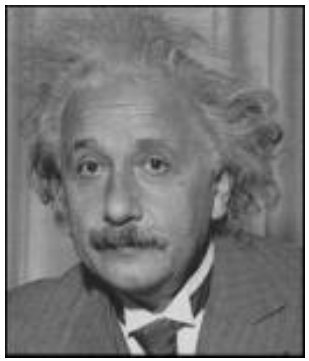
Queen Mary
University of London

Dr. Nigel Raine

Behaviour genetics
-"*genes or the environment*"?

The nature vs. nurture controversy

Can the choice of toys turn boys into girls and girls into boys?

Do genes determine sexual orientation?

Study confirms existence of gay gene in men

Parallel study fails to discover similar gene in lesbians, researchers say

BY WALLACE IMMEN
Medical Reporter

TORONTO — U.S. researchers say they have confirmed that genes play a role in homosexuality.

Expanding a controversial 1993 study of behavioural genes that run in families, they found strong evidence 36 pairs of lesbian sisters found no significant evidence that they share any genetic marker. "The finding in gay men but not lesbians suggests that the mechanisms underlying male and female sexual orientations are at least partially distinct," Dr. Hamer said.

Studies have always found that gay commented John Fisher, executive director of Equality for Gays and Lesbians Everywhere, a rights group based in Ottawa. "Those who are opposed to our lifestyle will be opposed no matter what the scientific reasons."

Mr. Fisher is most concerned that "the question is always phrased 'What

Royal experiments on the genetic origins of language

Psammetichus II (Egyptian Pharaoh; reigned 595 - 589 BC) was interested in the original language of man. Experiment – sent two newborn children into the mountains with a shepherd who was forbidden to speak to them. After 2 yrs, all they said was "Bek, bek". The king found out that the word "bekos" meant "bread" in Phrygian – hence he concluded that Phrygian was the mother of all languages.

Frederic II (King of Sicily 1194-1250) had several orphans raised in conditions with sufficient food and clothing, but no one ever spoke to them or had body contact with them. They all died and never spoke a word.

Development of social behaviour in rhesus monkeys

Infants isolated at birth and ‘reared’ by artificial surrogate

Physical development unaffected by isolation, but developed highly abnormal behaviour

Frightened of new objects or other infant monkeys

What social stimuli are needed to develop normal behaviour?

Development of social behaviour in rhesus monkeys

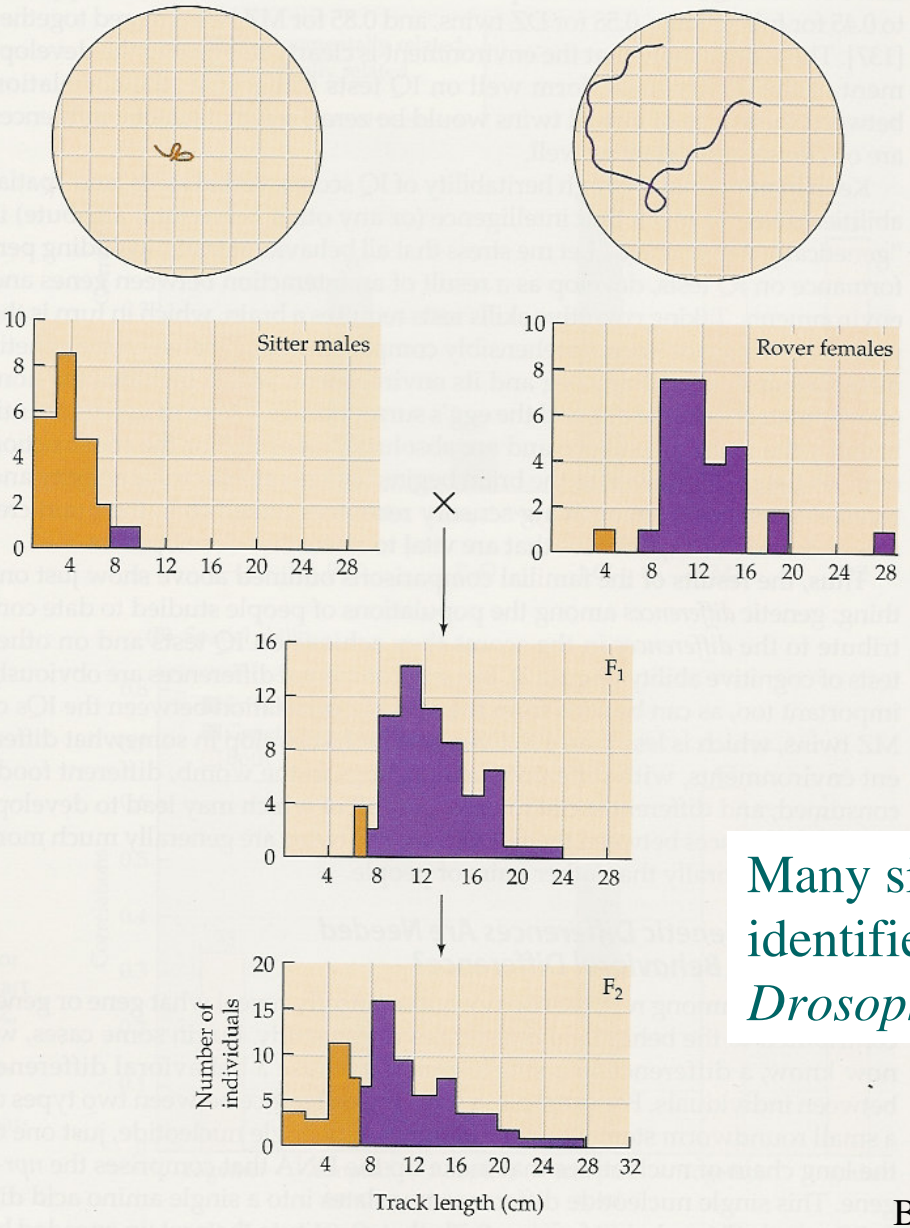
Presence of mother alone is not enough, need other infants.

Isolated infants raised with surrogates, but allow to play with 3 other infants for 15 mins/ day

Initially infants clung to each other, then began to play.

Surprisingly, 15 min play each day appeared to be enough for almost normal behaviour to develop.

What are the roles of genes in shaping behaviour?



8 Genetic differences cause behavioral differences in fruit fly larvae. Representative tracks made by sitter and rover phenotypes feeding in a petri dish appear at the top of the figure. When adult male flies of the sitter strain mate with adult females of the rover strain, their larval offspring (the F_1 generation) almost all exhibit the rover phenotype (that is, they move more than 7.6 cm in 5 minutes). When flies from the F_1 generation interbreed, their offspring (the F_2 generation) are composed of rovers (purple) and sitters (tan) in the ratio of 3:1. After de Belle and Sokolowski [307].

