

Biological Consequences of Hyperthermia

IEEE/ICES TC95 SC-4

29 Nov 07

COMMENTS RELATIVE TO THERMAL BIOEFFECTS

Medical Applications of Hyperthermia

- **Hyperthermia literature is voluminous**
- **Diathermy widely used in treatment of soft tissue injury**
- **Both apply >100 W/kg RF to patients without harm other than burns**

COMMENTS RELATIVE TO THERMAL BIOEFFECTS

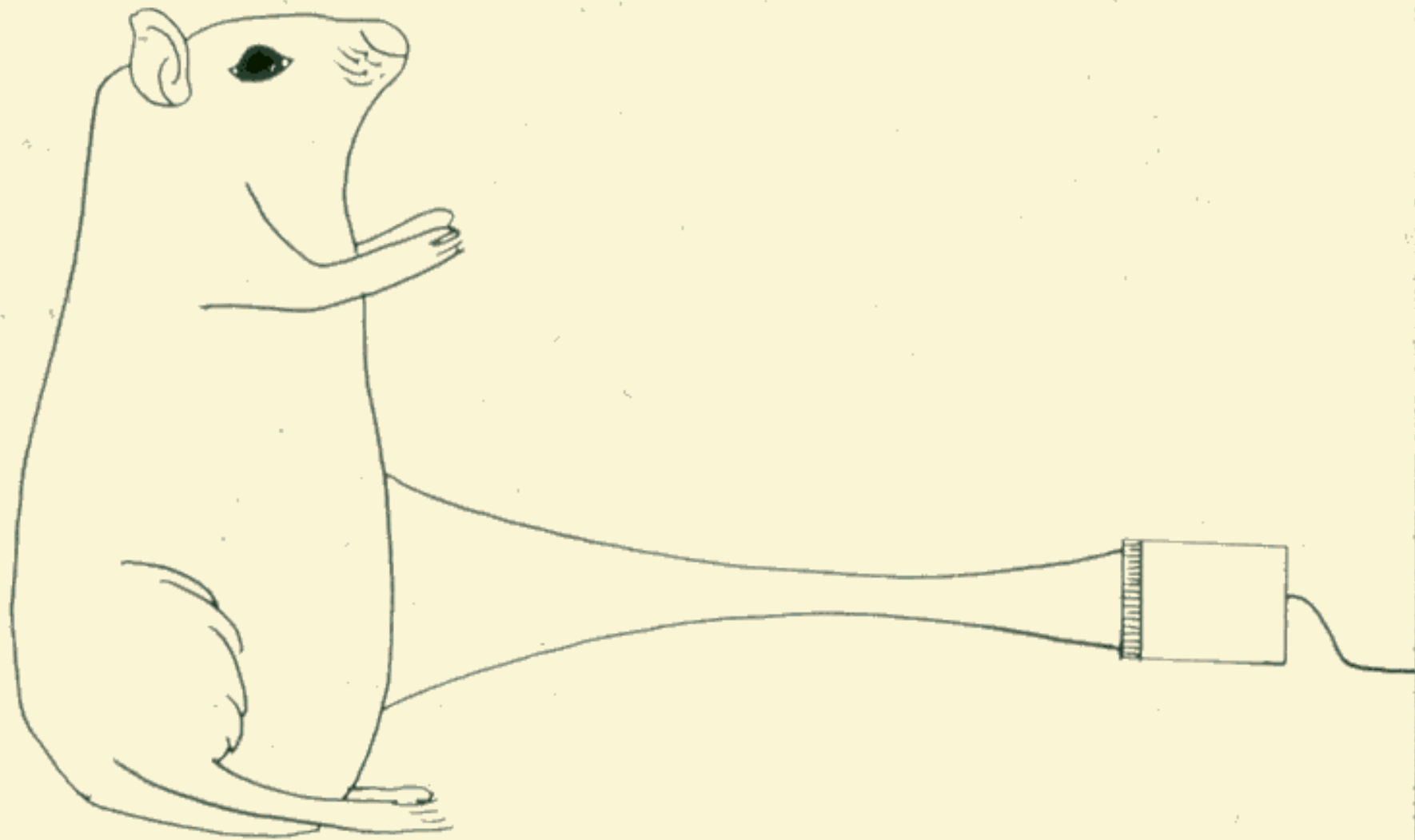
Thermal Bioeffects

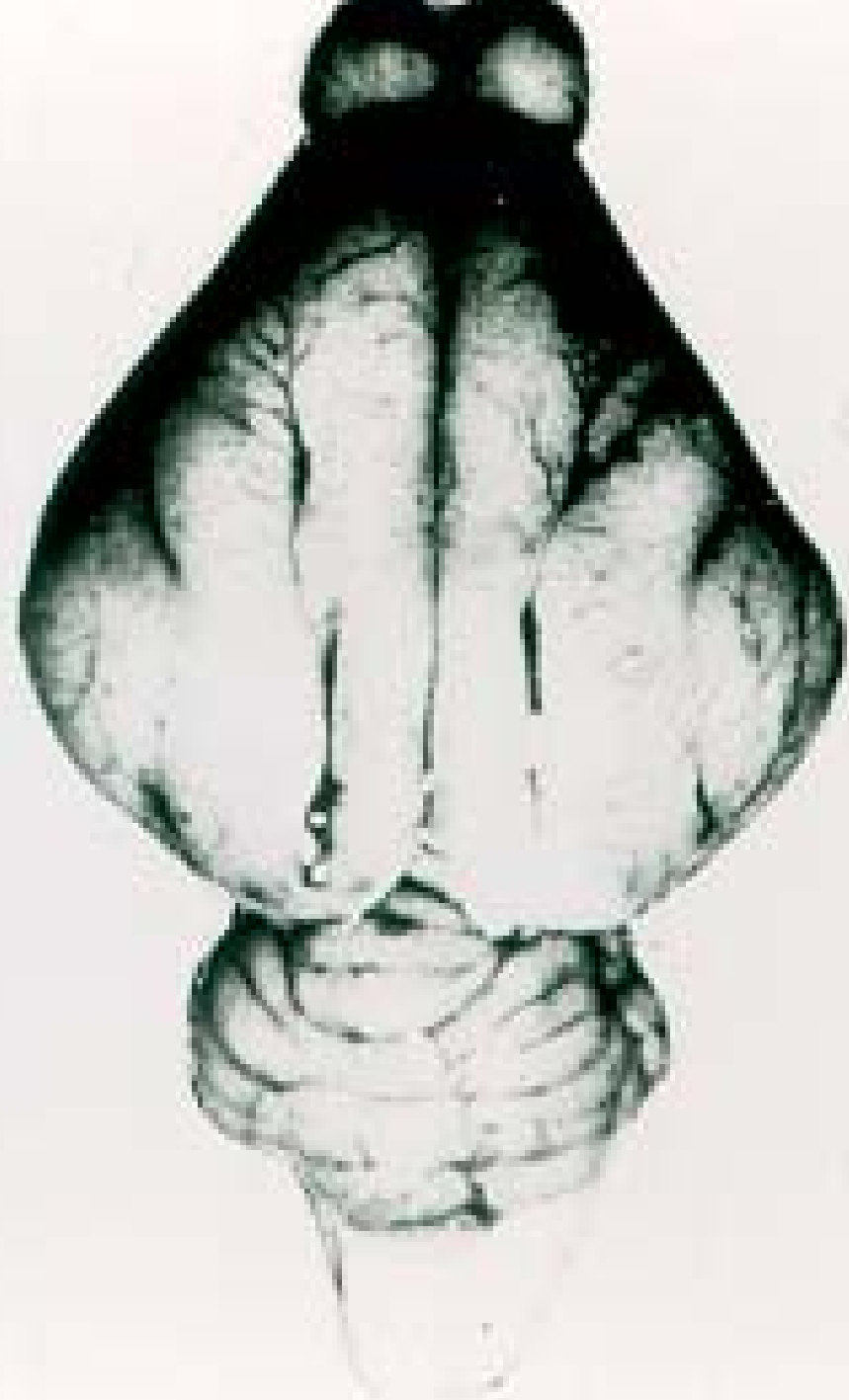
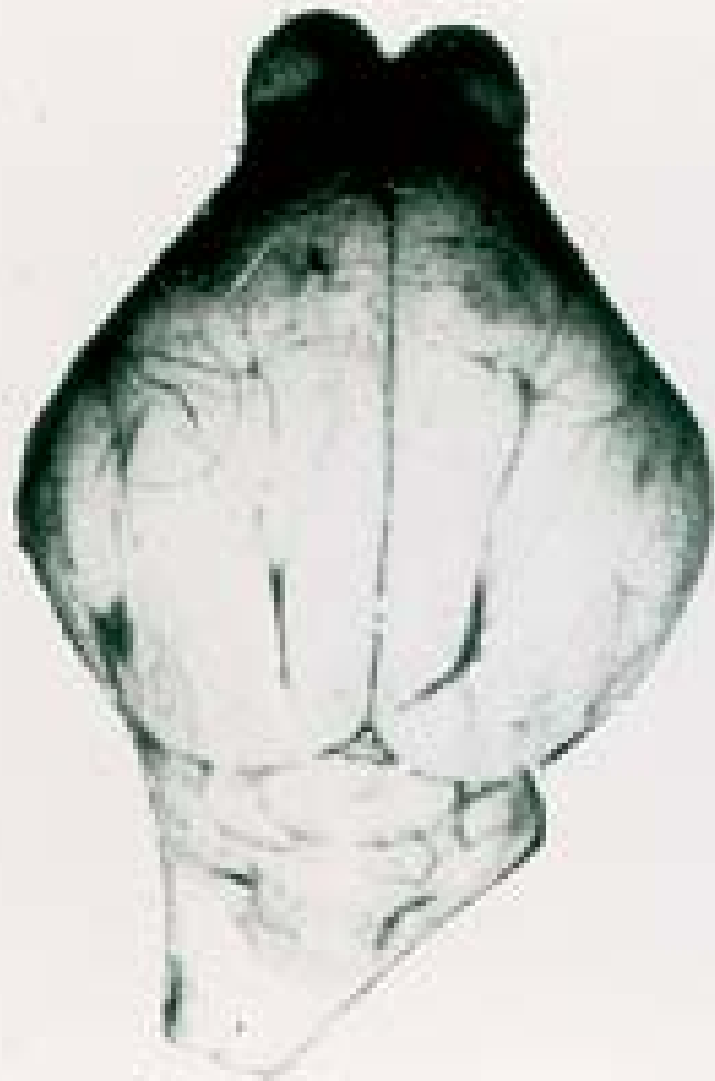
Most sensitive and important irreversible effects occur in:

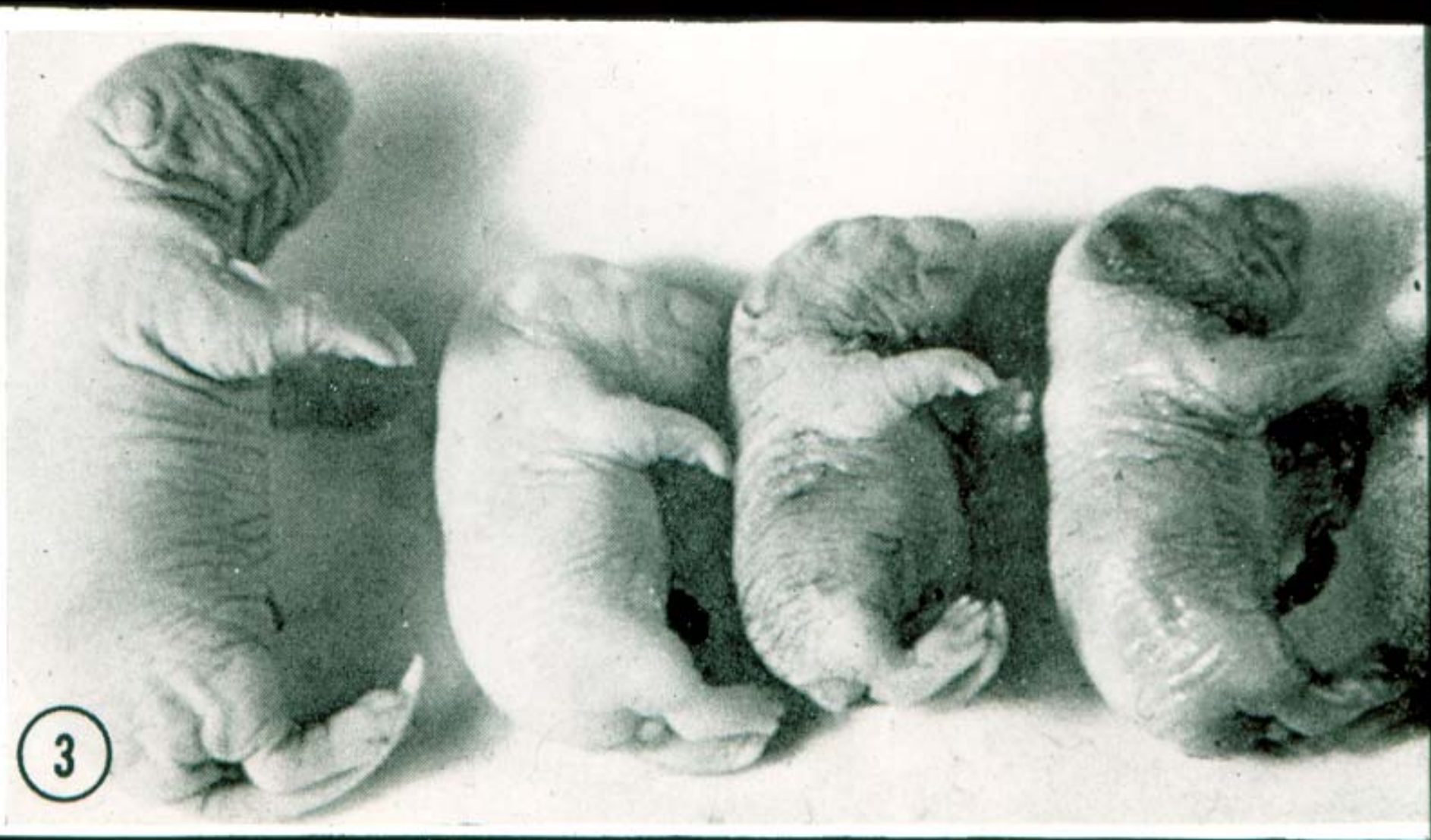
- ❖ Rapidly dividing cells**
- ❖ Fetal developmental abnormalities**



