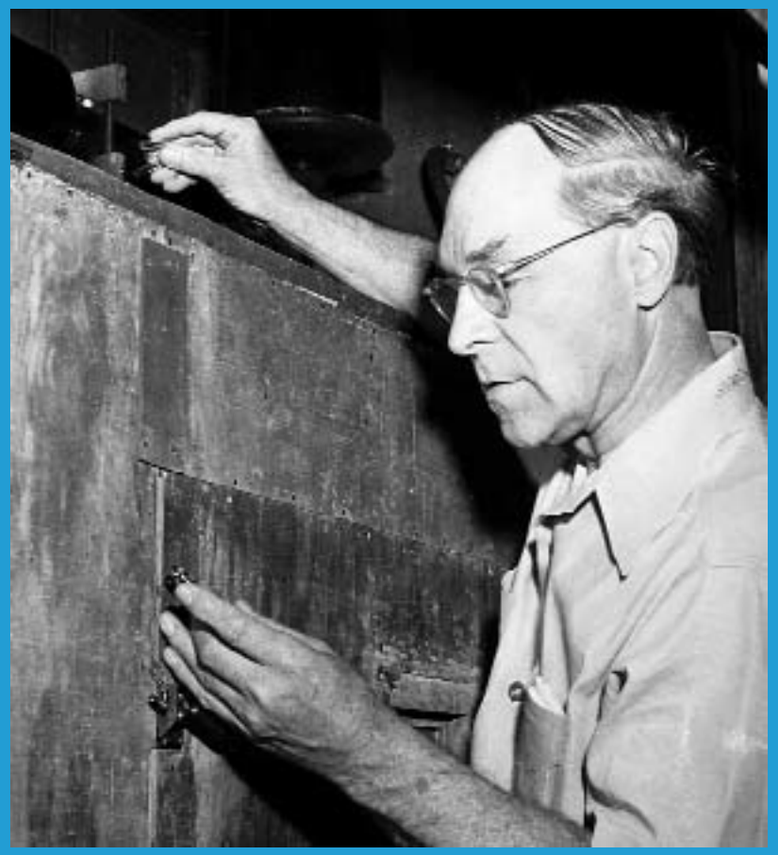
Genetic effects of ionizing radiation

Martin Walter, MD and Andreas Nidecker, MD, Prof emeritus



Hermann J Muller

ARTIFICIAL TRANSMUTATION OF THE GENE,
Science, VOL. LXVI, No. 1699
22 July 1927: 84-87

Spontaneous mutations in fruit flies are very infrequent
also
Mutation studies are very difficult because of rarity of phenotypical events

Effect of x-rays on the Genome of Fruit Flies

- x-rays produce reliable big numbers of phenotypically visible mutations in fruit flies.
  Mutation studies are facilitated by x-ray radiation of fruit flies

- Nobel Price 1946 in Medicine and Physiology for Hermann J Muller

Are there other artificial expositions to radiation we can learn from?

- Mayak (Kyshtym disaster) – 29th September 1957
- Sellafield (Windscale) – 8th October 1957
- Three Mile Island – 28th March 1979
- Chernobyl – 26th April 1986
- Fukushima – 11th March 2011

Consequences of ionising radiation through releases of radioactive material in the biosphere

- Solid cancers and hematologic malignancies
- Immunological diseases (like Diabetes mellitus typ I, Hashimoto thyreoiditis, immunodeficiency)
- Cardiovascular diseases
- Effects on neurological and brain development
- Teratogenetic effects
- **and last but not least: Hereditary and genetic consequences for the following generations**

