

Thermal Thresholds for Teratogenicity, Reproduction and Development

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Thermal Thresholds For Developmental Abnormalities

- $>1.5\text{ }^{\circ}\text{C}$ $> 1\text{ hour}$
- $2.0 - 2.5\text{ }^{\circ}\text{C}$ $0.5 - 1\text{ hour}$
- $> 4.0\text{ }^{\circ}\text{C}$ $10 - 15\text{ minutes}$

Thermal Bioeffects

Most sensitive and important irreversible effects occur in:

- ❖ **Rapidly dividing cells**
- ❖ **Fetal developmental abnormalities**

Impact of Thermal Effect

Most Organs

- Cell death replaced
- Reversible

Embryo and Fetus

- Cell death has major Effect
- Not reversible

HYPERTHERMIA

A Known Teratogen in:

Birds

Hamsters

Mice

Rats

Guinea Pigs

Sheep

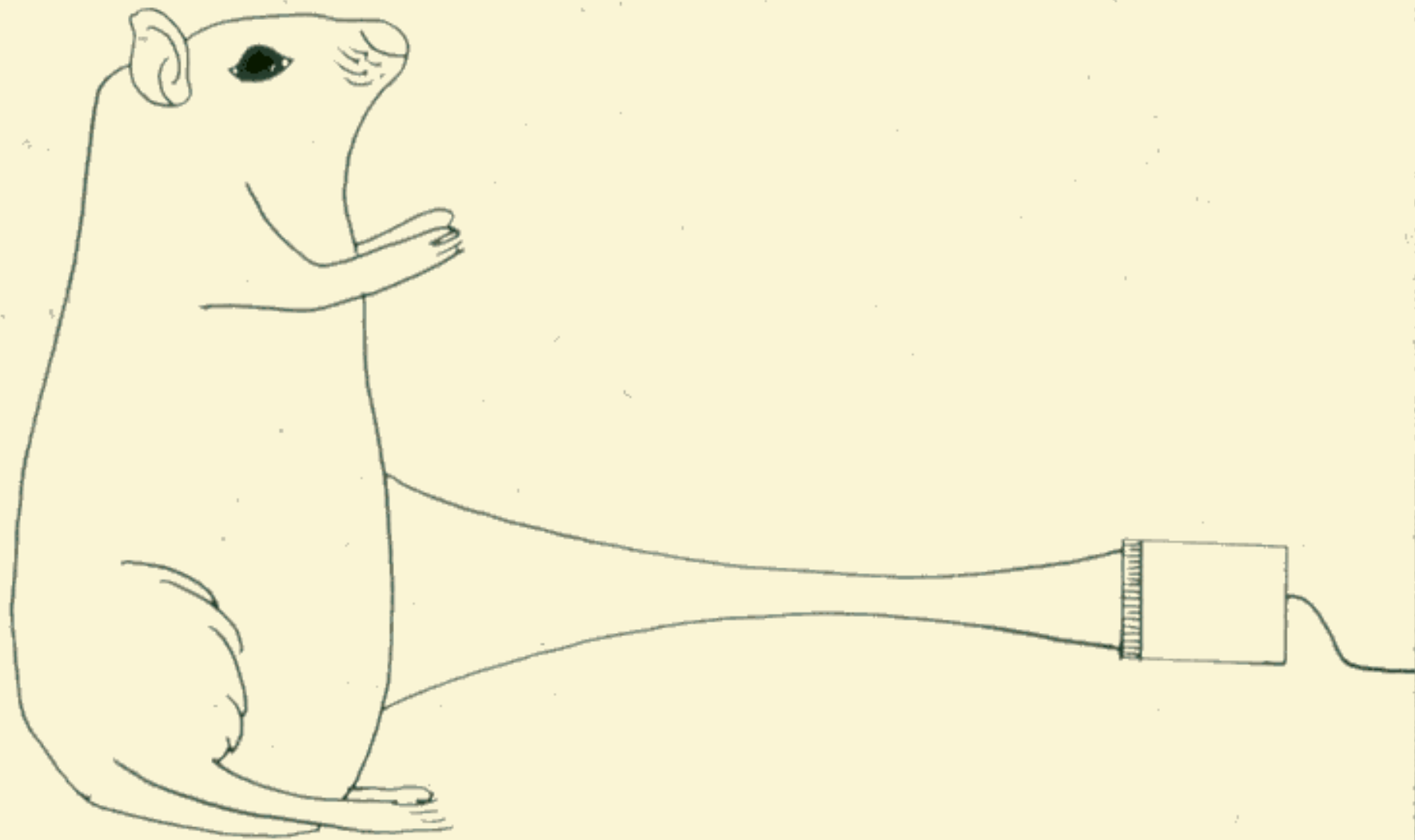
Cattle

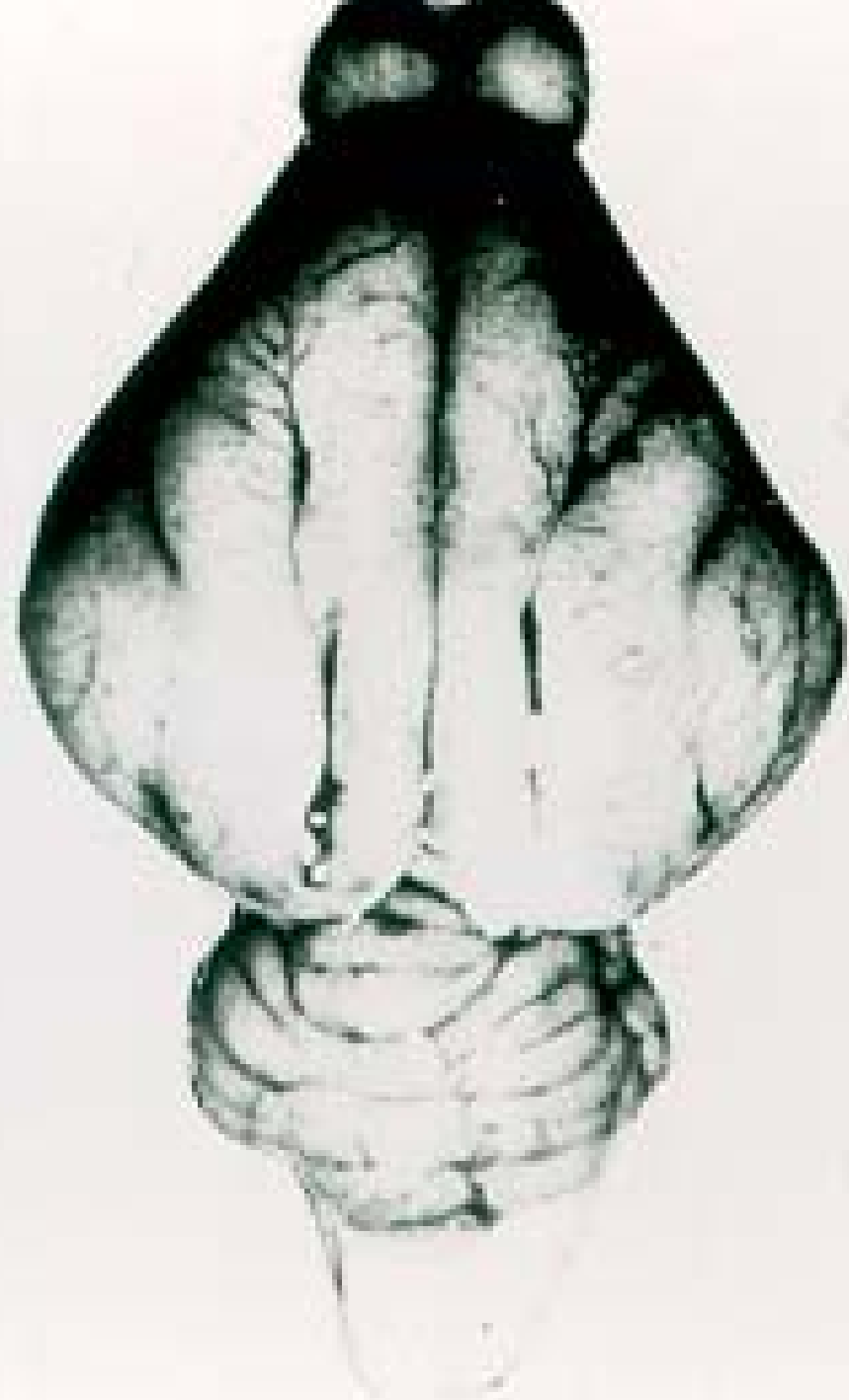
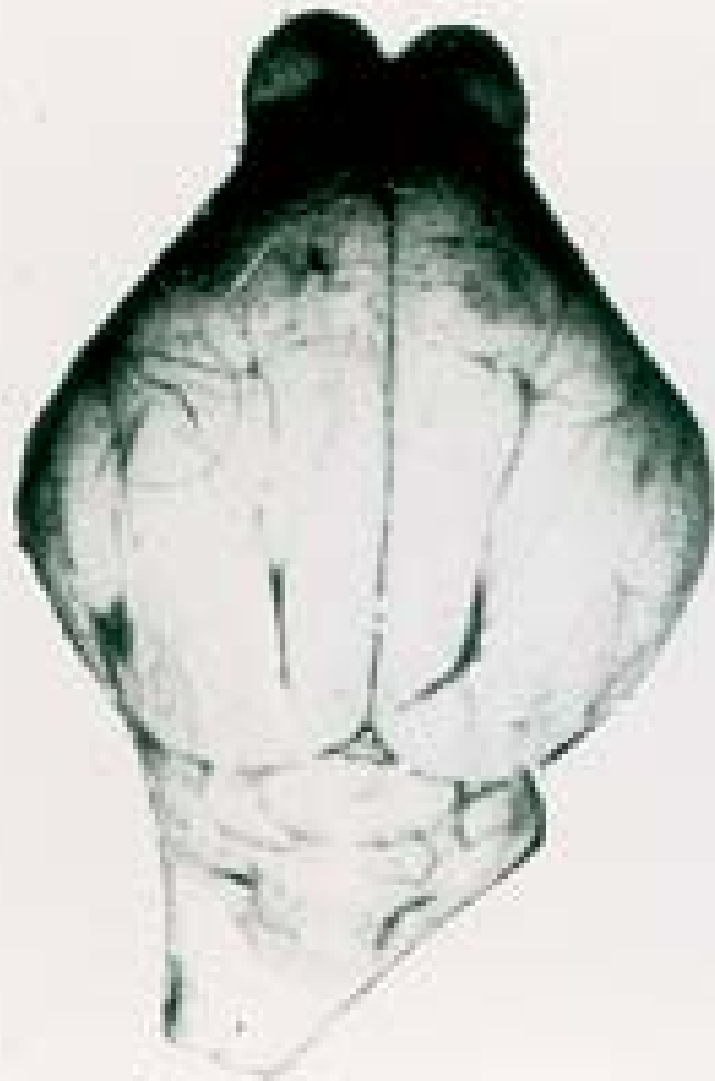
Non-Human Primates