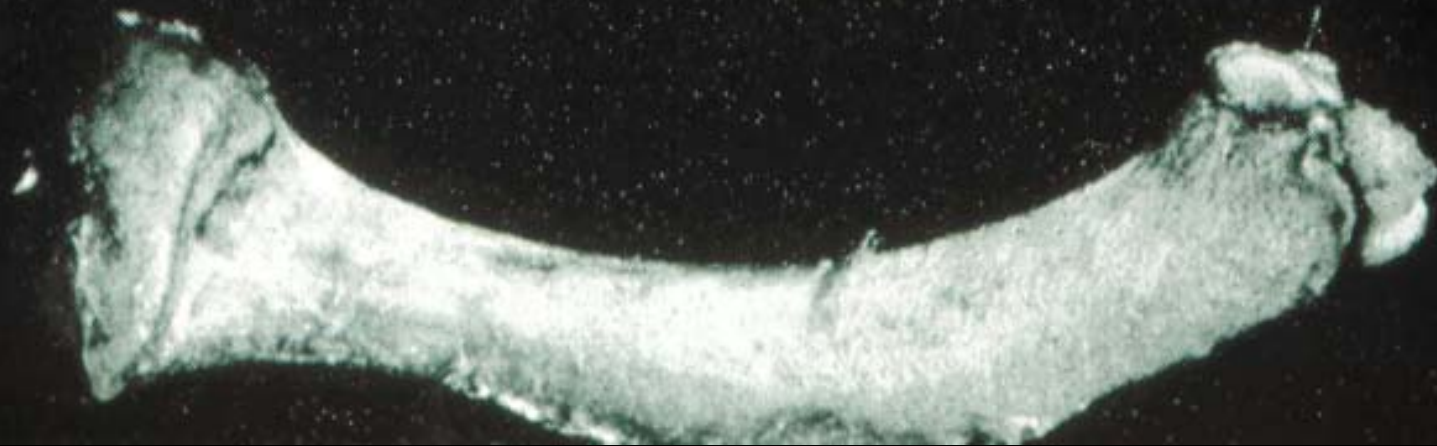




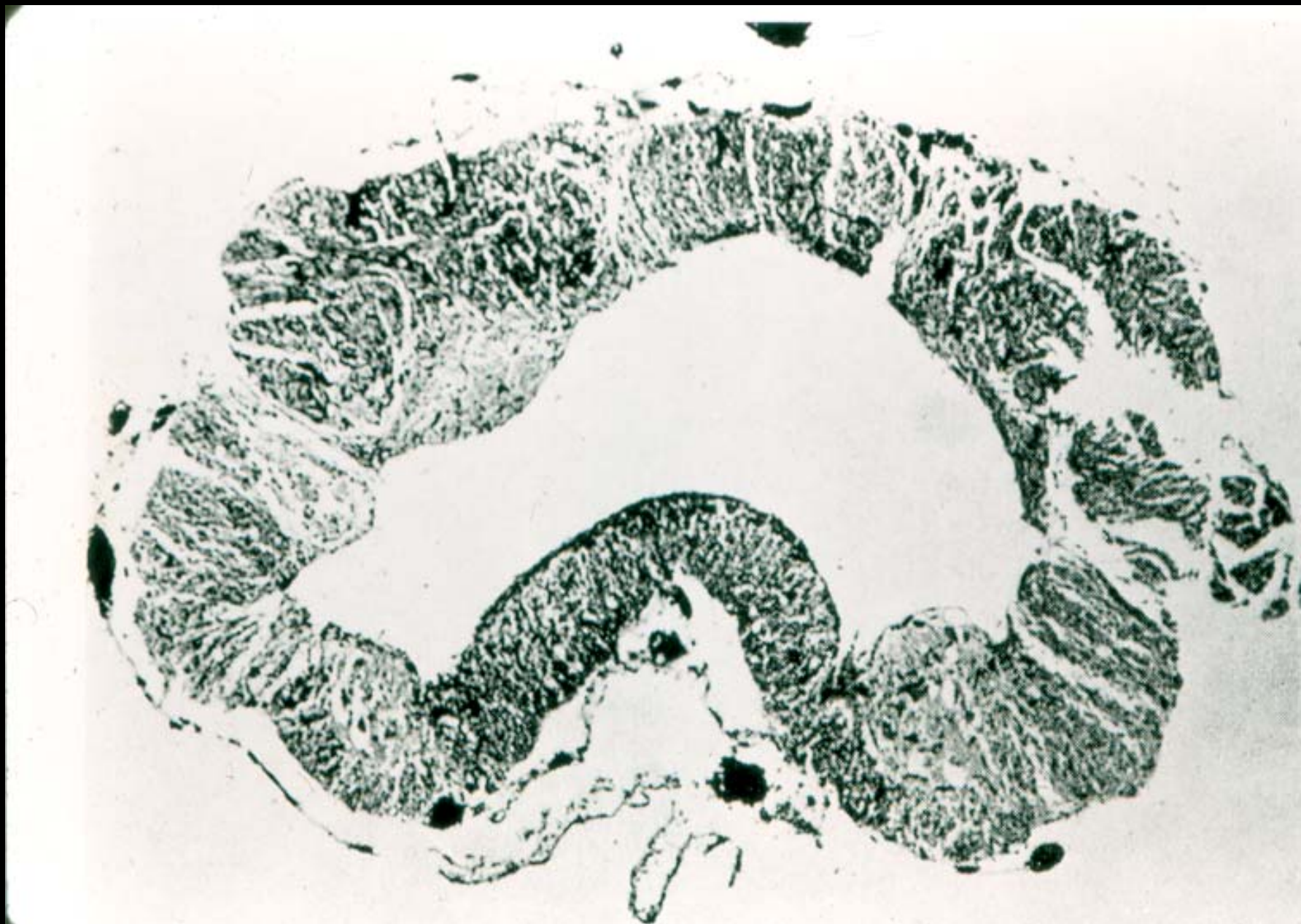


