EFFECT OF CLIMATE ON MAMMALIAN REPRODUCTION

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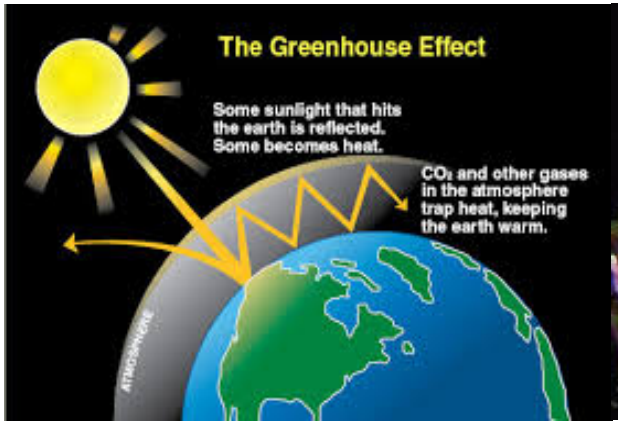
What is climate change?

A change in global climate patterns apparent from the mid to late 20th century onwards, attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels



Past and Present

- Ice age-------- modern climate

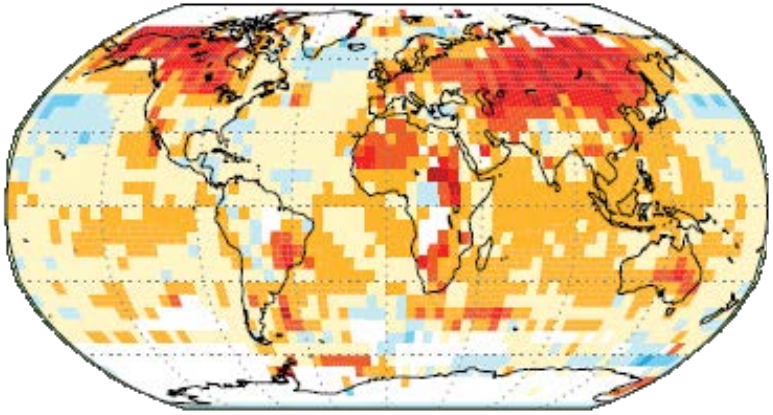
Image courtesy USGS National Ice Core Laboratory. Denver, Colorado, USA

A scientist holding an ice core—a sample taken from polar ice caps or mountain glaciers.

Ice cores reveal clues about climate changes in Earth's past.

The Climate is Changing

- Temperatures are rising
- Sea levels are rising
- The ocean is acidifying
- Climate change is reflected in water cycle changes
- Species extinction by 0.01% every year (WWF)