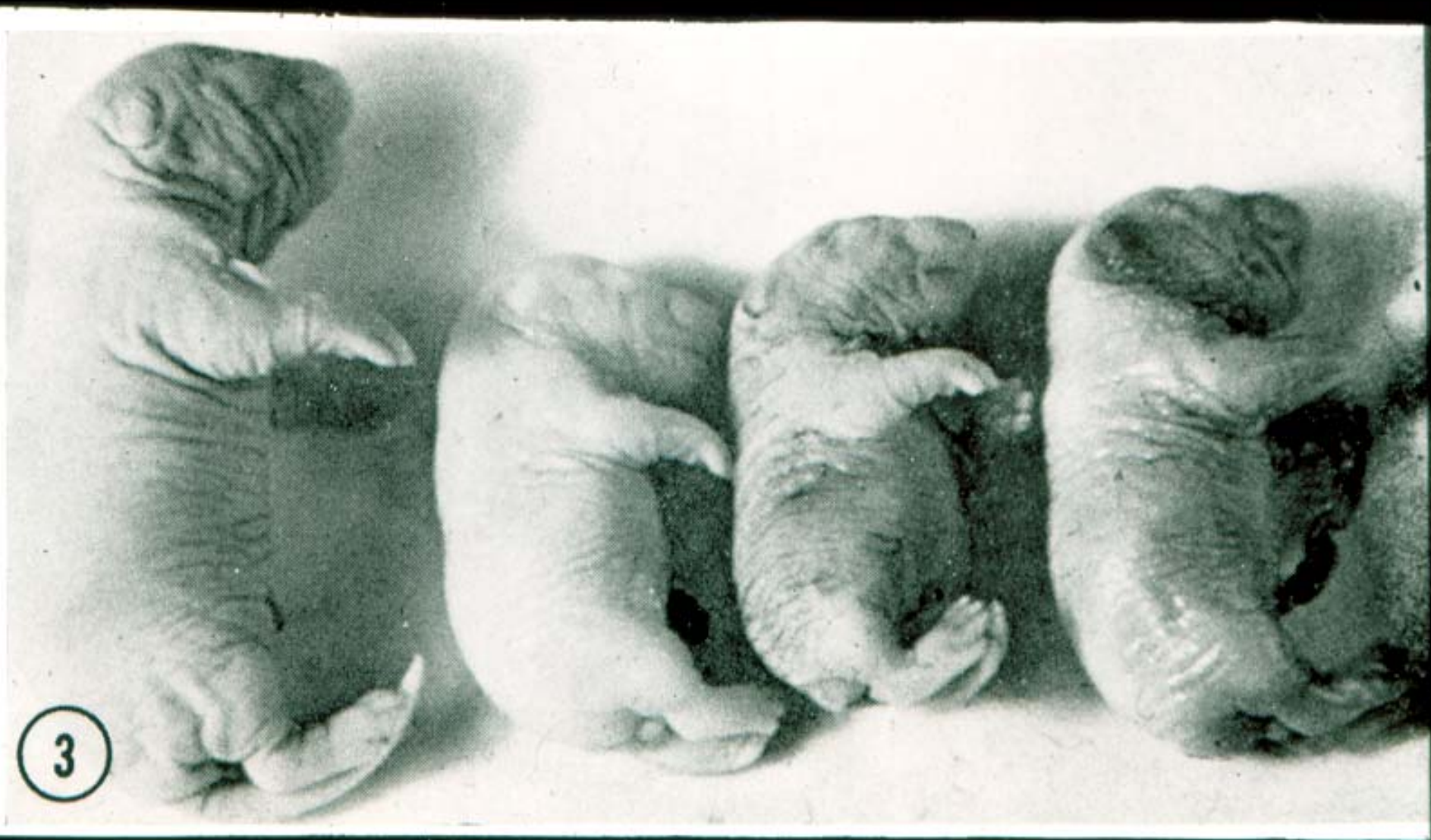






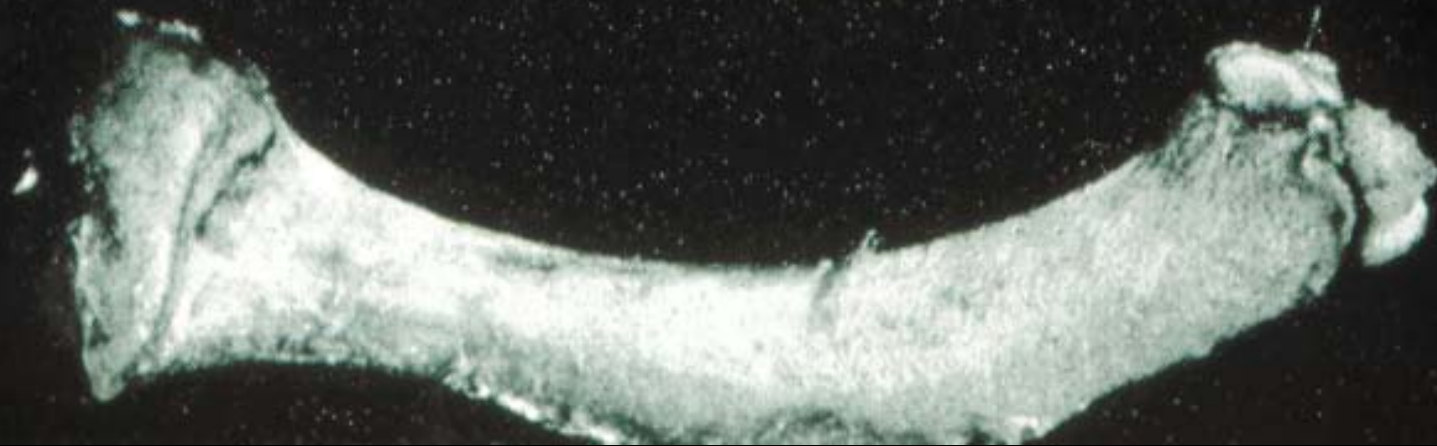