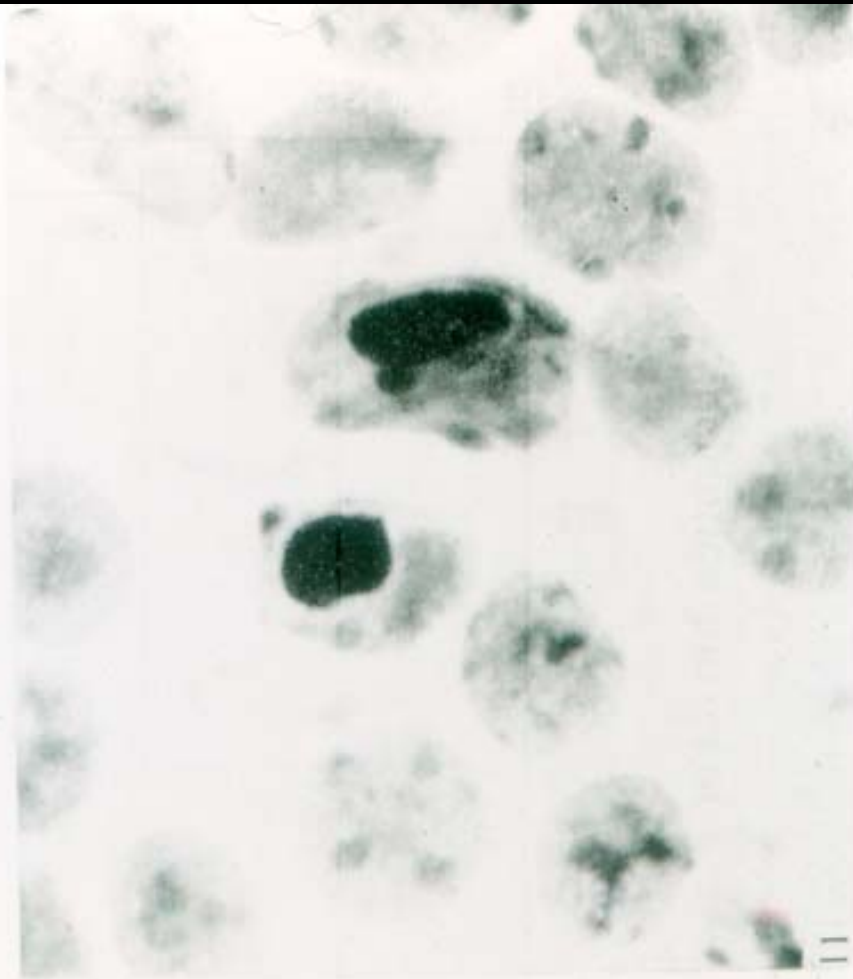
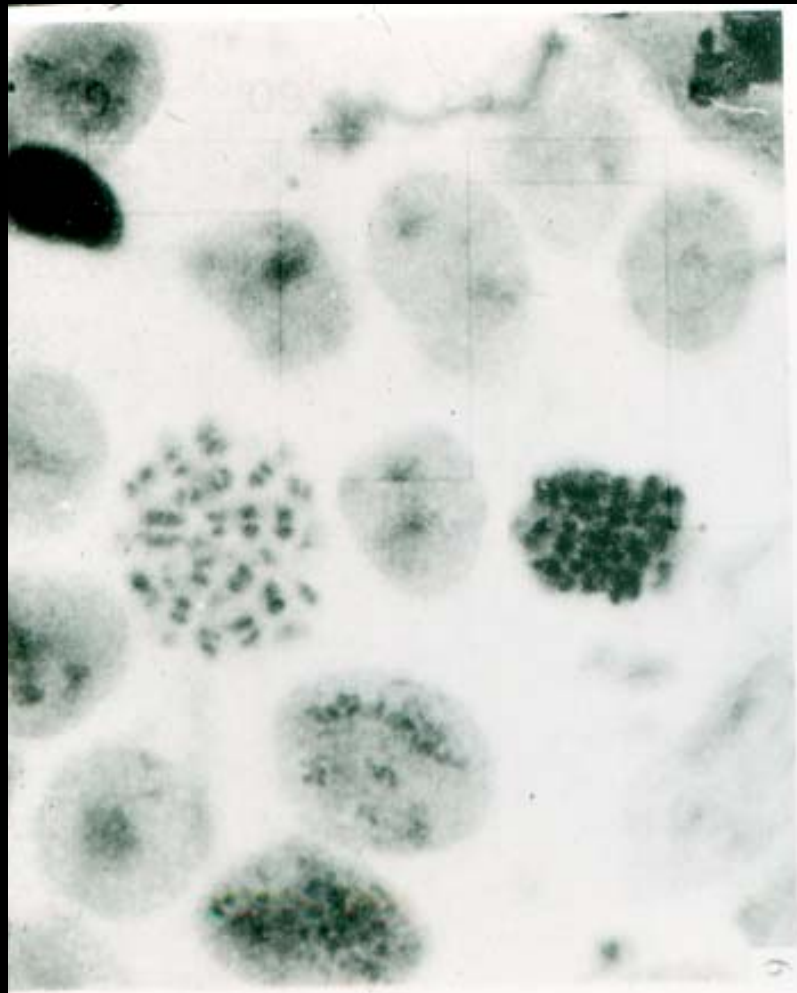