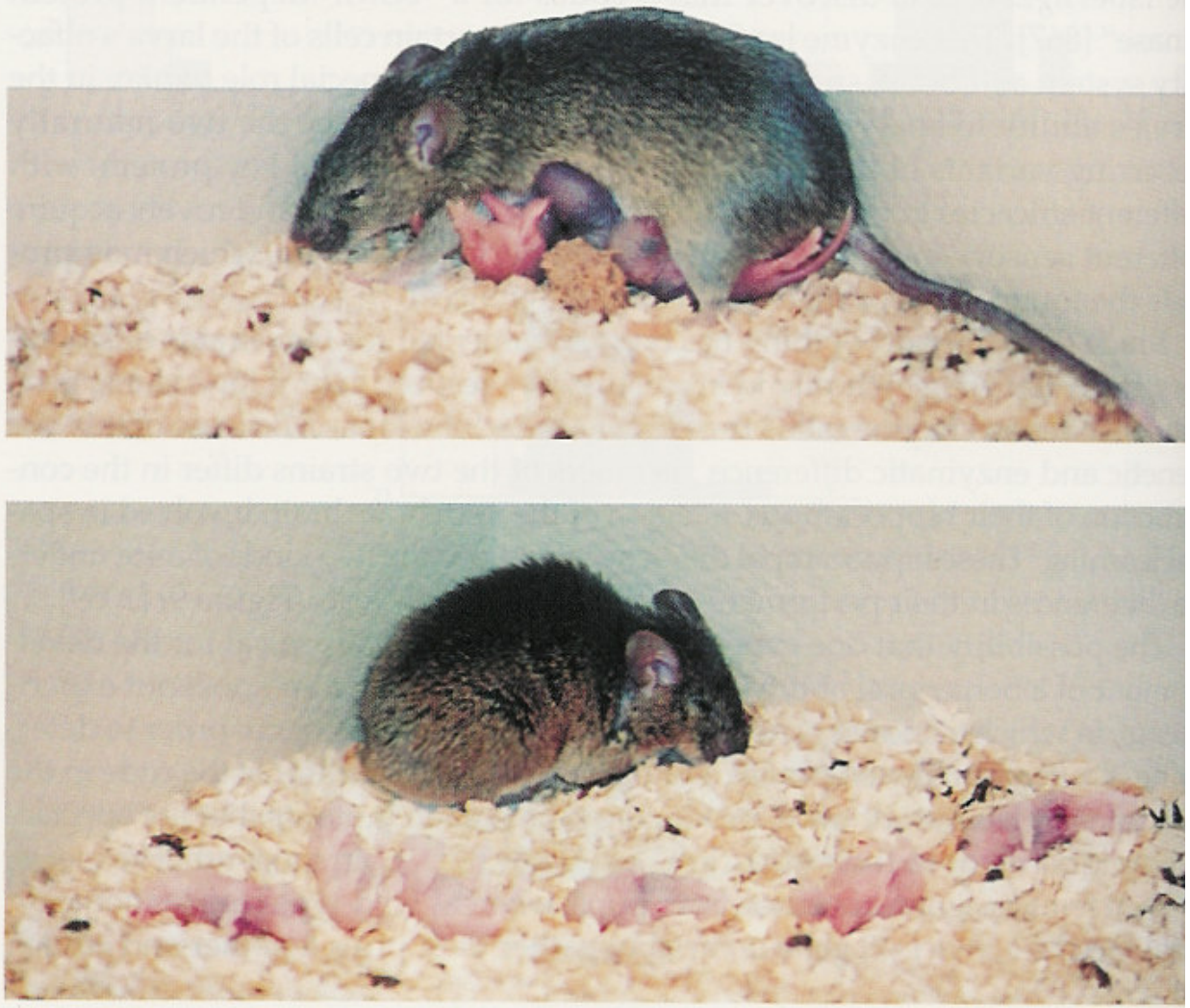
Many single gene effects identified, e.g. *for* gene in *Drosophila melanogaster*.

Belle & Sokolowski (1987)

Other interesting behavioural mutants in *Drosophila*

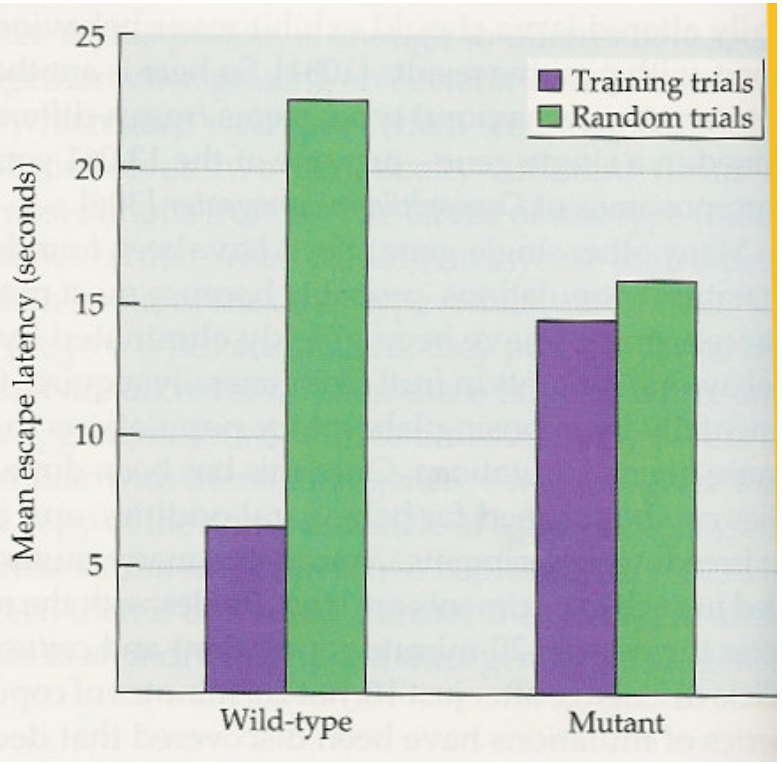
- STUCK - males which don't disengage after normal 20 min. of mating
- COITUS INTERRUPTUS - males which disengage after 10 not 20 mins.
- BANG SENSITIVE - a sudden jolt causes the fly to become "paralysed"

Genetic control of maternal behaviour in mice



10 A single gene affects maternal behavior in laboratory mice. Wild-type female mice gather their pups together and crouch over them (above), but females with inactivated *fosB* genes (below) do not exhibit these behaviors (the pups can be seen scattered in the foreground). Photographs courtesy of Michael Greenberg; from Brown et al. [173].