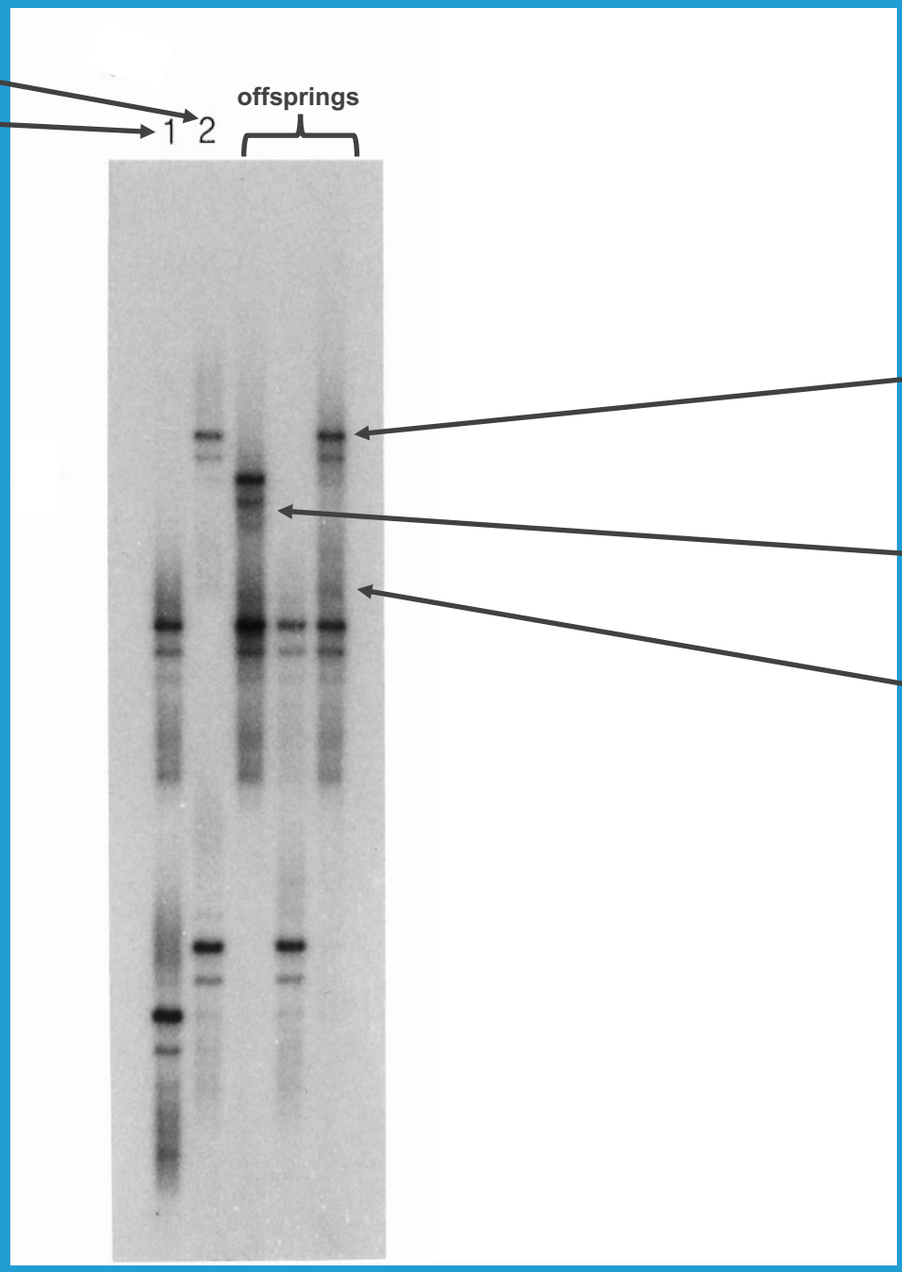
Barn swallows - albinism at Chernobyl

Pictures taken by Timothy Mousseau. Acknowledgements for the permission to use them.