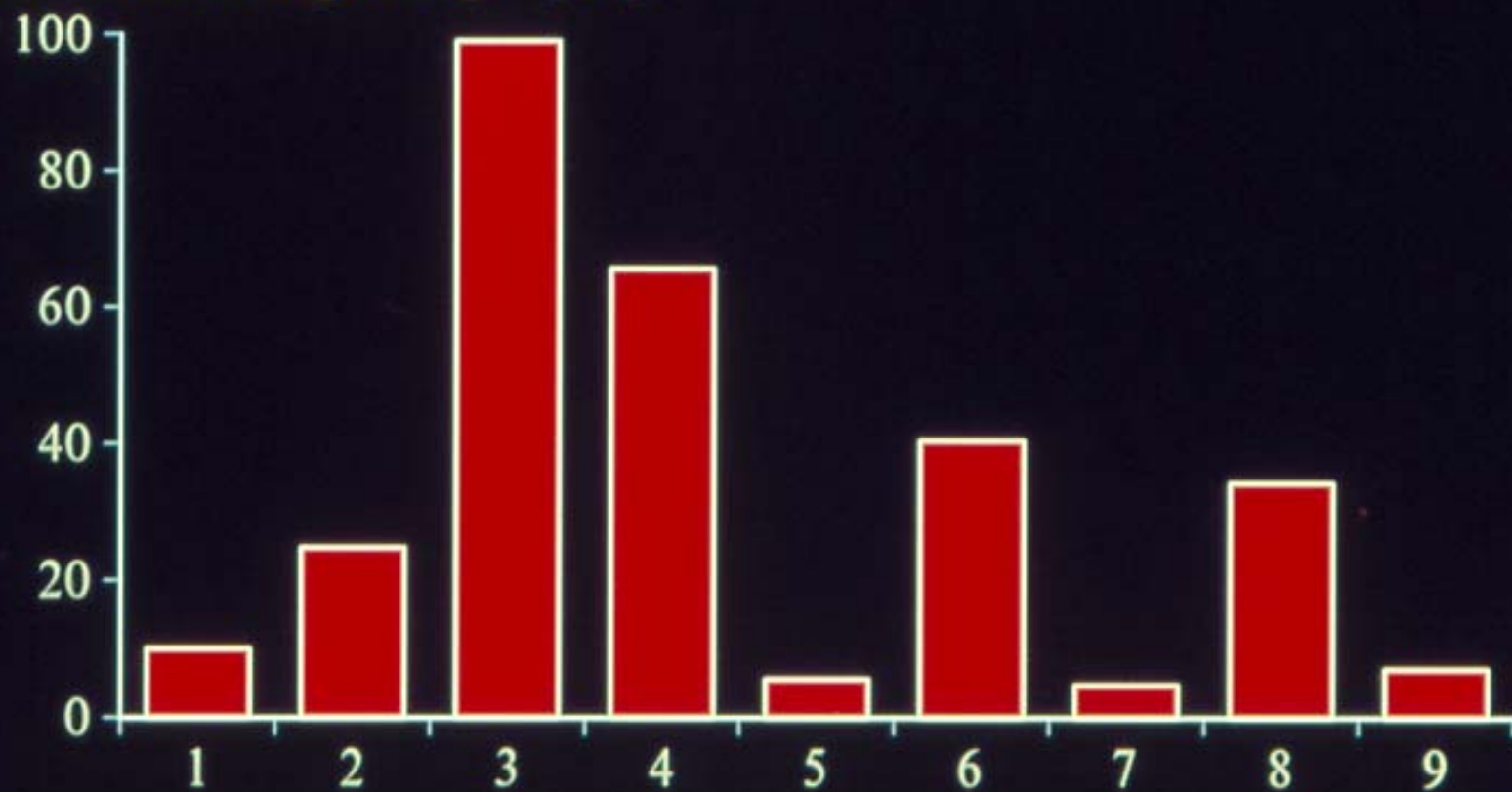








Micrencephaly (%)