Genes involved in spatial learning

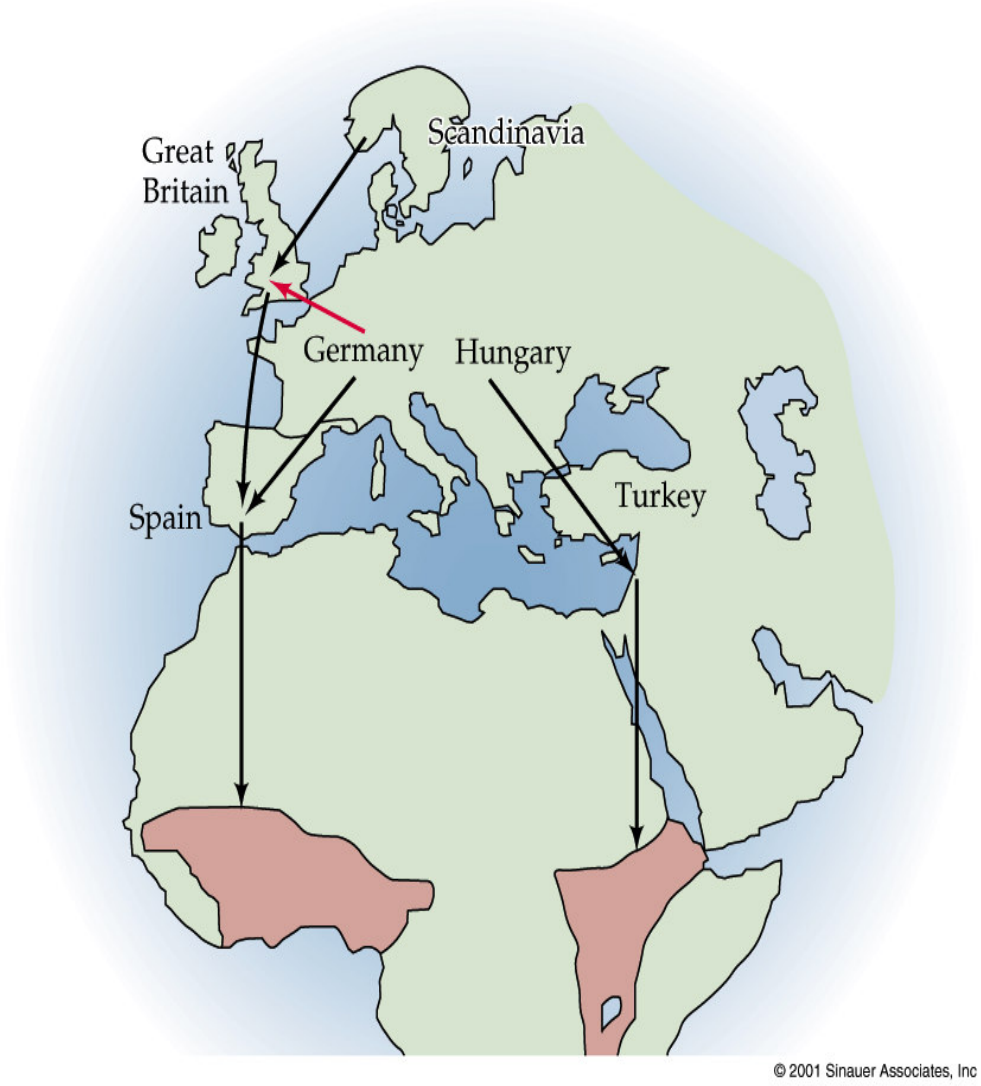


Frankland et al (2001) Nature

Alpha-calcium-calmodulin-dependent kinase II (alpha-CaMKII): a synaptic protein enriched in the hippocampus – needed in changing synaptic strengths and making memory permanent