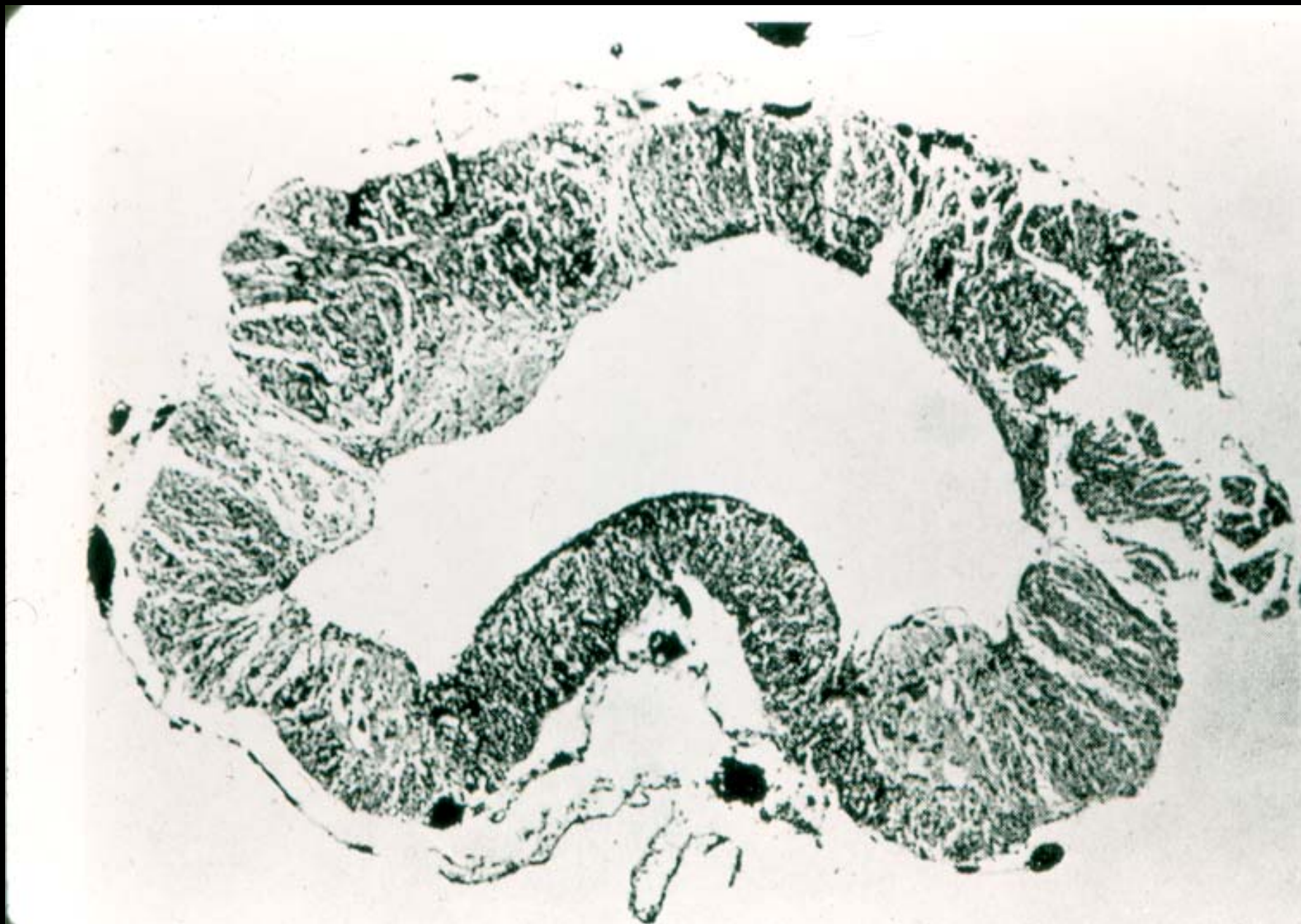


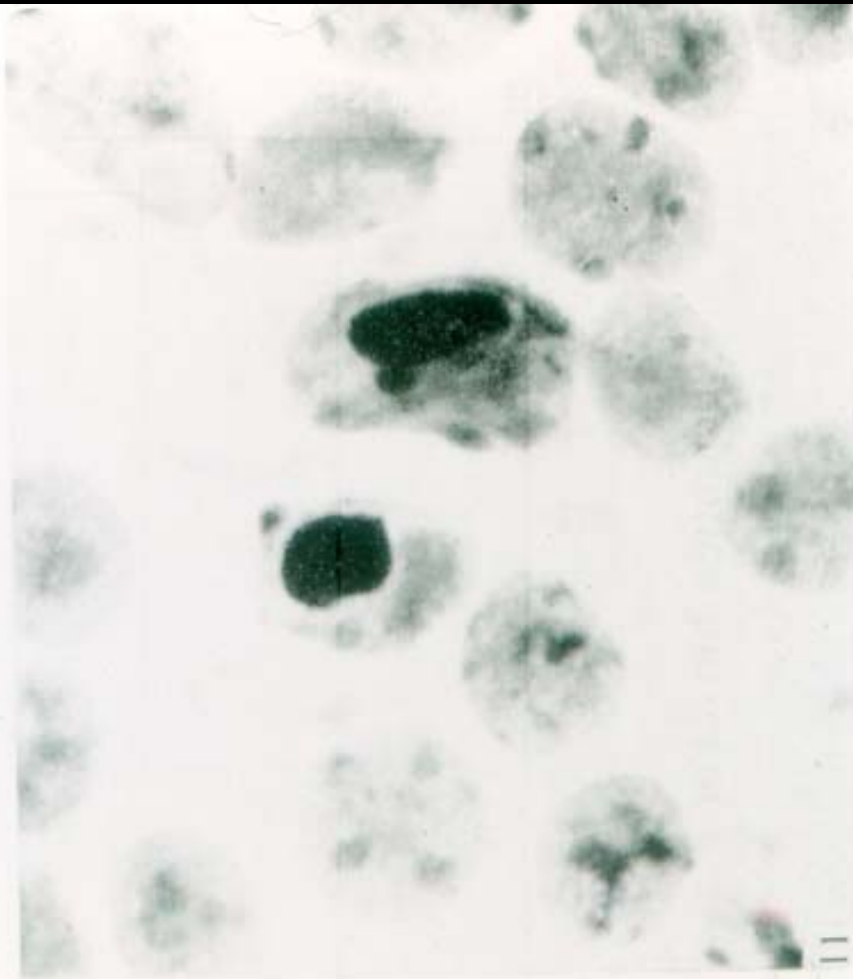
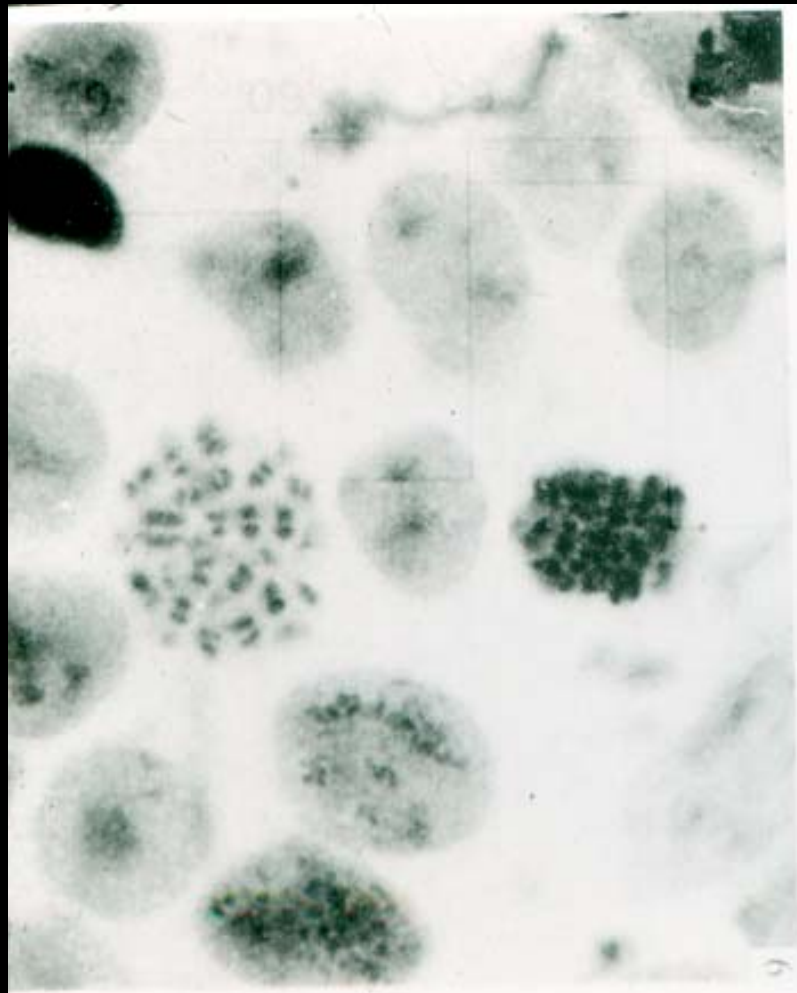