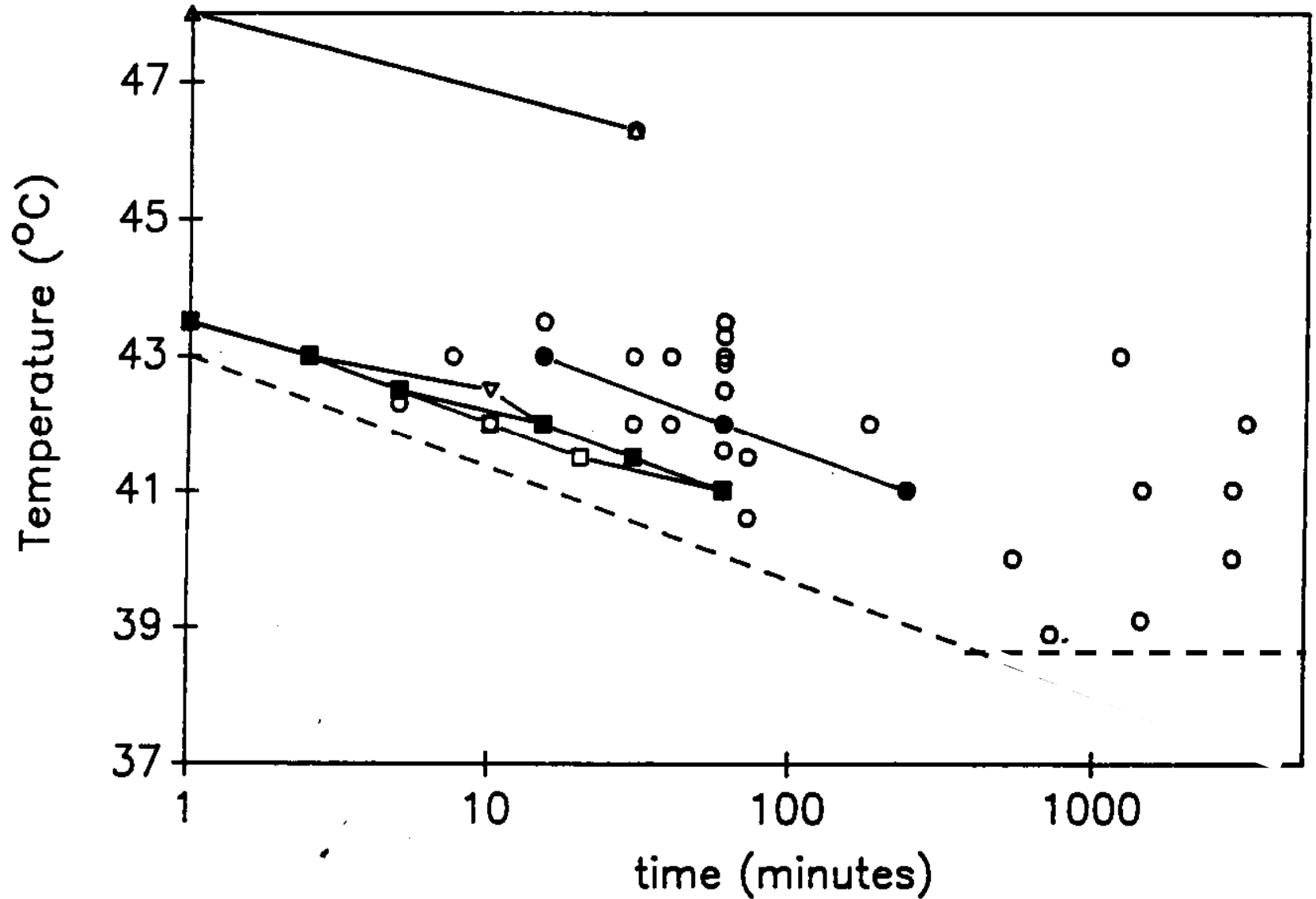


Age at Time of Exposure (week of gest.)