Genes and behaviour

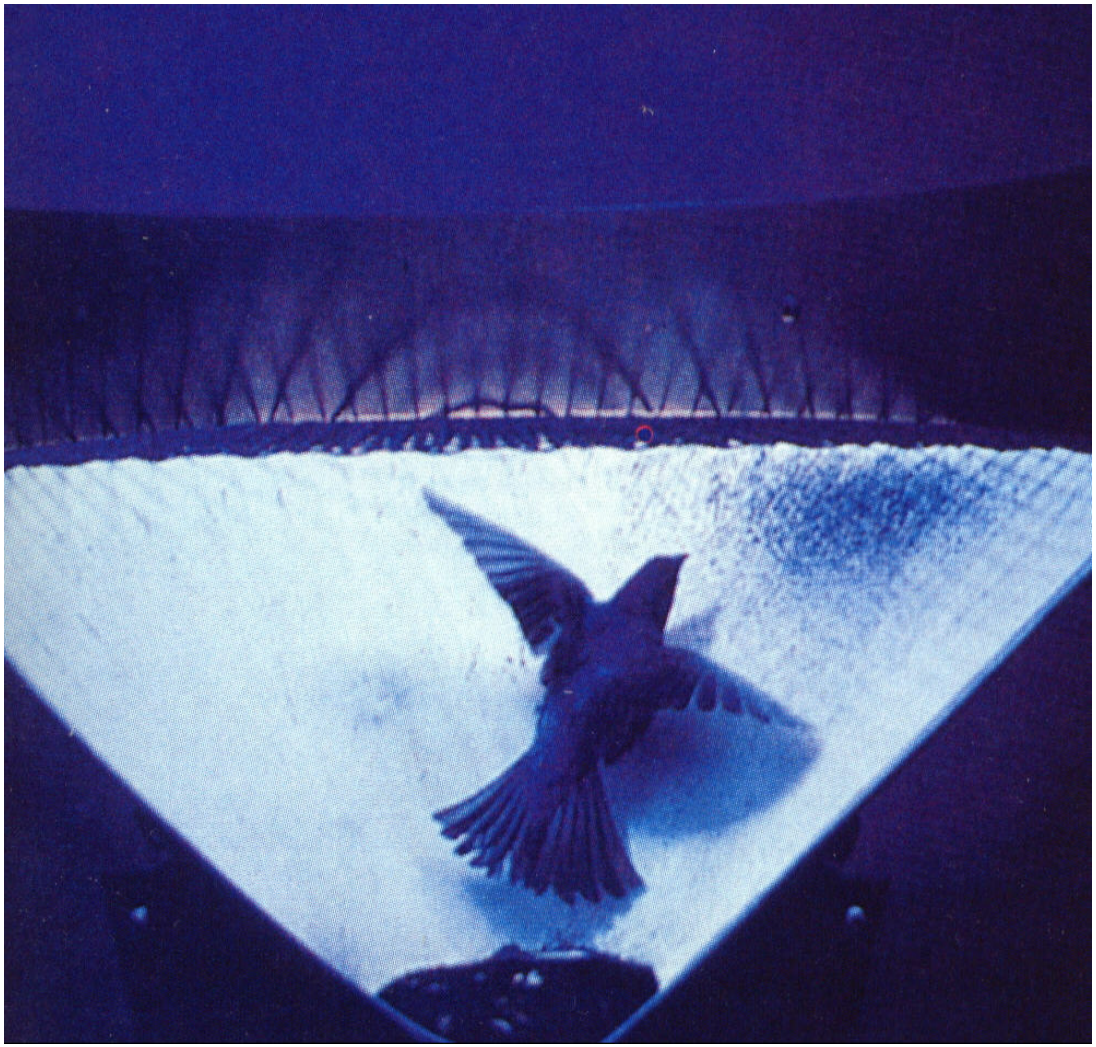
Blackcap warblers



1. Dr. Peter Berthold examined genetic basis of migratory behaviour
2. Why does British population not migrate?
3. Bred blackcaps over-wintering in England in captivity