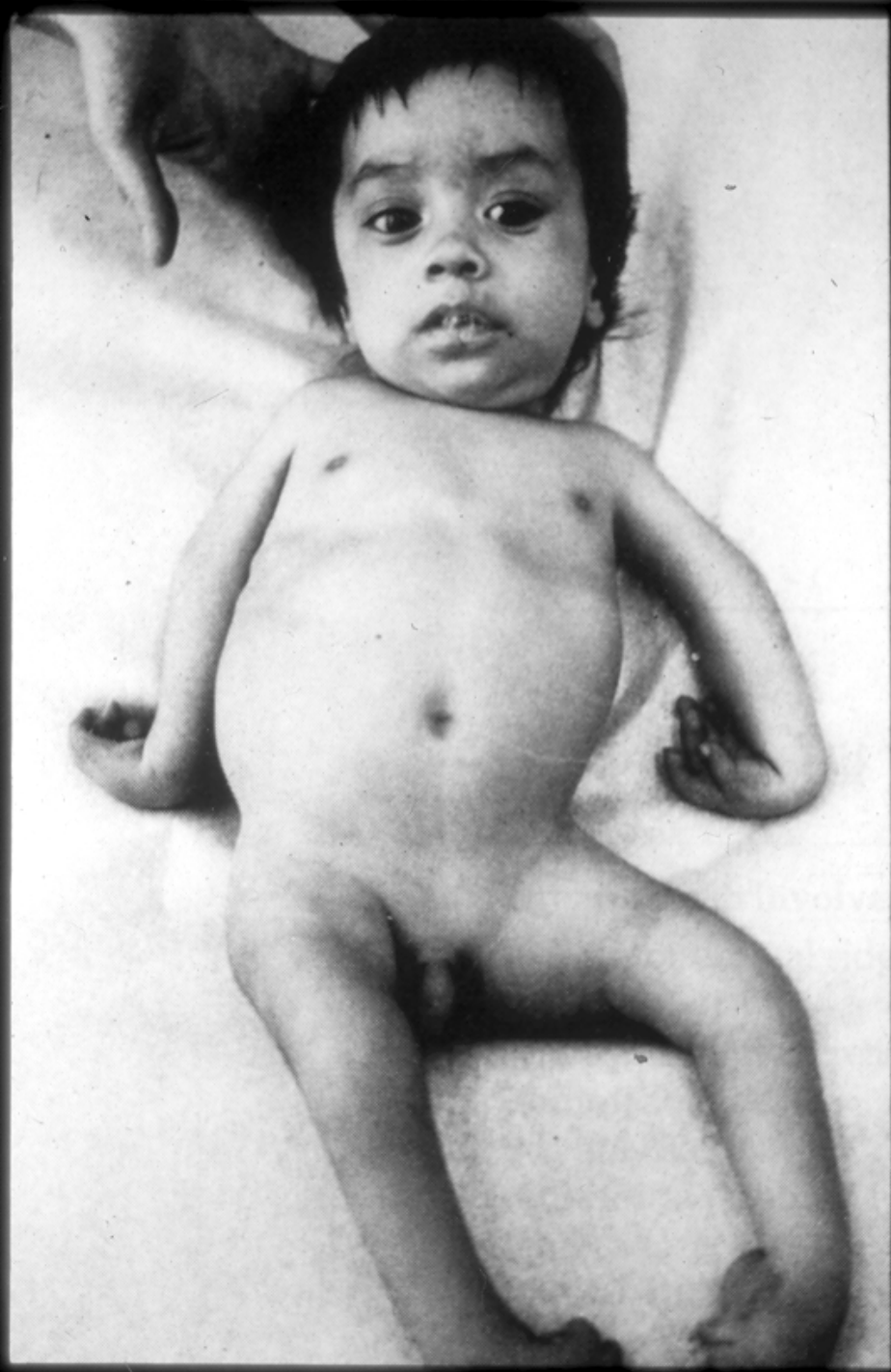
Arthrogryposis Multiforma



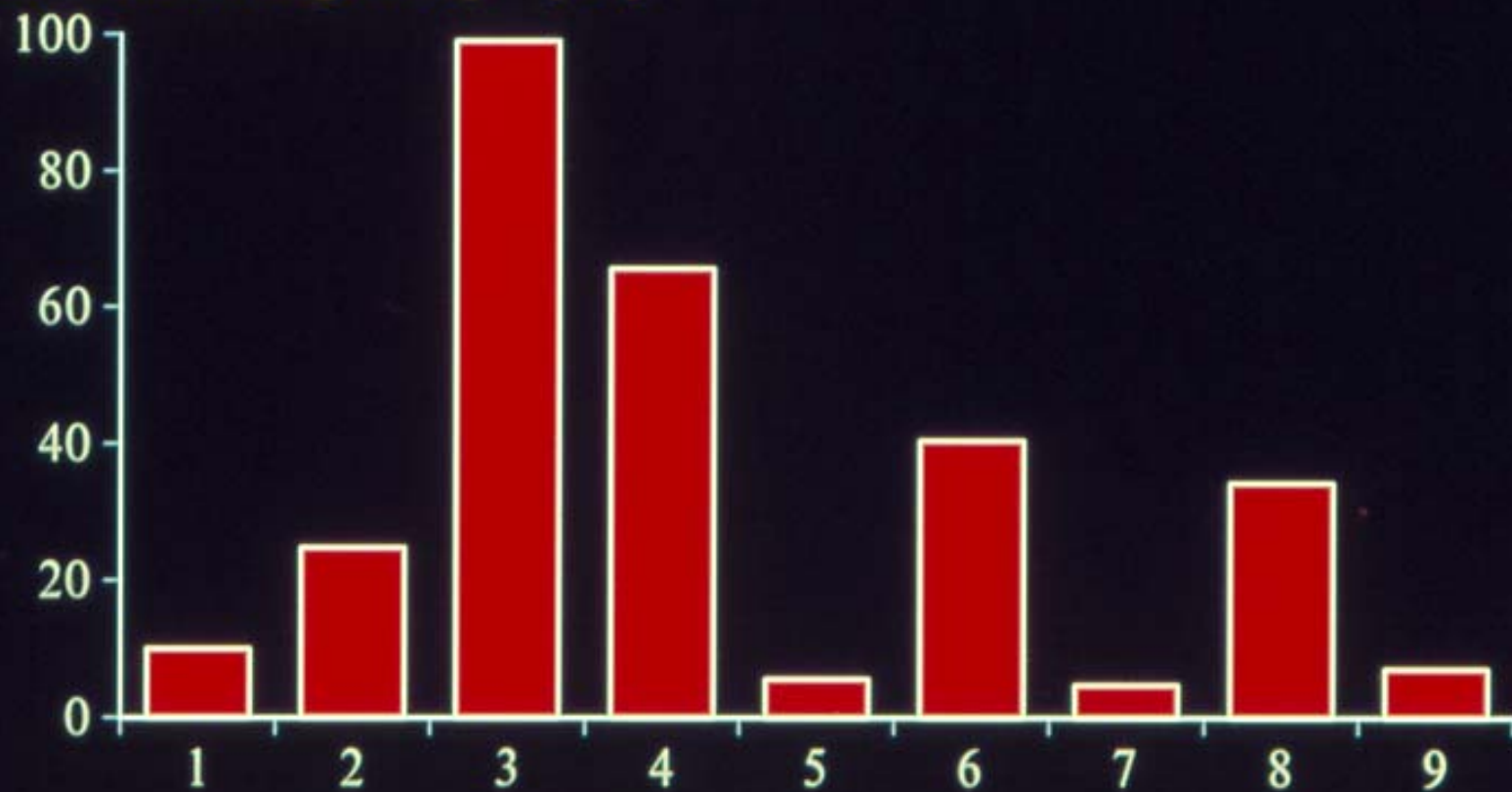






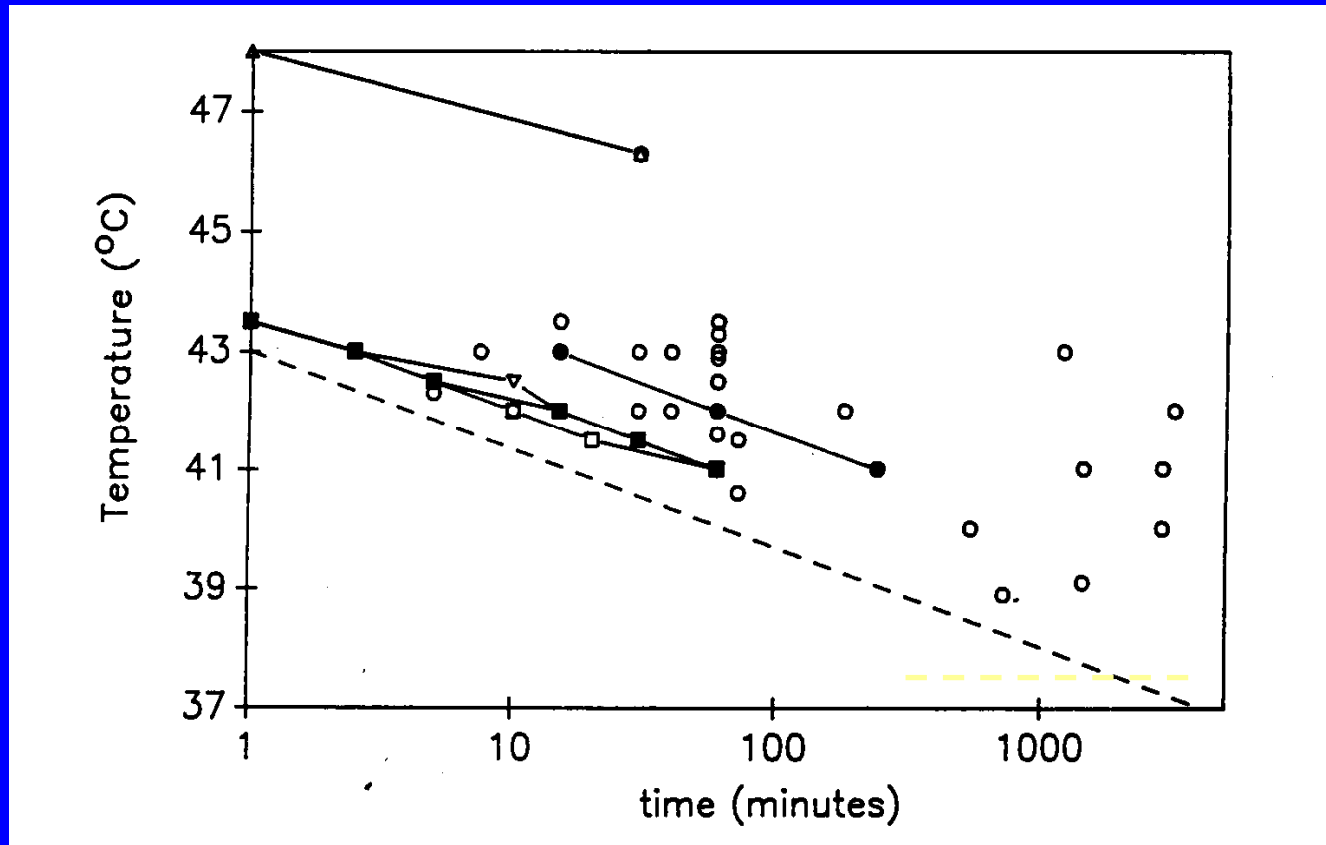


Micrencephaly (%)



Age at Time of Exposure (week of gest.)

Fetal Developmental Abnormality Thresholds



Temperature Rise From Whole Body SAR

SAR	Temp Rise	Comment
15 W/kg	4.0 °C	Abnormality
4 W/kg	1.0 °C	No Harm
1.5 W/kg	0.4 °C	Safe Level
0.4 W/kg	0.1 °C	RF Standard