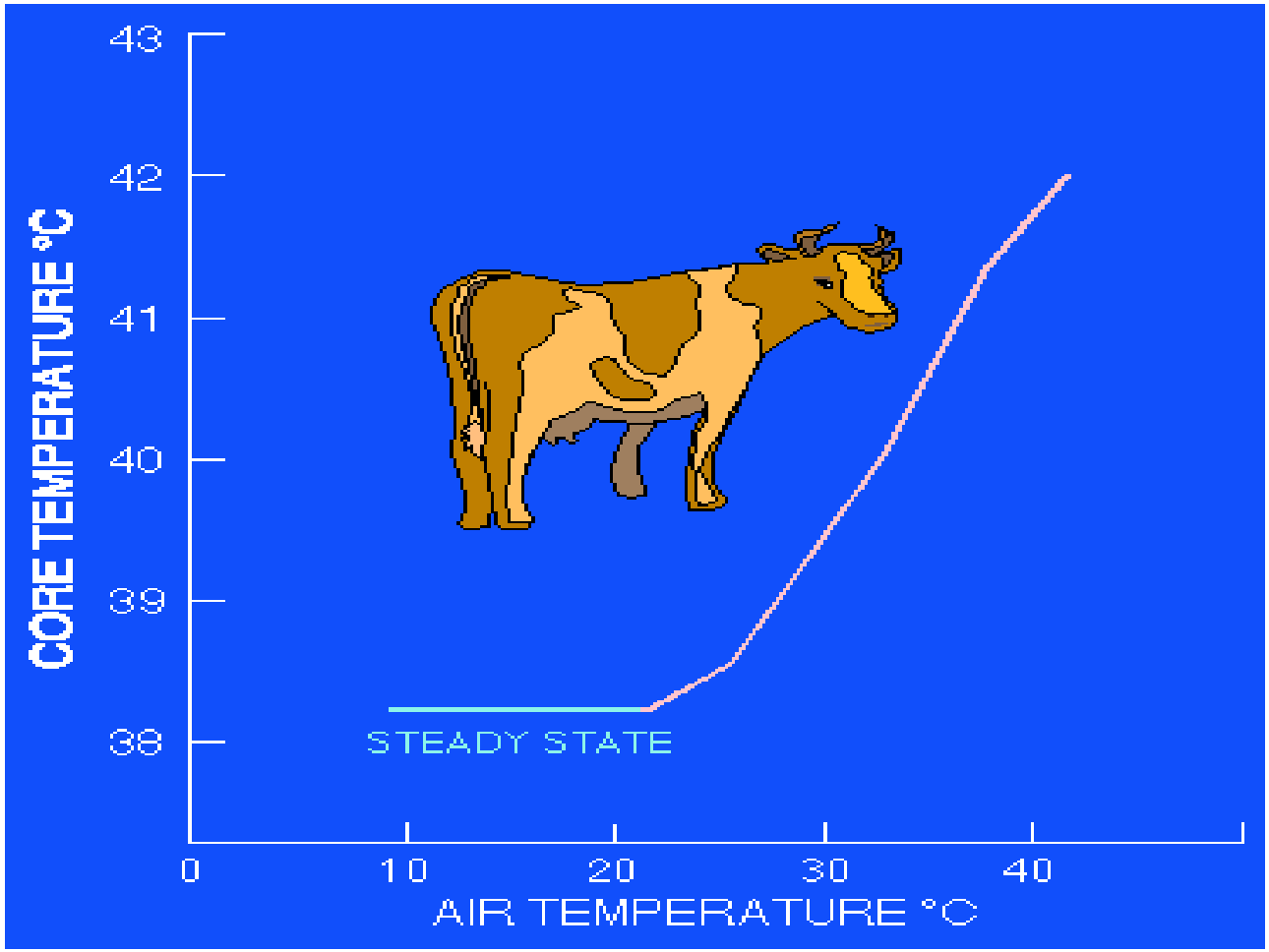


Temperature rise, indicated by color (red=higher rate of increase). Earth's surface temperature has risen ~1.3˚ F since 1850.

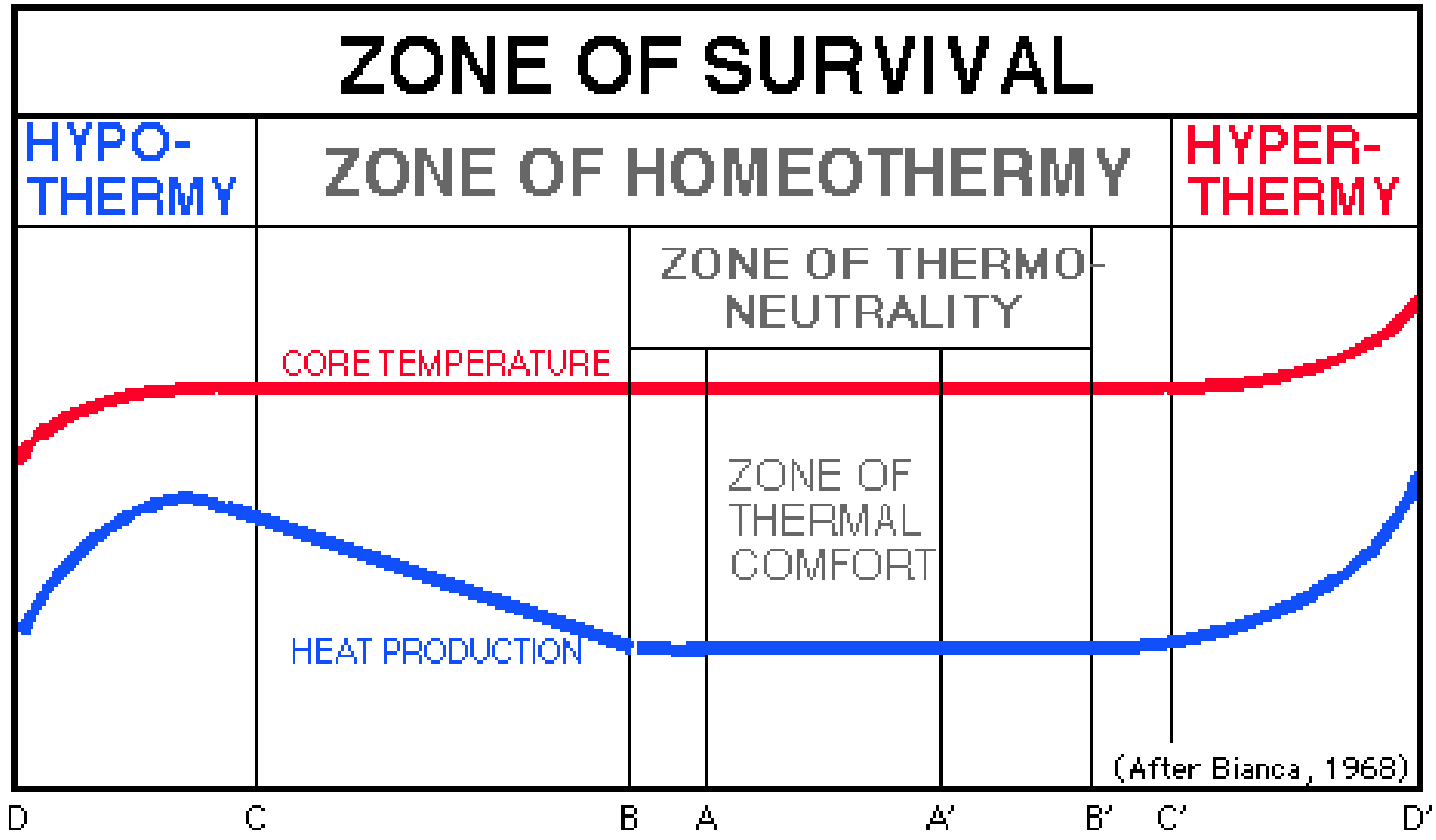
(Image courtesy of the Joint Institute for the Study of the Atmosphere & Ocean, U. of Washington)