Fitness loss and germline mutations in barn swallows breeding in Chernobyl, Hans Ellegren et al, Nature, 1997

2 mother

1 father



band from the mother (X)

new bands (N)

bands from the father (Y)

Example of a microsatellite germ line mutation for a barn swallow family in the Chernobyl population. Line 1 the father, lane 2 the mother, other lanes show offspring, Hans Ellegren et al, NATURE, 1997

Wild animals in Chernobyl and Fukushima

Mousseau and Møller, Journal of Hereditiy 2014

- Significant genetic, physiological, developmental and fitness effects stemming from exposure to radioactive contaminants
- Barn swallows with aberrant white feathers in Fukushima in 2012 to 2014
- Fur of animals (cattle with white spots)

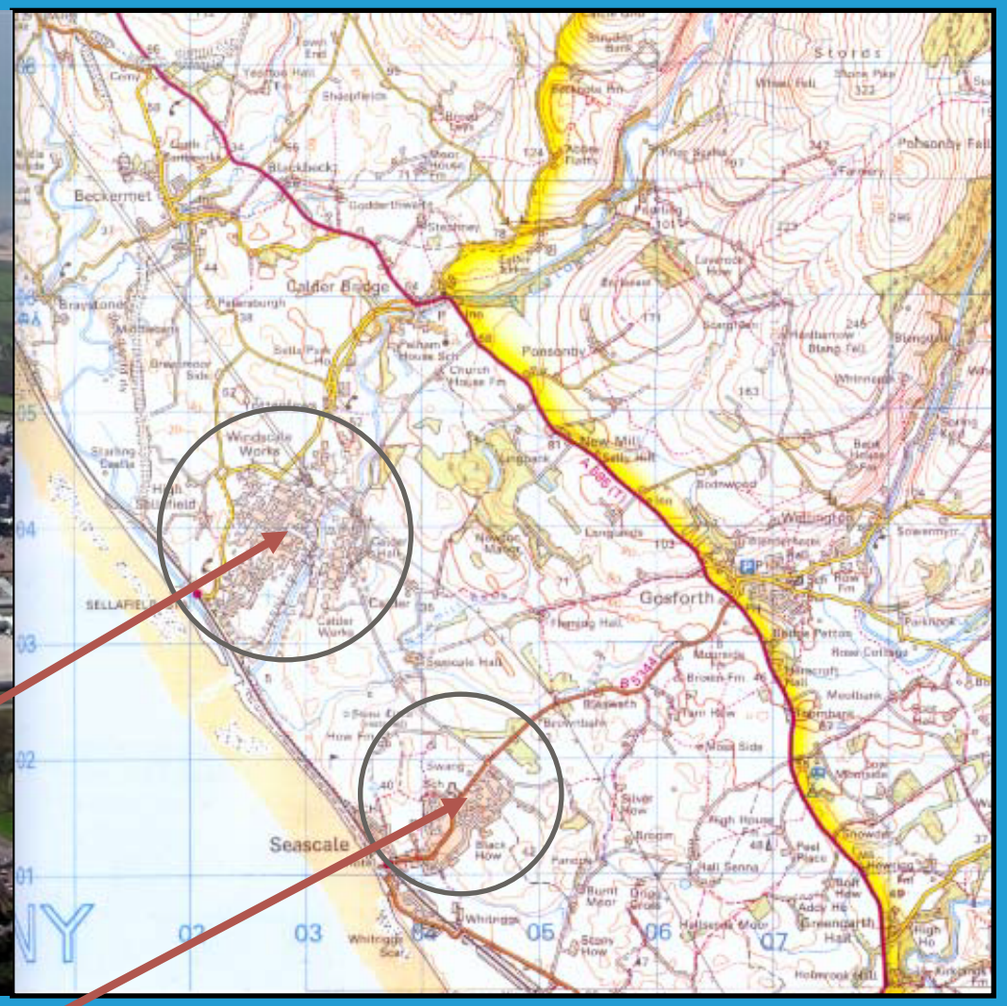
Yorkshire TV (Cutler)
„Windscale, the nuclear laundry“
1.11.1983