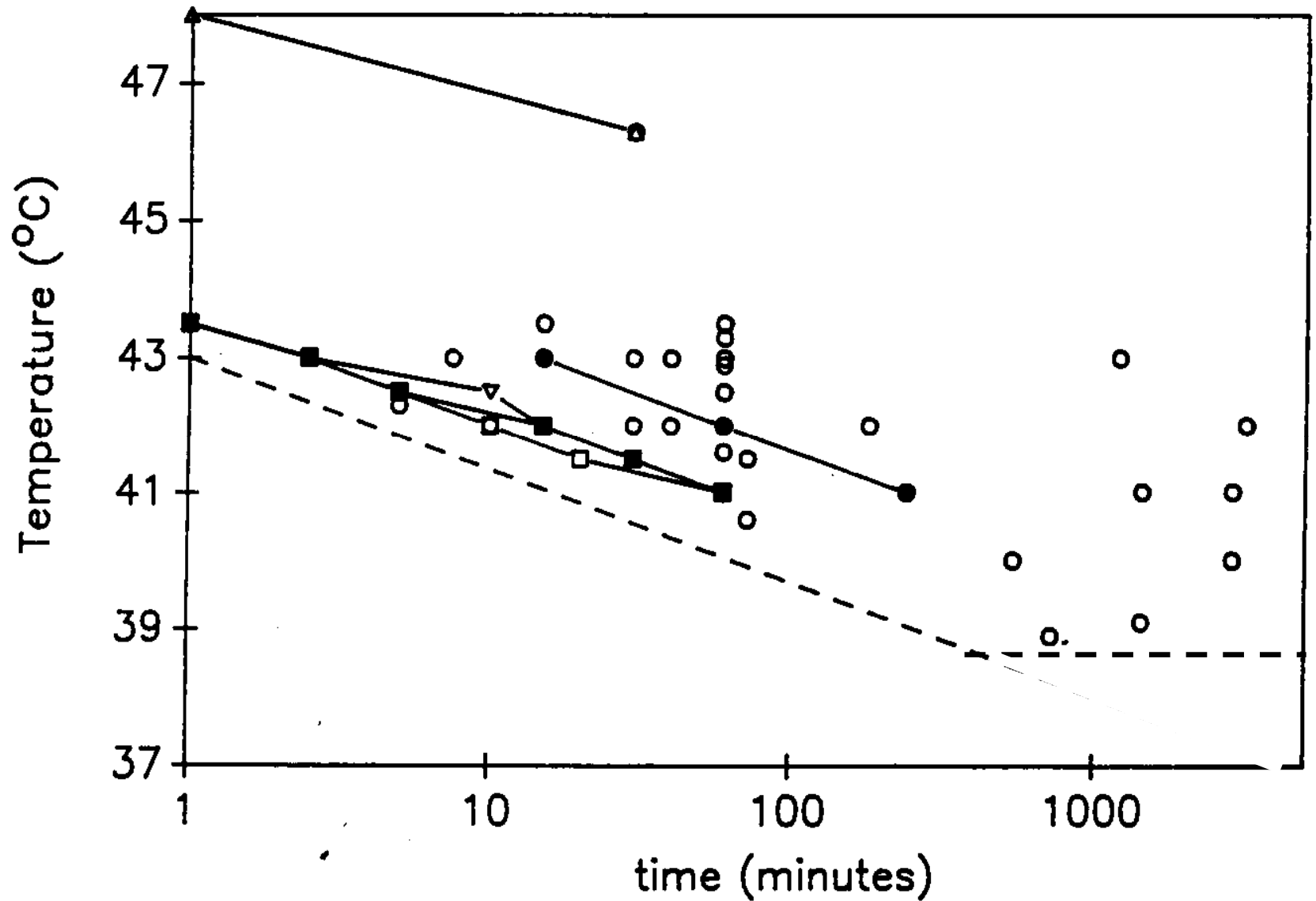
Note: Diurnal Variation = ± 0.5 °C

Thank You

COMMENTS RELATIVE TO THERMAL BIOEFFECTS

Thermal effects	Temp (°C)	Exposure duration (min)	t_{43}^{\dagger} (min)	Species	Reference
Abnormal closure of anterior neuropore	43.0	7.5	7.5	Rat	Walsh (1985b)
Abortion	40.6	72	2.6	Monkey	Hendrickx et al. (1979)
Absence of optical vesicles	43.0	7.5	7.5	Rat	Walsh (1985b)
Absent cerebral cortical plate	43.0	60	60.0	Guinea Pig	Upfold et al. (1986)
Agenesis	43.3	60	90.9	Guinea Pig	Edwards (1971)
Agnathia	43.0	60	60.0	Mouse	Pennycuik (1965)
Anencephaly	43.0	40	40.0	Rat	Edwards (1968)
Anophthalmia	40.6	72	2.6	Monkey	Hendrickx (1979)
Arthrogryposis	42.9	60	52.2	Guinea Pig	Edwards (1971)
Beak defects	41.0	1440	90.0	Chicken	Nielsen (1969)
