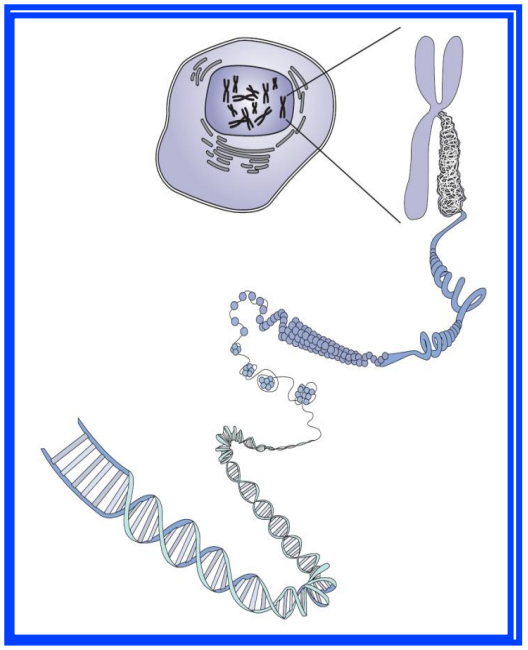
Heritable Effects

Risks of Heritable Effects for Human Beings



- Radiation effects on gonads (reproductive cells)
  - ◎ Gene mutations
    Changes in genetic information in DNA (point mutation)
  - ◎ Chromosome aberrations
    Structural chromosomal aberrations
    * Increases in hereditary diseases in the offspring have not been proved among human beings.

- Risks of heritable effects (up to children and grandchildren)
  = Approx. 0.2%/Gy (Two out of 1,000 people per gray)
  (2007 Recommendations of the International Commission on Radiological Protection (ICRP))

  This value is indirectly estimated using the following data:
  - Spontaneous incidences of hereditary diseases among a group of human beings
  - Average spontaneous gene mutation rate (human beings) and average radiation-induced mutation rate (laboratory mice)
  - Correction factor for extrapolating potential risks of induced hereditary diseases among human beings based on radiation-induced mutation rate among laboratory mice

- Tissue weighting factor for gonads (ICRP Recommendations)
  0.25 (1977) → 0.20 (1990) → 0.08 (2007)

Heritable Effects

Chromosomal Aberrations among Children of Atomic Bomb Survivors

Stable chromosome aberrations among children of atomic bomb survivors

Sources of aberrations	Number of children with chromosome aberrations (percentage)	
	Control group (7,976 children)	Exposed group (8,322 children) Average exposure dose: 0.6 Gy
Derived from either of the parents	15 (0.19%)	10 (0.12%)
Newly developed cases	1 (0.01%)	1 (0.01%)
Unknown (Examination of parents was not possible.)	9 (0.11%)	7 (0.08%)
Total	25 (0.31%)	18 (0.22%)

Source: Prepared based on "Chromosomal Aberrations among Children of Atomic Bomb Survivors (1967 - 1985 surveys)" on the website of the Radiation Effects Research Foundation (https://www.rerf.or.jp/programs/roadmap/health_effects/geneefx/chromeab/)

Heritable Effects

Survey of Children of Childhood Cancer Survivors

- An epidemiological survey to compare children of childhood cancer survivors in the United States and Canada (average gonadal dose is 1.26 Gy for females and 0.46 Gy for males) and children of those survivors' siblings does not show any increases in chromosome aberrations and Mendelian disorders expected from the average gonadal doses.*

Source: Green DM et al: J Clin Oncol Vol.27, 2009: 2374-2381

* Based on a study on hereditary influences using mice, the ICRP estimated the doubling dose** for genetic diseases due to radiation as 1 Gy.

** The doubling dose here means the gonadal dose that increases the incidence rate of genetic diseases twofold.

Heritable Effects

Abnormalities at Birth among Children of Atomic Bomb Survivors (Malformations, Stillbirths, Deaths within Two Weeks)

		Father's dose (Gy)			
		<0.01	0.01-0.49	0.5-0.99	>=1
Mother's dose (Gy)	<0.01	**2,257/45,234 (5.0%)**	**81/1,614 (5.0%)**	**12/238 (5.0%)**	**17/268 (6.3%)**
	0.01-0.49	**260/5,445 (4.8%)**	**54/1,171 (4.6%)**	**4/68 (5.9%)**	**2/65 (3.1%)**
	0.5-0.99	**44/651 (6.8%)**	**1/43 (2.3%)**	**4/47 (8.5%)**	**1/17 (5.9%)**
	>=1	**19/388 (4.9%)**	**2/30 (6.7%)**	**1/9 (11.1%)**	**1/15 (6.7%)**

Source: M. Ohtake et al.: Radiat. Res. 122: 1-11, 1990.

Heritable Effects

Other Epidemiological Surveys of Children of Atomic Bomb Survivors

Deaths from malignant tumors, etc. developed by the age of 20

The follow-up survey of 41,066 subjects revealed no correlation between parents' gonadal doses (0.435 Sv on average) and their children's deaths.

(Source: prepared based on Y. Yoshimoto et al.: *Am J Hum Genet* 46: 1041-1052, 1990.)

Incidence rate of cancer (1958 - 1997)

As a result of the follow-up survey of 40,487 subjects, development of solid tumors and blood tumors was found in 575 cases and 68 cases, respectively, but no correlation with parents' doses was observed (the survey is still underway).

(Source : prepared based on S. Izumi et al.: *Br J Cancer* 89: 1709-13, 2003.)

Deaths from cancer

As a result of the follow-up survey of 75,327 subjects conducted from 1946 to 2009, there were 1,246 deaths from cancer, but no correlation with parents' doses was observed.

(Source : prepared based on E. Grant et al.: *Lancet Oncol* 16: 1316-23, 2015.)

Prevalence rates of lifestyle-related diseases (2002 - 2006)

The clinical cross-sectional survey of approx. 12,000 subjects revealed no correlation between parents' doses and their children’s prevalence rates of lifestyle-related diseases (the survey is still underway).

(Source : prepared based on S. Fujiwara et al.: *Radiat Res* 170: 451-7, 2008.)