1956 – 1984

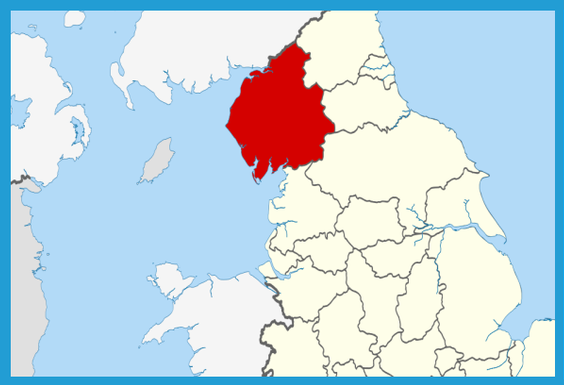
7 cases of leukaemia younger than 22 year old at diagnosis, living in Seascale village

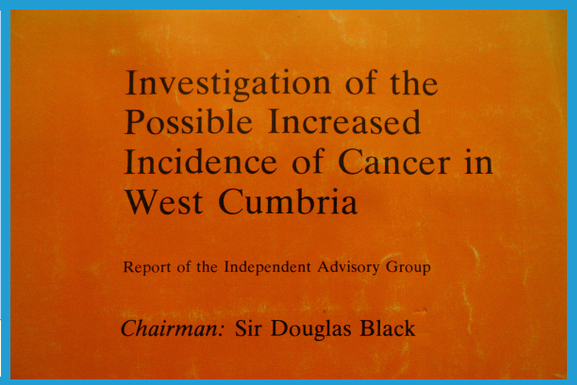
and

10-fold risk for leukaemia in children younger than 10 years (5 cases of leukemia born in Seascale village)



The **reprocessing plant** at Sellafield





LNHL (Leukaemie and Non Hodgkin Lymphoma) 66 cases (<25 yrs old people) and preconception dose of Sellafield workers in West Cumbria (Gardner et al 1990)