Genes and behaviour

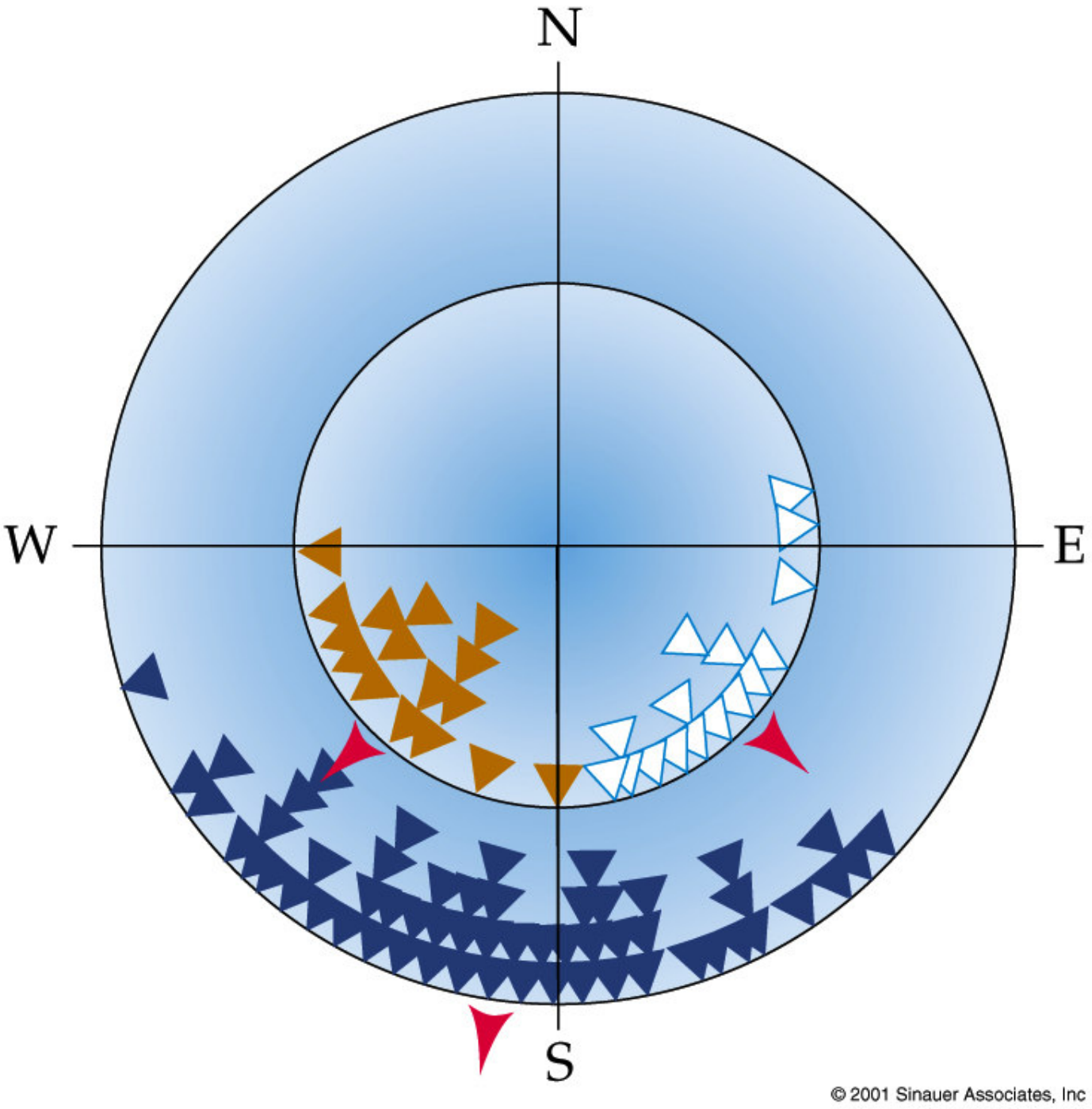
Blackcap warblers



4. Raised juveniles in absence of parents

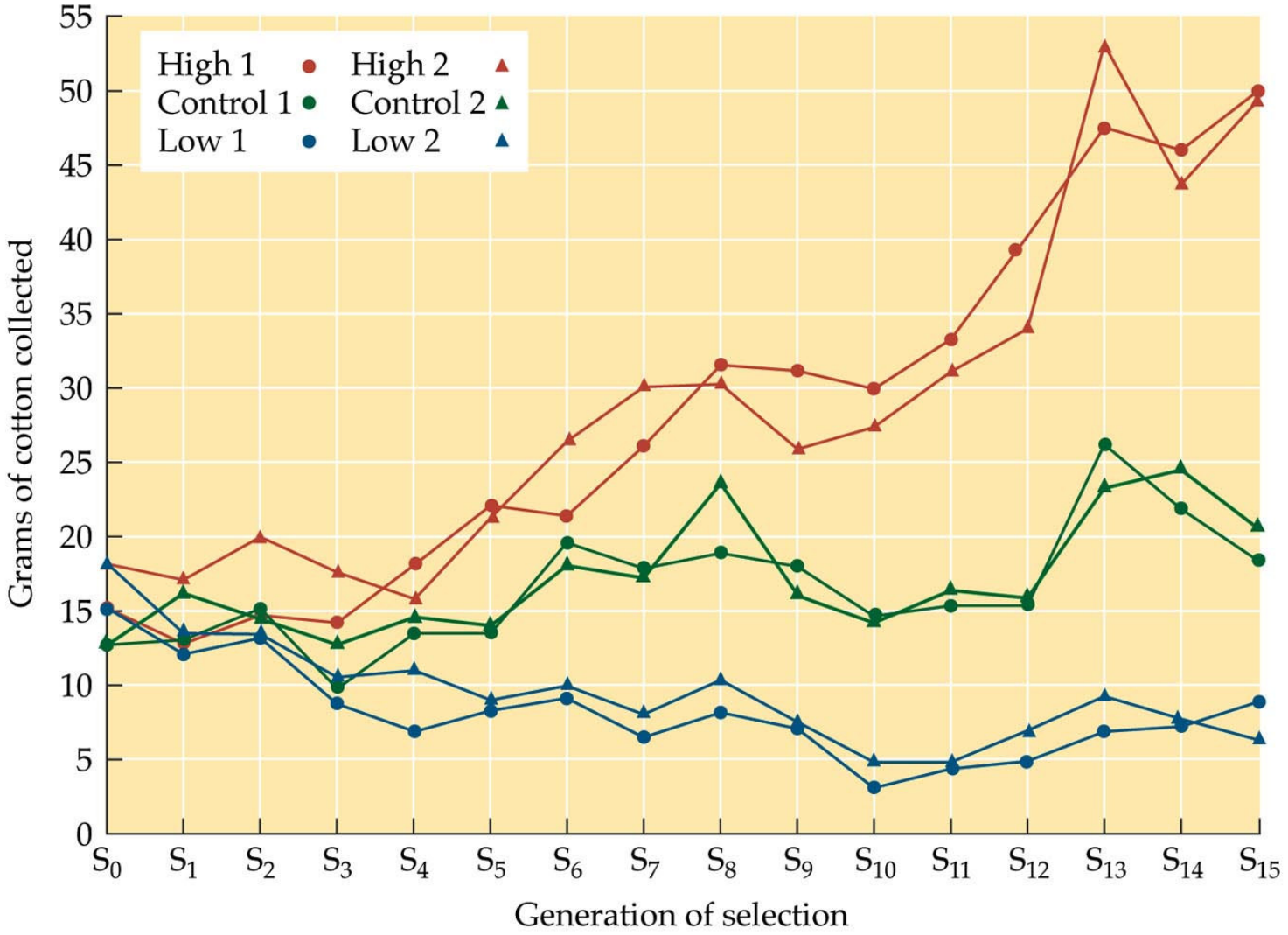
5. Found that juveniles showed heightened nighttime activity when fall arrived (indicative of migration)

6. Used funnel cage to determine migration orientation



- Crossed blackcaps from south-western Germany with those from Hungary
- Looked at migration orientation of hybrid young
- Found it was intermediate to parental generation

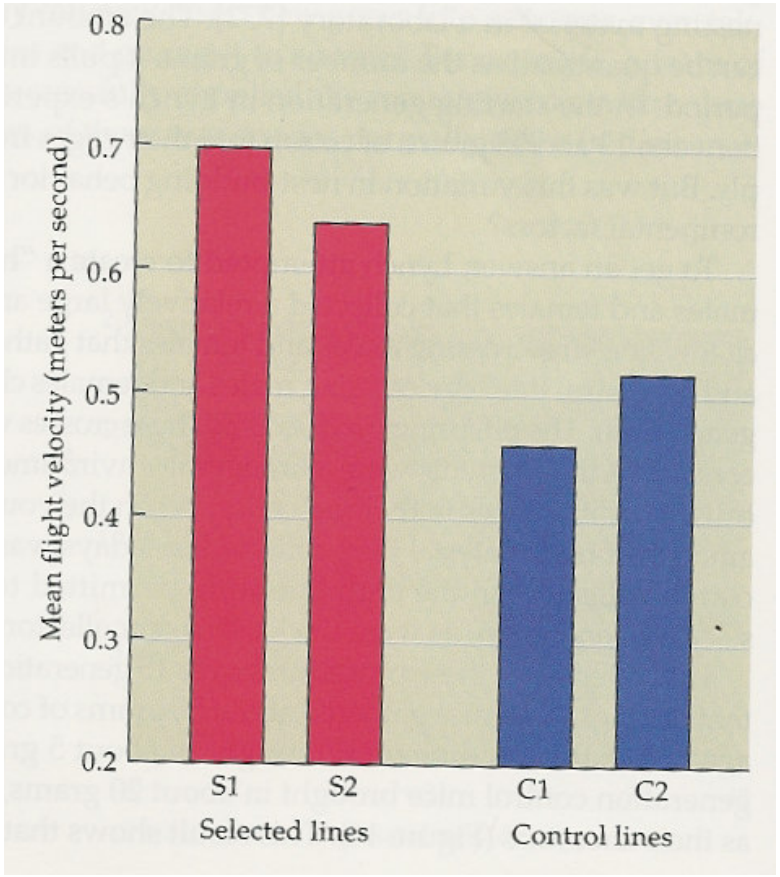
Artificial selection experiments



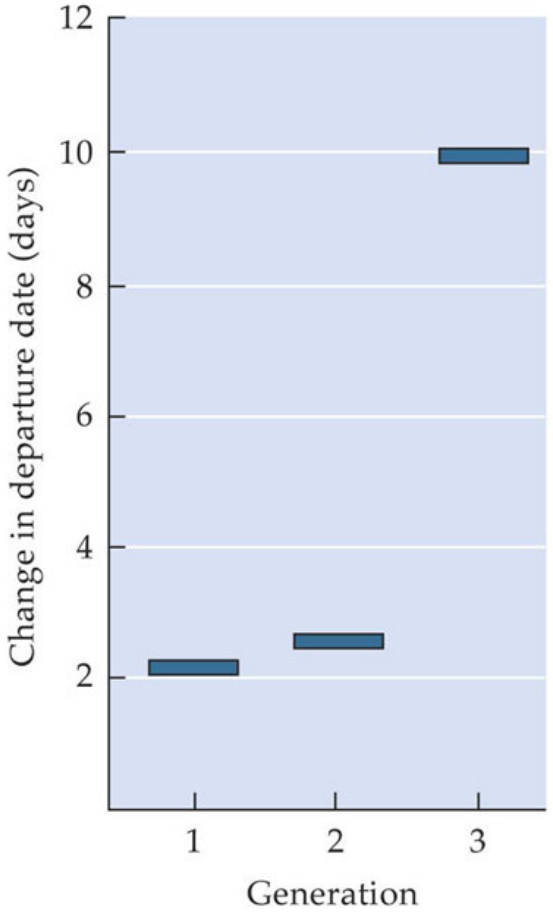
ANIMAL BEHAVIOR, Eighth Edition, Figure 3.24 © 2005 Sinauer Associates, Inc.