Are Mammals Homeotherms ?

Mammals **do not have** precise control over the core temperature which plays an important role in adaptation (McLean, 1991)



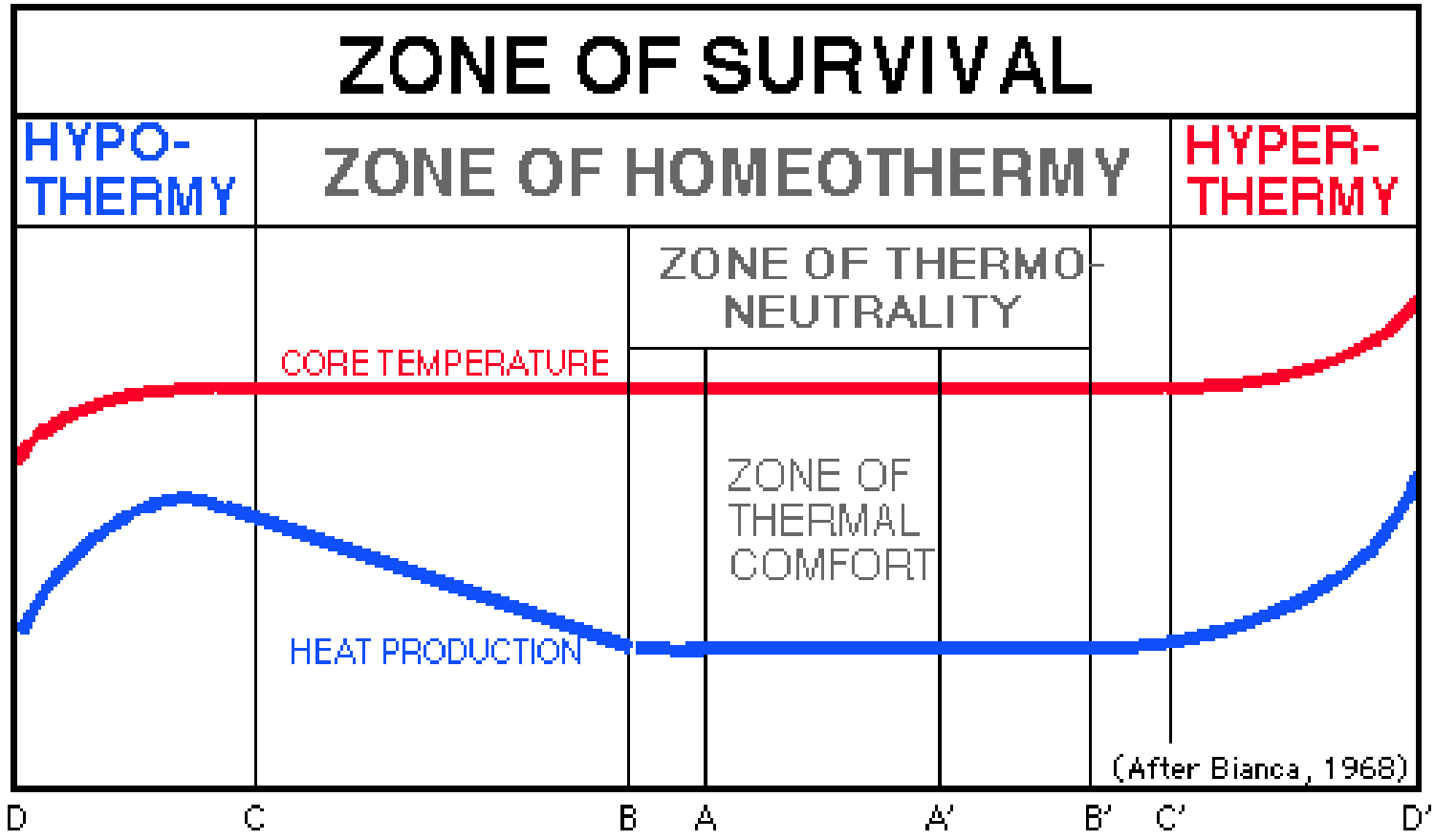
Thermoregulatory Overview



Lower lethal temperature: below15-20 deg C (Core temperature)