Dosis (mSv)	Relative risk Area controls
1-49	1.06
50-99	1.16
100-	**6.24**

Martin J. Gardner et al, British Medical Journal, 1990

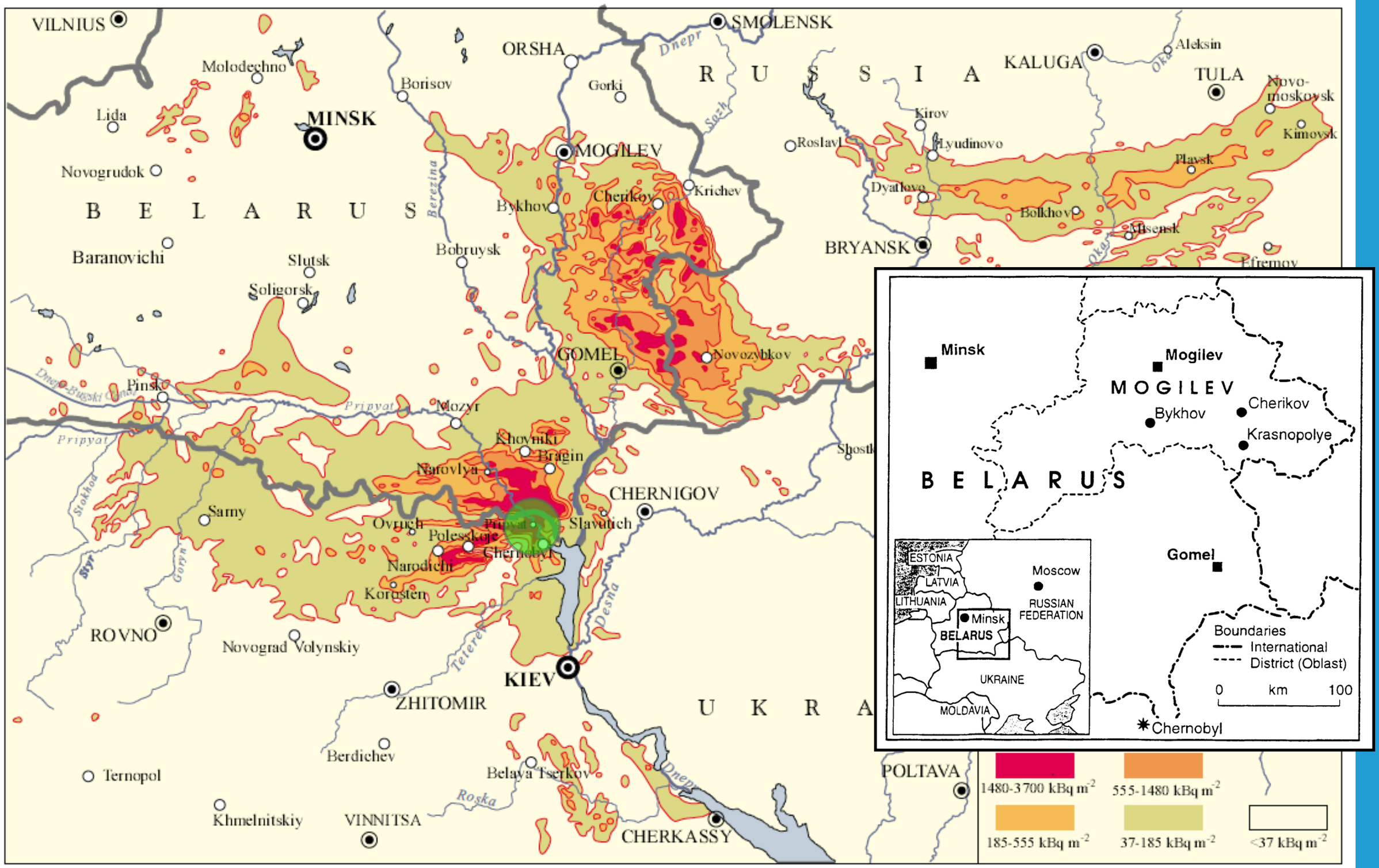
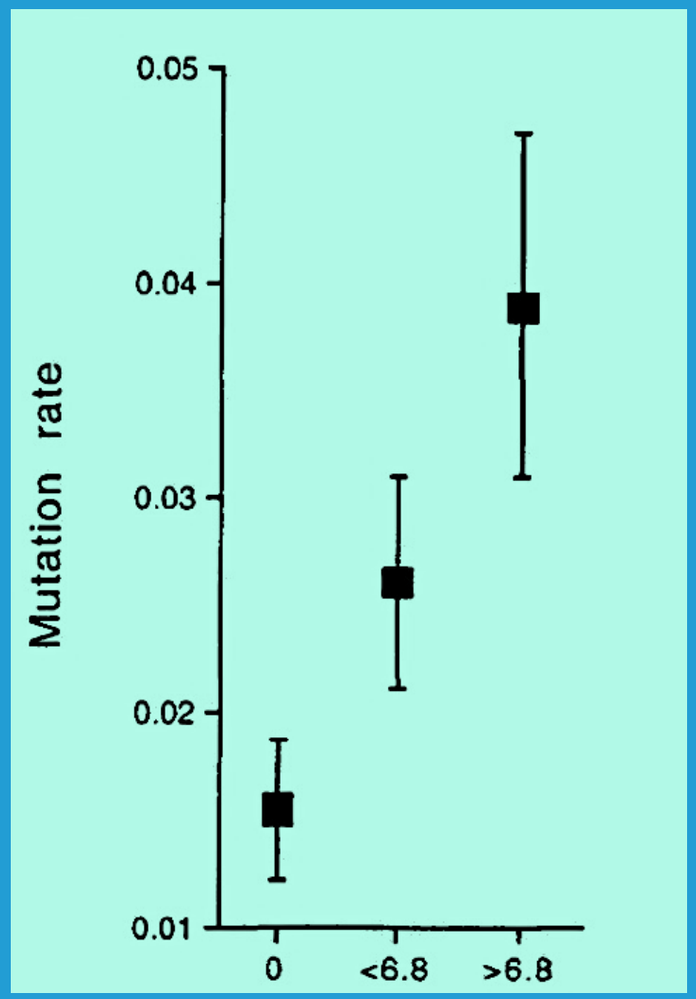


Figure VI. Surface ground deposition of caesium-137 released in the Chernobyl accident [I1, I3].