Lynch (1980) Genetics 96: 757

Artificial selection experiments



Upwind flight speed



Migration departure

Song dialects in birds – genetic or learnt?

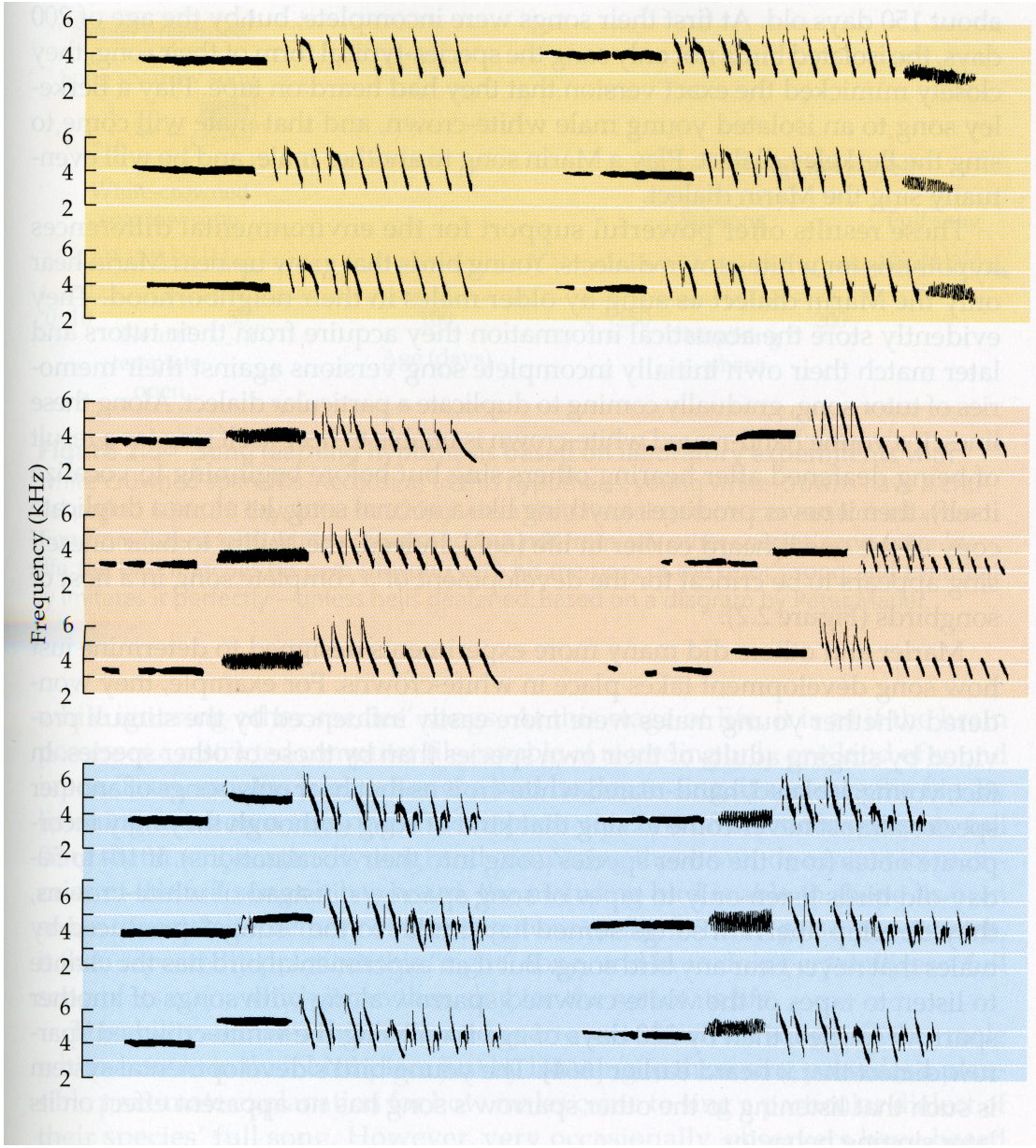
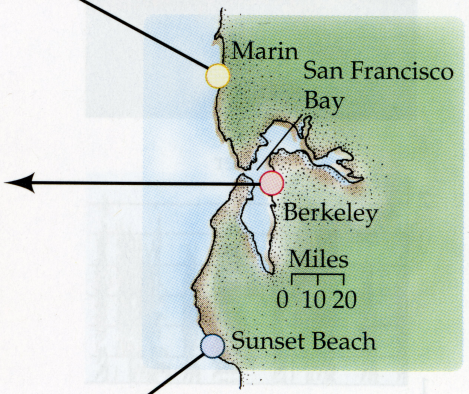
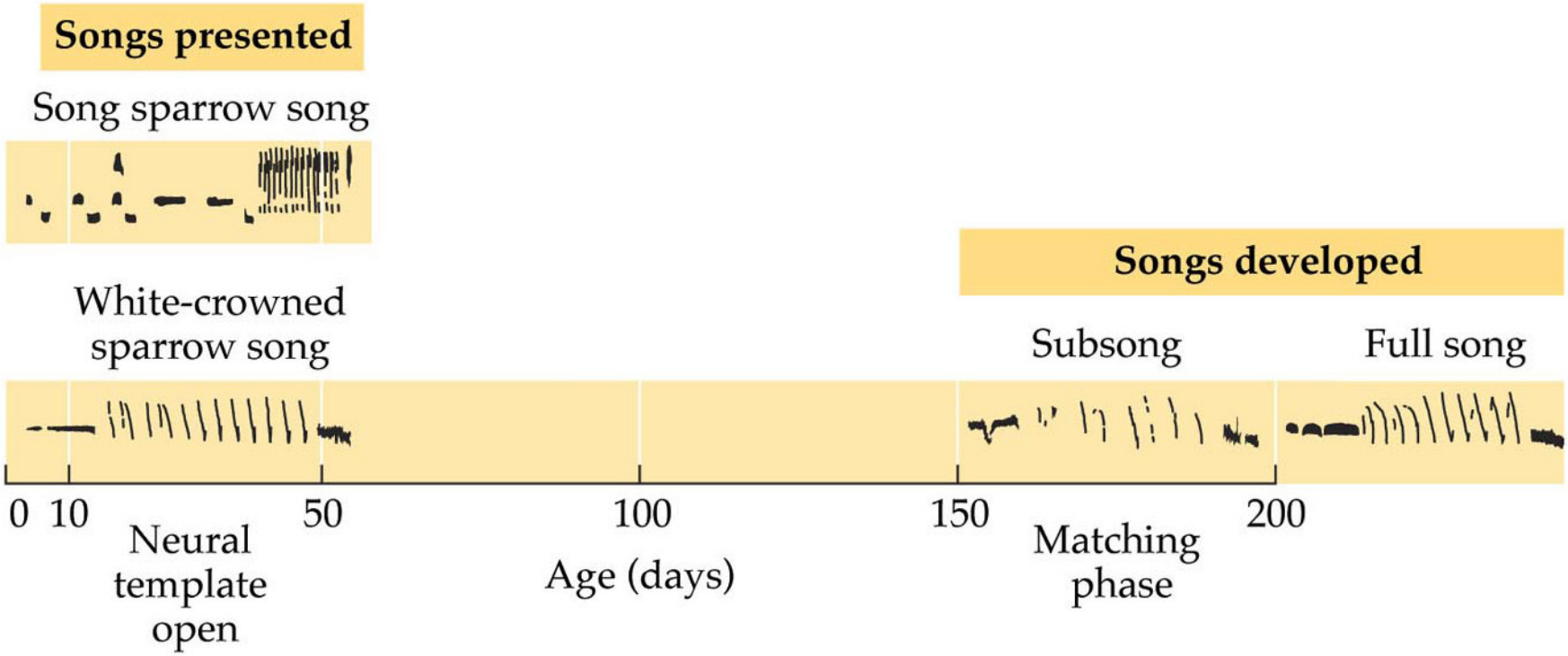