Upper lethal temperature- 42-45 deg C

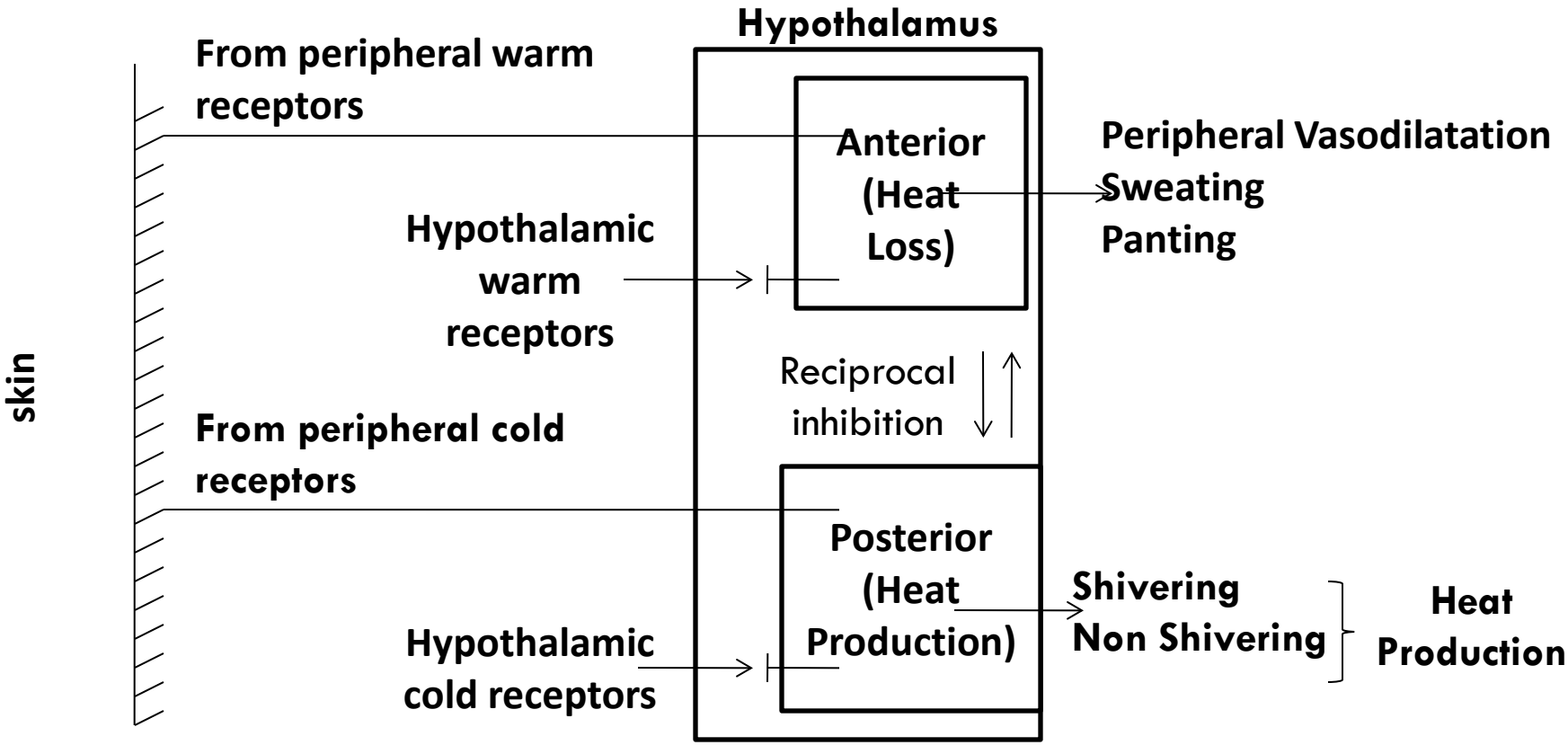
Thermoregulatory Overview



Between C' and D' pregnant females experience mild hyperthermy also killing vast number of embryos on a global scale