UNSCEAR (Last updated: Tuesday, 16 December 2008) - http://www.unscear.org/unscear/en/chernobylmaps.html

mutation rate per band (controls)	0.0154	twofold increase of mutations
mutation rate per band (exposed)	0.0303	



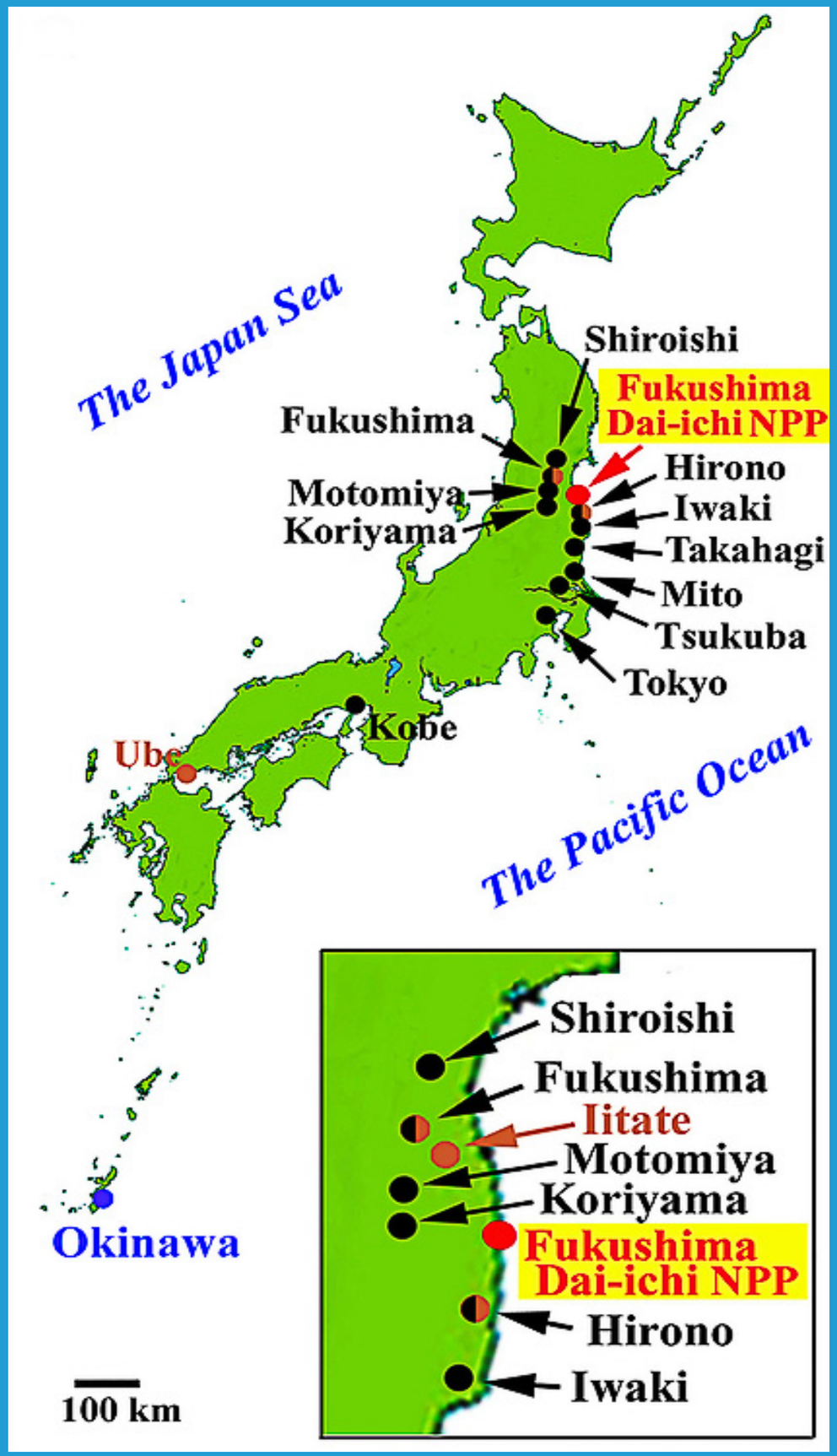
^{137}Cs surface contamination Ci km^{-2} (6.8 Ci km^{-2} = 251.6 kBq m^{-2})