Figure 2.1 Song dialects in white-crowned sparrows from Marin, Berkeley, and Sunset Beach, California. Males in each location have their own distinctive song dialect, as revealed in these sonograms of the songs of six birds from each location. Sonograms shown on the same color are the same dialect. Sonograms courtesy of Peter Marler.



Song learning hypothesis

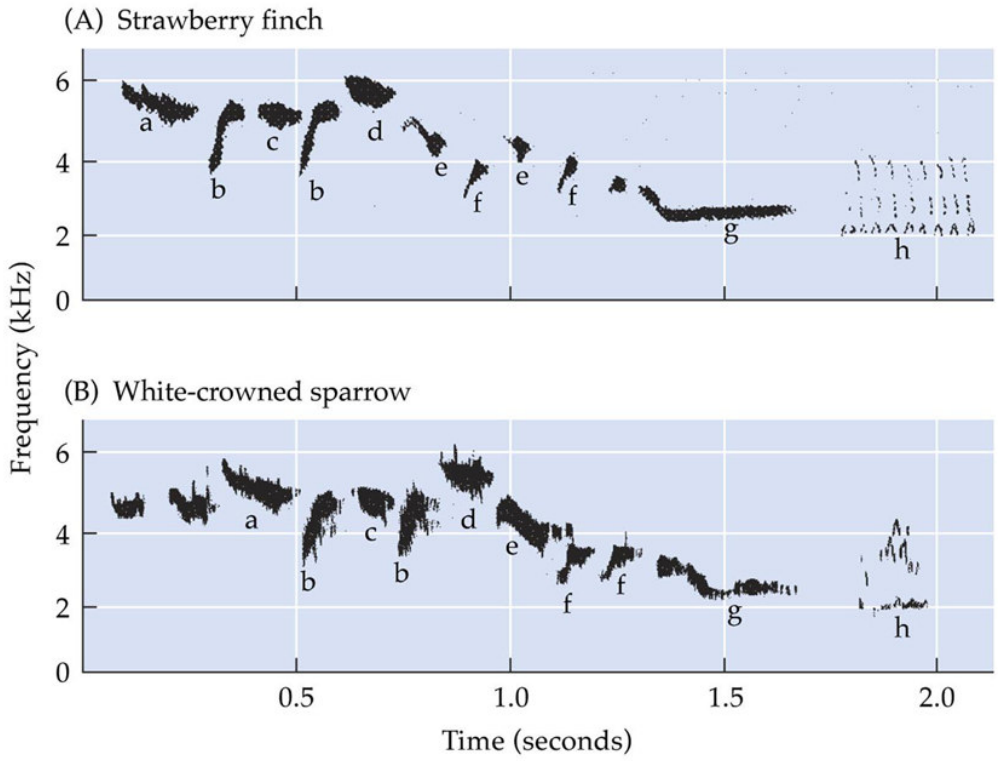


Selective storage of songs happens in early development

Songs are tried and matched to sample

Good matches are repeated and developed into full song

Birds can learn ‘songs’ from other species



White crown sparrows can learn strawberry finch songs

Kuro the starling learned human vocalisations – e.g. “see you soon baboon” and “basic research”.