Behavioral abnormalities	41.5	60	7.5	Marmoset	Poswillo et al. (1974)
Blebbing of cell membrane	43.0	180	180.0	Chin. Hamster	Bass et al. (1978)
Brain cavitation	40.0	540	8.4	Sheep	Hartley et al. (1974)
Brain growth retardation	40.0	2880	45.0	Rat	Cockcroft and New

Fetal Developmental Abnormality Thresholds



Temperature – Duration Relationship

$$\text{CEM}_{43} = t \times R^{(43 - T)}$$

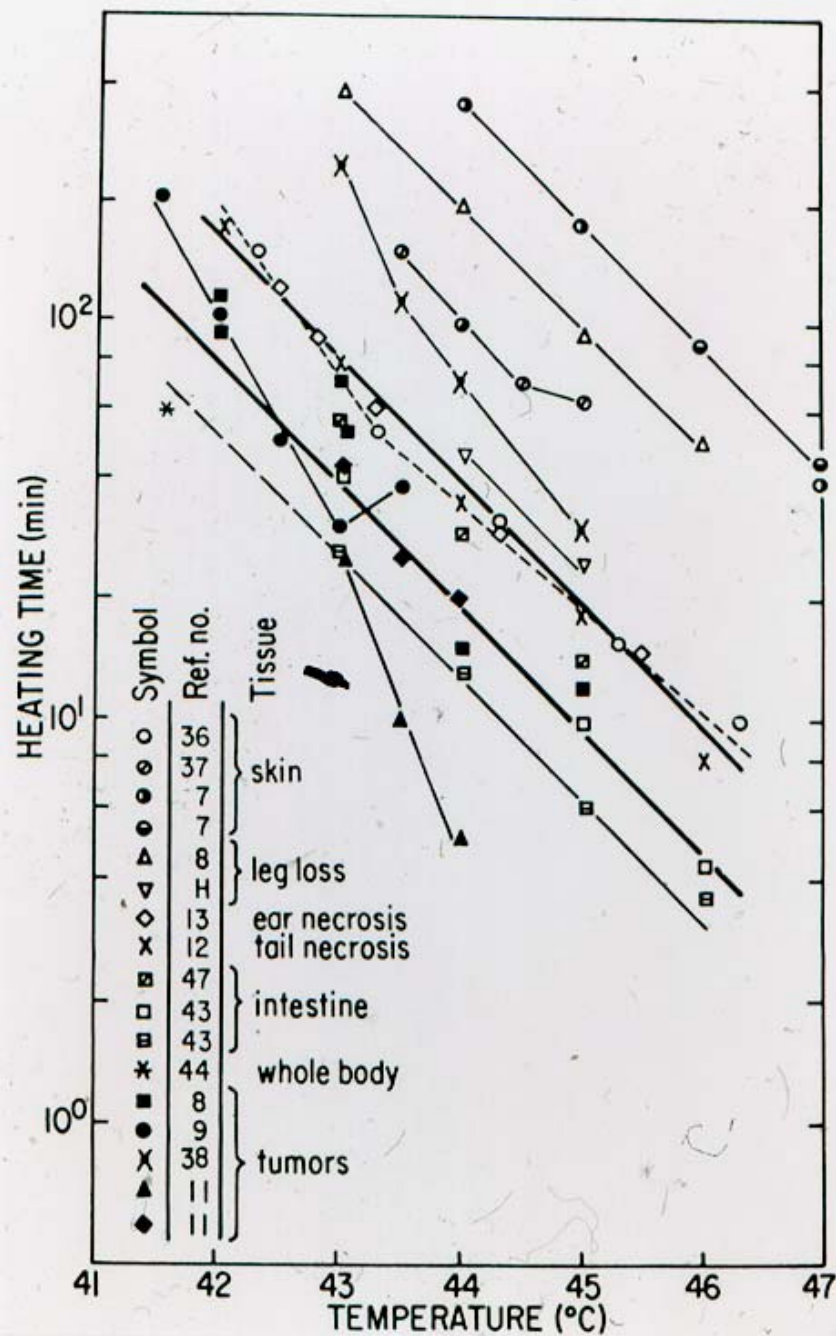
where,

t = Time in minutes

T = Temperature

CEM_{43} = Time to produce same effect at 43 degrees

R= 0.25 if Temp < 43 degrees
0.50 “ “ > “ “



SAFE TEMPERATURES

Temperature

Minutes

43

1

42

4

41

16

40

64

39

∞

THERMAL ISSUES

A diagnostic exposure that elevates embryonic and fetal in-situ temperature above 41 degrees for 5 minutes or more should be considered hazardous

The End