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



COMMENTS RELATIVE TO THERMAL BIOEFFECTS

Temperature – Duration Relationship

$$t_{43} = t \times R^{(43 - T)}$$

where,

t = Time in minutes

T = Temperature

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

R = 0.25 if Temp < 43 degrees

0.50

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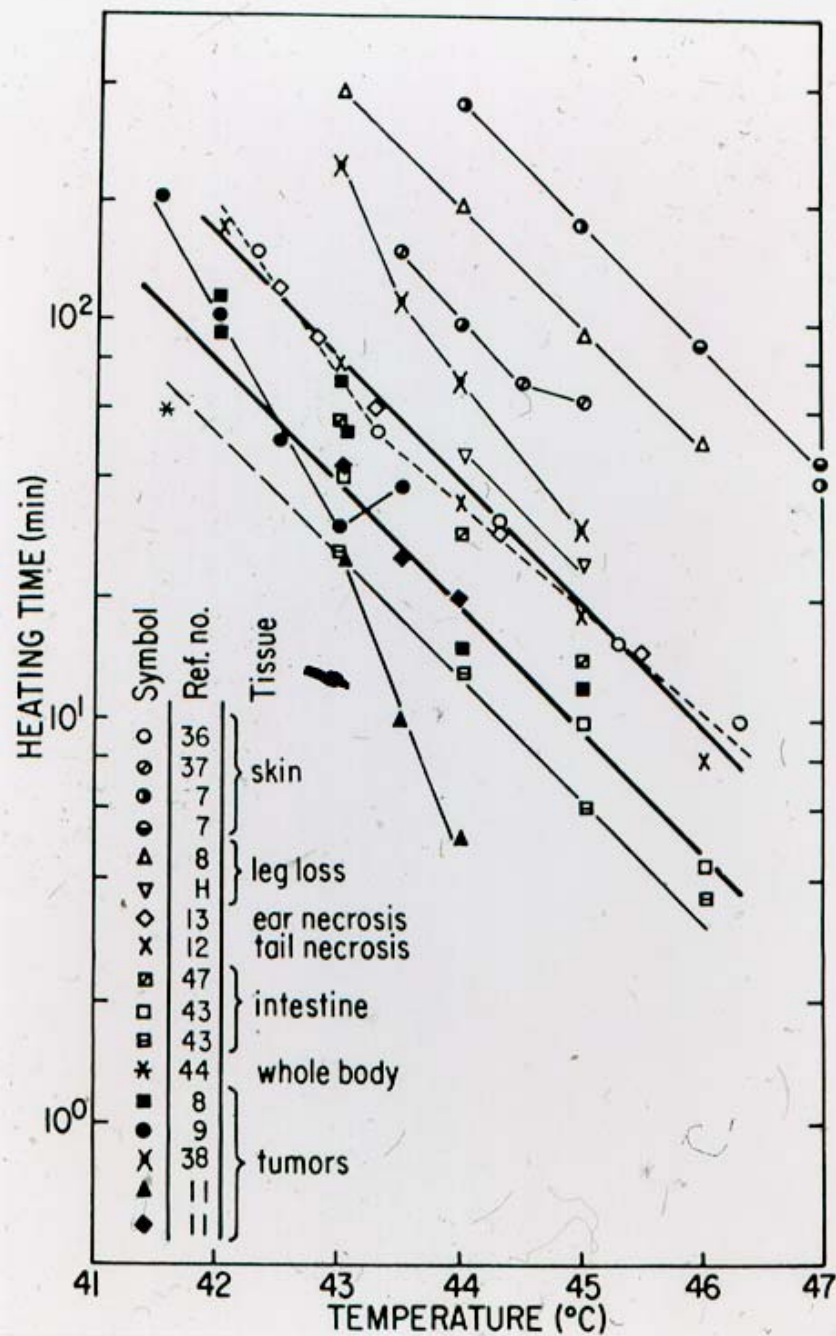
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COMMENTS RELATIVE TO THERMAL BIOEFFECTS

SAFE TEMPERATURES

Temperature	Minutes
43	1
42	4
41	16
40	64
39	∞



COMMENTS RELATIVE TO MEDICAL OPINION

Medical reasonableness of C95.1

- **very conservative**
- **Some concerns will never be completely eliminated**

COMMENTS RELATIVE TO MEDICAL OPINION

Electromagnetic Hypersensitivity

- ❖ No level low enough
- ❖ Bergqvist study

COMMENTS RELATIVE TO MEDICAL OPINION

Acquainted with many overexposures:

- Severe overexposures cause relatively minimal damage
- Burning is the damage
- Pain is helpful in protecting from damage

COMMENTS RELATIVE TO MEDICAL OPINION

We live in a dangerous world

- We attempt to minimize or eliminate risks
- Risks from RF fields under C95.1-2005 limits are *de minimus*
- Normal diurnal temperature variation exceeds what can occur under C95.1-2005

The End