Regulation of Body Temperature

Temperature regulating system consists of 3 components : sensors, thermostatic control unit, thermoregulatory effectors



Simplified representation of the temperature regulating system (Bianca, 1968)

Physiological

Heat	Cold
Decrease BMR, decrease thyroid activity, decrease feed intake, increase evaporative cooling by sweating , panting, vasodilatation, short hair coat/fur, increase surface area	Shivering, exercise, tensing of muscles, increase metabolic rate by increasing glucocorticoids/thyroid hormones, increase feed intake, decrease evaporation, sweating, vasoconstriction, increase insulation, counter-current heat exchange

Behavioral (Hafez, 1968c)

Heat	Cold
• wallowing and rooting • licking body surfaces • night grazing • succulent feeds • anorexia • body extension • group dispersion • excessive drinking • decreased locomotor activities • moistening body surfaces • seeking low temperature	• hibernation • body flexor • huddling • extra locomotor activities • nest building • seeking warm environment

Morphological

Environmental stress	Morphological adaption
• solar radiation	• long limbs, long open coat
• high temperature	• hair shedding in summer, increase surface area, long ears, loose coarse wool, fine dense wool
• low temperature	• long and fine hair, thick subcutaneous fat, abundant brown fat, thick heavy coat
• high humidity	• dark pigmentation, sparse hair
• seasonality in food	• adipose tissue reserves in hump, tail, rump
• desert	• thick skin, hard tissue around mouth, thick mouth, long papillae, increase drinking capacity, hump to conserve water, ability to survive dehydration
• high altitude	• increase oxygen carrying capacity, increased concentration of RBC's, ability to transfer oxygen from capillary blood to tissue cells, high efficiency in nutrient extraction

Impacts on Animal Productivity

Productive traits	Hot		Cold	
	Effects	Reference	Effects	Reference
Maintenance	↑	Ames (1986)	↑	Ames (1986)
Feed intake	↓	Ames (1986) and Ronchi et al. (2002)	↑	Ekpe and Christopherson (2000)
Milk production	↓	Valtorta et al. (2002)	↓ (Below -5° C)	Leva et al. (1996)
Daily gain	↓	Sakagauch and Gaughan (2002)	↓ (Below -0° C)	Johnson (1986a)
Egg production	↓	Anjum et al. (2002)	↓ (Below -9° C)	Hafez (1986a)
Egg shell thickness	↓	North and Bell (1990)	No Effect	-
Wool production	↑	Woods et al. (1995)	↓	Woods et al. (1995)

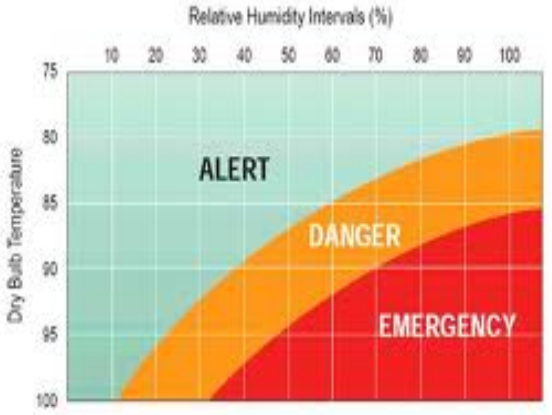
Morbidity and Mortality

Category	Effect	Reference
Non infectious disease	Increased	Kelley (1986)
Immunity during hot or cold weather	Decreased	Kelly (1982)
Moderate heat stress (THI= 72±2.6)	No effect	Lacetera (2002)
Microbial insult due to thermoregulatory behavior (huddling, seeking shade and migration)	Increased	Kelly (1986)
Mortality due to heat waves	Increased	Khalifa(1999), Hann et al., (2000)

THI- a *de facto*

THI= 0.72 (W°C + D°C) + 40.60 (McDowell *et al.* , 1976)

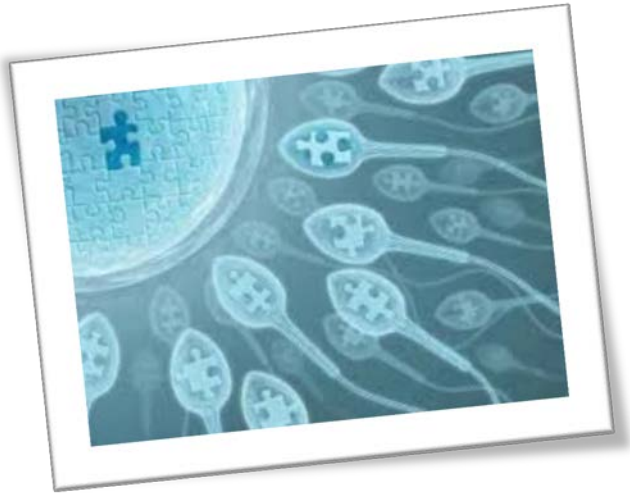
Category	THI value
Normal	<74
Alert	75- 78
Danger	79- 83
Emergency	>84