Yuri E. Dubrova et al, Nature, 1996

The pale grass blue butterfly (Zizeeria maha)

The biological impacts of the Fukushima nuclear accident on the pale grass blue butterfly
Atsuki Hiyama, Chiyo Nohara et al, Scientific reports, 2012

Fukushima's Biological Impacts: The Case of the Pale Grass Blue Butterfly
Wataru Taira, Chiyo Nohara et al,, J Hered. 2014



Capture of butterflies

144 first voltine adults of Zizeeria maha (111 males and 33 females) from 10 localities

The butterflies were transferred to the Ryukyus university at Okinawa.

Eggs were reared at Okinawa and butterfly mated also there for the F1- and F2-generations

Atsuki Hiyama et al, Scientific reports, 2012

Overall abnormality rate (OAR) of adults

Adult samples	OAR (%)
Field-caught (P generation) in May (10 localities)	13.2
F_1 from the May samples (8 localities)	18.3
F_2 from the May samples (6 localities)	33.5
Field-caught (P generation) in September (7 localities)	28.1
F_1 from the September samples (6 localities including Kobe)	51.9
F_1 from the September samples (5 localities excluding Kobe)	60.2
External radiation exposure	31.7
Control (no exposure)	16.7
Internal radiation exposure	39.6

Some abnormalities of the offspring of irradiated pale grass blue butterflies

Atsuki Hiyama et al, Scientific reports, August 2012

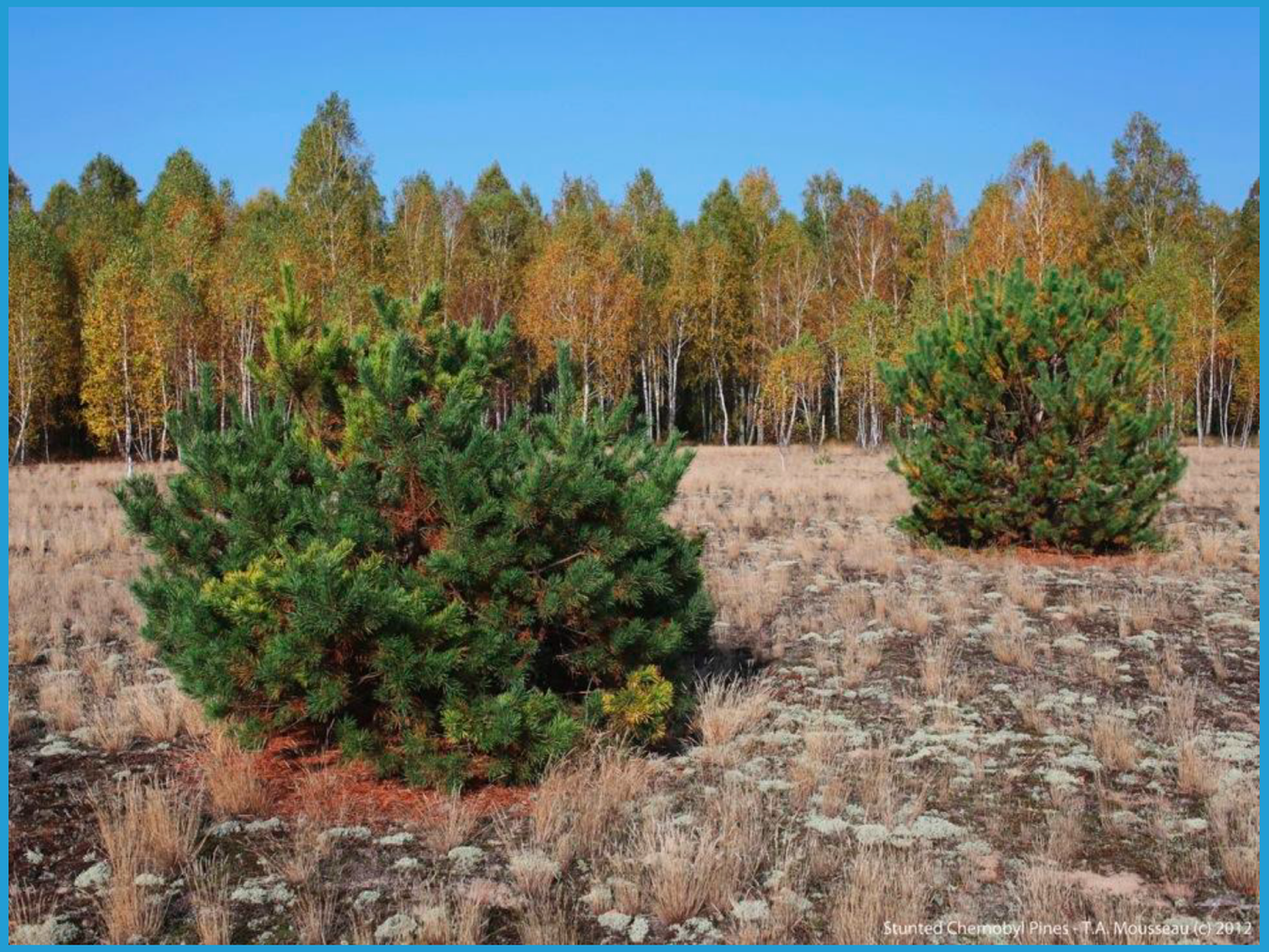
Cornelia Hesse

Flora

Pictures taken by Timothy Mousseau. Acknowledgements for the permission to use them.

Difference in width of tree rings in pine logs from Chernobyl. The year of the accident in 1986 is clearly visible from the change in the color of the wood, Timothy Mousseau et al., Trees, 2013

Malformation of Scot Pine



Pictures taken by Timothy Mousseau. Acknowledgements for the permission to use them.

Summary of examples presented

- **Ionising radiation** is mutagenic
- **Humans** as all living beings are genetically affected by radiation induced mutagenesis