- Temperature and humidity do influence much of the heat exchange and performance of livestock

Fertility is a Complex Trait

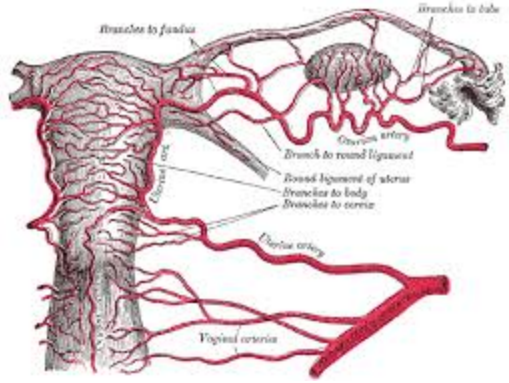
- The climate is an important factor
- **"Mammals are Homeotherms so Climatic Warming poses little danger"**
- Embryonic death in cows is believed to be much higher in the tropics than it is in the temperate zones (Stott & Williams, 1962)



Hot Climate on Animal Reproductive Performance

Reproductive traits	Effect	Reference
Puberty	Delayed puberty in both males and females	Fuquay (1986)
Spermatogenesis and semen quality	High volume during summer, reduced semen quality	Abdalla (1996), Kelly and Hurst (1963)
Estrous cycle and ovulation	Decrease the length and intensity of estrous	Lucy (2002)
Fertilization and conception rate	Impaired fertilization and embryonic development	Lucy (2002) and Putney et al., (1989)
Gestation	Small offspring at parturition	Ealy et al., (1993) and Fukuay (1986)
Fertility	Affected by climate and adaptability	Jayarajan (1992)

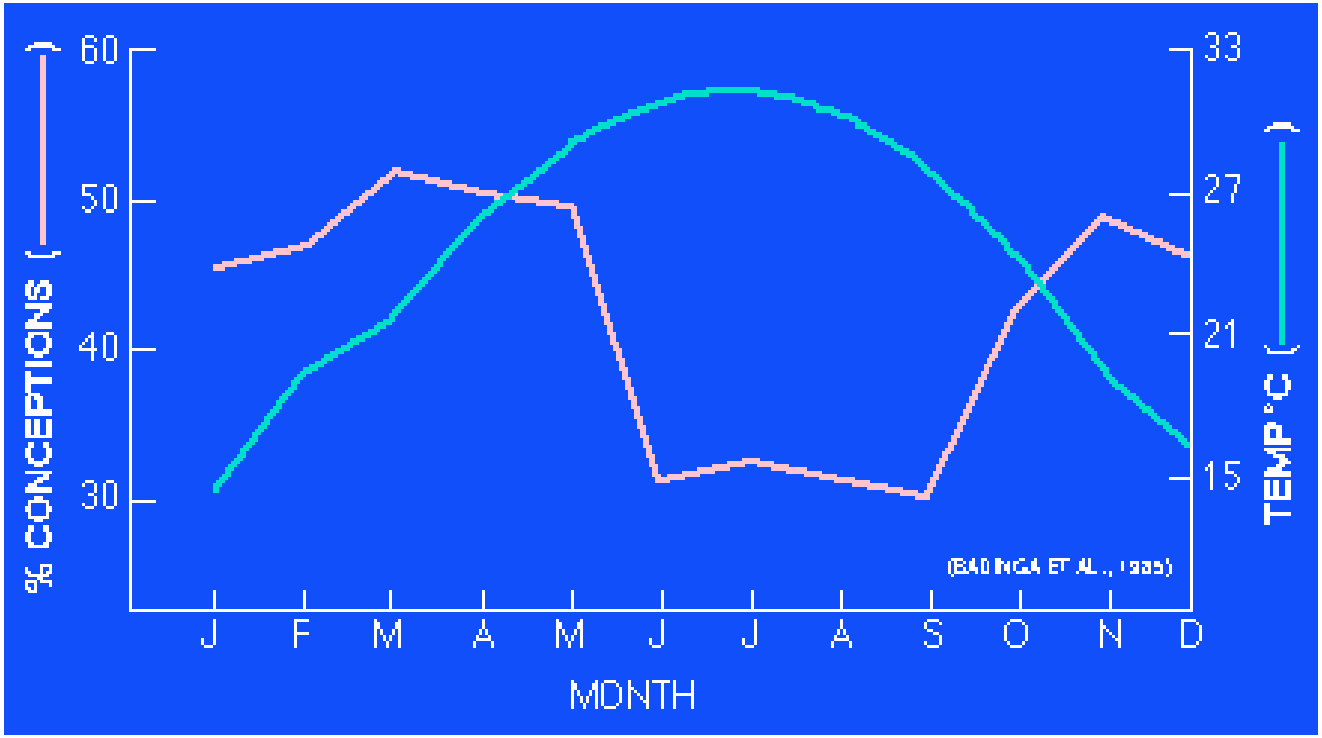
Heat and Fertility- Females



- Dominant effect in Females
- Uterus is where embryos develops
- The cardiovascular system exerts control upon the core temperature
- A rise of uterine temperature by only 1.0-1.5°C above optimum will kill an embryo in large numbers
- Reduce population numbers and collapse in vulnerable regions
- Embryo mortality can reach 100% in unacclimatized ewes which are not dangerously stressed (Thwaites 1985)
- heat stress delays puberty both in males and females where ambient temperature of 27-40°C reduced semen quality
- Heat stress induced alterations in synthesis of conceptus proteins involved in embryonic development and maternal recognition of pregnancy (Putney et al. 1988)

A Critical Balance

- Optimum environmental temperature for conception
- In Virginia cattle the optimum environmental temperatures for conception are between 50°F (10°C) and 73°F (23°C), with maximum conceptions at about 59°F (15°C)



Badinga et al. 1985).

Humans too ????

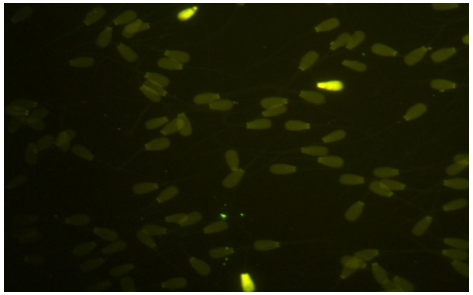
- Humans are not immune
- For human females, a bath in water of 40°C for 15 to 25 minutes can raise the core temperature to 38.5°C, sufficient enough to damage a fetus (Ridge and Budd 1990)

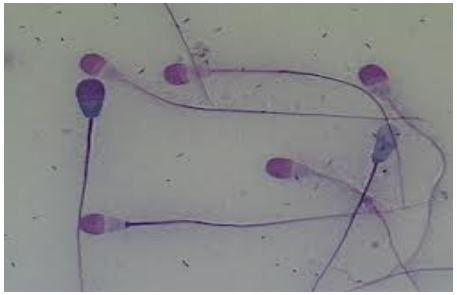


Heat and Fertility- Males

Major contribution for semen variation is environment (temperature, humidity, nutrition, management and seasonal changes)

- Delays body growth and sexual maturity
- Under development and Degeneration of testes
- Poor libido
- Abnormal cells
- Dead and damaged sperm cells