- **Childhood leukemia** may have resulted from pre conception irradiation of the spermatogonia
- **There is a risk of stillbirth** to mothers who conceived a child with fathers exposed to radiation at Sellafield prior to conception
- **The dose-effect relationship** and the exact mechanism of the mutagenic process in humans are not fully understood presently.

- **The families** living in the contaminated Mogilev area who had been irradiated with up to 5 mSv per year from 1986 on, and whose children were born in 1994, experienced a two-fold increase in minisatellite-mutations compared with a control group from the UK

- **The butterfly** study demonstrated significant abnormalities, in both germline and physiological or somatic damage, following the Fukushima accident. Some traits have been passed from the F1 to the F2 generation

- **Barn swallows** experienced partial albinism and fitness loss. Their population diminished in numbers and a decline in life expectancy was observed

- **Effects on Flora,** like growth disturbances, chromosome aberrations, malformations, mutations and reproductive disturbancies

Conclusions

- It is not acceptable and ethical to relocate children, young fertile or pregnant women in contaminated areas, which would result in radiation doses of up to 20 mSv per year as it is done by the Japanese government.
- There are population groups other than children, pregnant women and their fetuses who are more sensitive to ionising radiation than the general population. We must locate and identify such hypersensitive groups and protect them stronger.

A Final Point:

- We must respect the precept widely recognized as the precautionary principle. For the long term good of humanity, we think that the precautionary principle should be applied. As a general guideline, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent health damage.

  Resettlement to areas which would expose people to dosages of up to 20 mSv per year can not be allowed.

Thank you for your attention