Cold Effects on Fertility

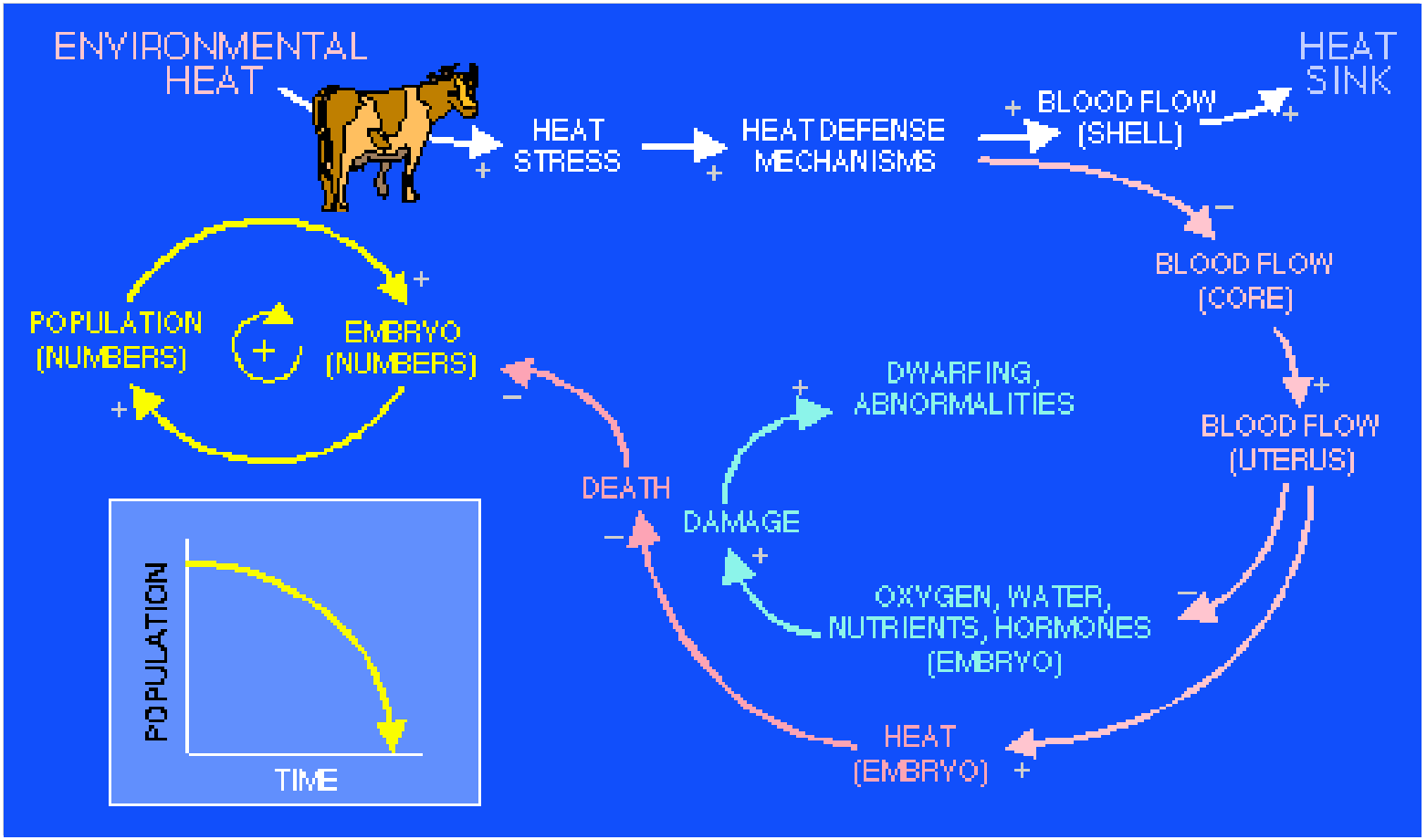
- Reduce estrual activity
- Decline in estrual activity at temperatures below 25°C
- Metabolic and endocrine adjustment is needed to maintain body heat
- Sperm damage

Global Changes- Local Impacts

Although climate change is global, the ecological impacts are often local

What's happening in your backyard?

Causal Loop Diagram showing how Excessive Environmental Heat can trigger Collapse of Mammalian Populations



The Weakest Link: Climate and Developing Embryos

Some Scientist claim that half the presently existing plants and animals species maybe extinct by 2100 (Wilson, 2002)

Remedies……

- Most livestock perform better at 4 to 24°C and humidity of 40-80%
- The eastern region of Bengal experiences hot and humid climate where the peak temperature ranges from 38-40°C in the months of April-May-June and heavy rainfall accompanied by high humidity ranging from 80-90% with high environmental temperatures in the months of July-Aug-Sept

Management during heat stress

- ***Shelter:*** East west direction, provision of adequate shade of at least 20 to 40 square feet per animal, 2 ft high from the surrounding area
- ***Thermal comfort inside the shed:*** Roofing material, adequate height of at least 8 feet so that there is free flow of air inside the animal houses
- ***Water:*** Clean, fresh and cool. The intake of water increases during lactation, increased ambient temperature, increased dry matter content of the fodder and consumption of salt. As milk is 87% water, lactating animals should be provided water @litre/ 0.9 litre of milk produced
- ***Working period of cattle:*** Cooler part of the day
- ***Feeding high energy diets:*** During summer, early morning and late evening
- ***Grazing:*** Graze 6 to 8 hours during the cooler parts of the day. Early grazing even before onset of sunrise during summer is advisable.

Management during cold stress

- ***Feed and Water:*** Provide good amount concentrate feeds. Offering feed during the afternoon or evening produces greater body heat during the night thus, reducing cold stress
- ***Protect animals from wind and cold:*** Make shift houses with well covered walls with polythene sheets, gunny bags, bamboo mats straw panels and provide straw beddings and artificial
- During winter months protection from direct cold wind through the use of gunny bags/polythene sheet/bamboo mats etc for a transient period of 15-30 days in Gangetic West Bengal would be sufficient.

Greenhouse would expand the number of hot days per year, and a rapid climate change would prevent mammals from easily adapting to the new temperature regime

THE CLIMATE CHALLENGE IS LARGE AND COMPLEX

LET US ALL, THINK GLOBALLY AND ACT LOCALLY !!!


Thank You