Song dialects in white crowned sparrows

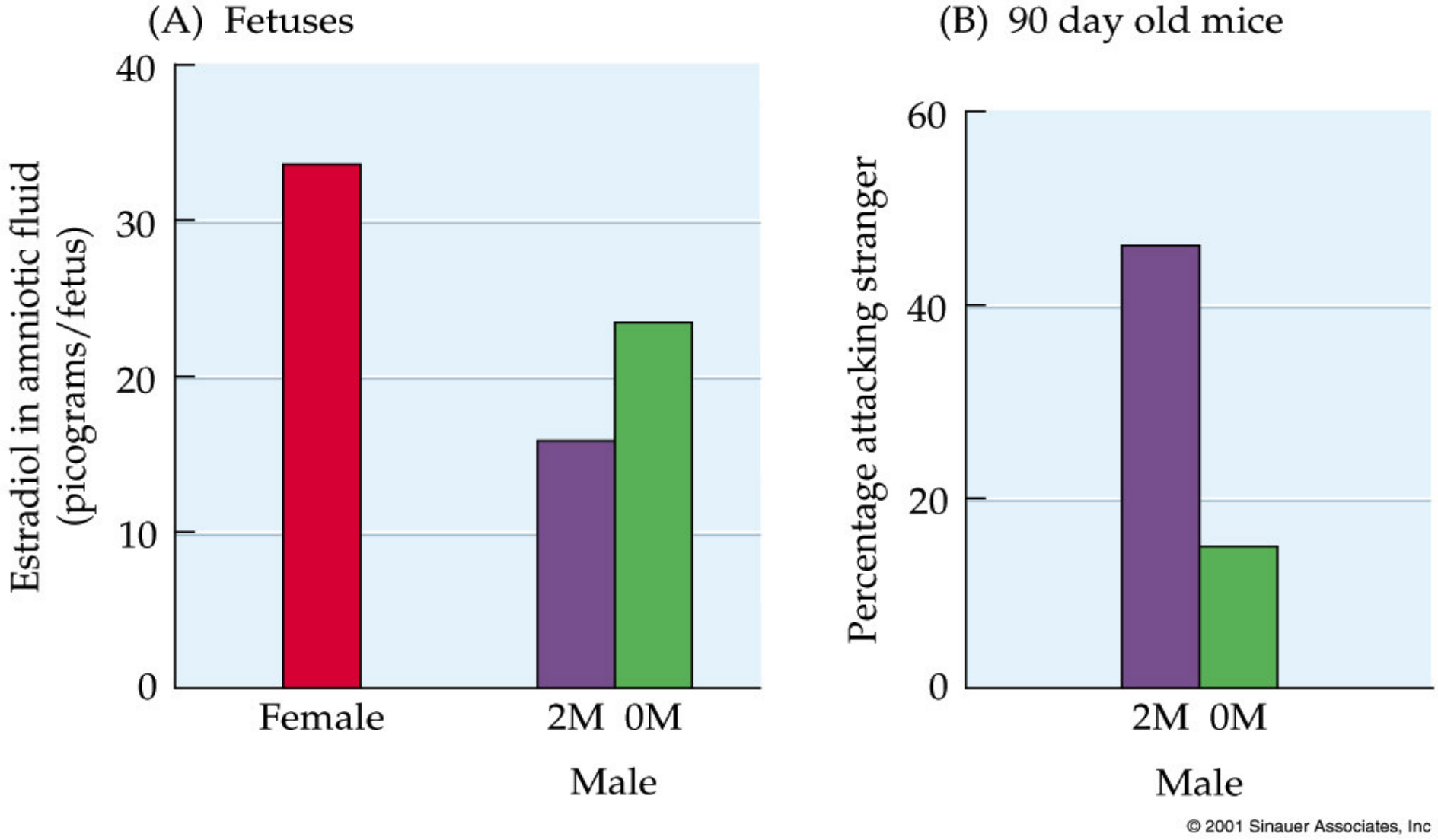
- lab raised birds with input only from loudspeakers: need to hear song in critical period of 10-50 days after hatching
- will learn any dialect of white crowned sparrows – but not the songs of other birds (from tape)
- They suggests they have a neural template for what qualifies as a ‘white crowned sparrow song’
- **But**: if birds are raised with tutors (same species, different species) they can learn other tunes, even outside the critical period

Environment and behaviour

gestation environment and aggression

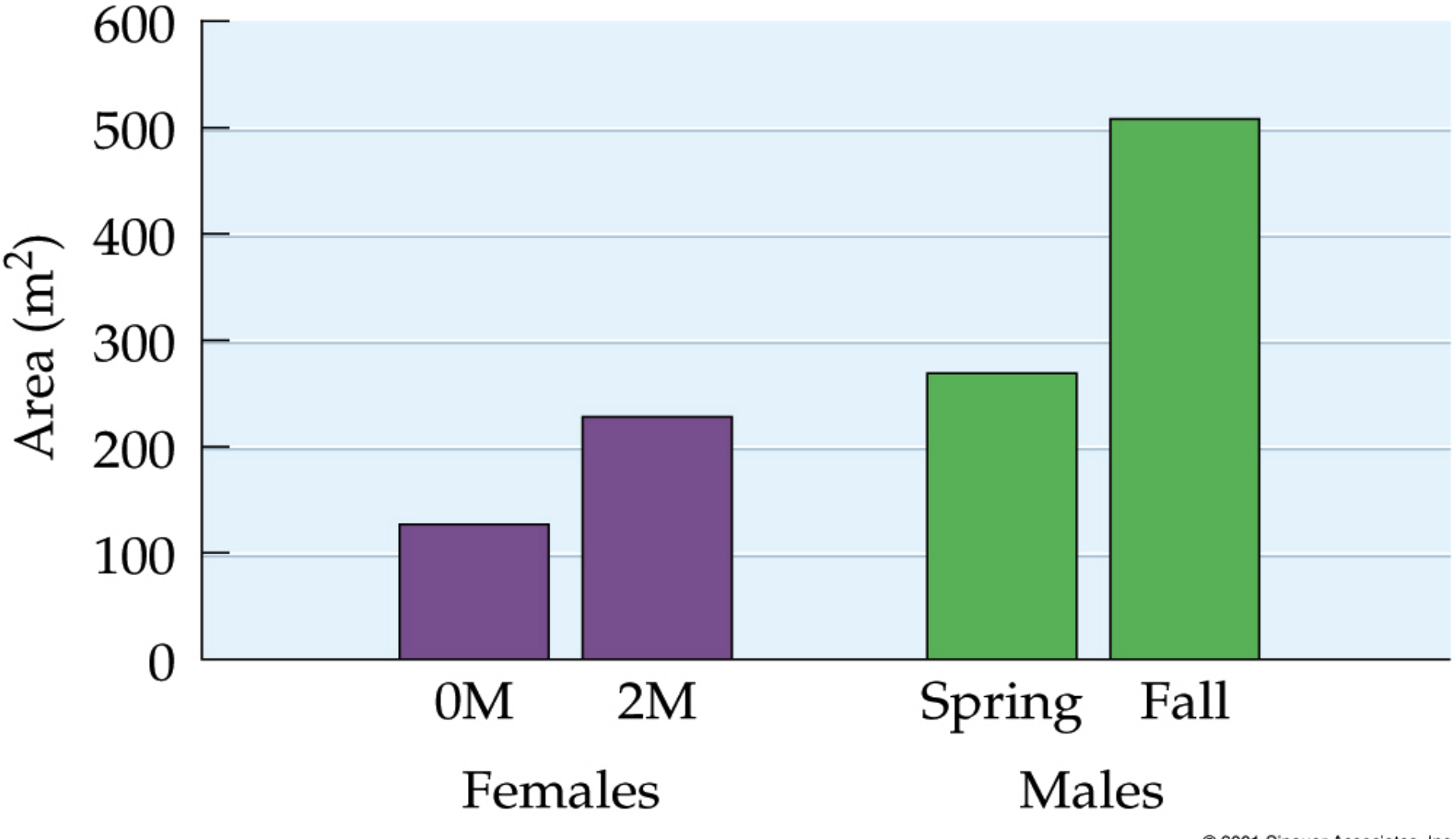
1. Mouse pups were delivered by caesarean and position within womb was noted.
2. Some males were situated in the womb between two sisters, or two brothers (similarly for females).
3. After birth, males were castrated and administered sex hormones (testosterone) to control for post-birth hormonal environment.

Prenatal environment influences aggression in male mice



Prenatal Environment and female behaviour in rats

home range size



Social dominance and brain development

1. Two morphs of an African cichlid (*Haplochromis burtoni*): territorial and satellite

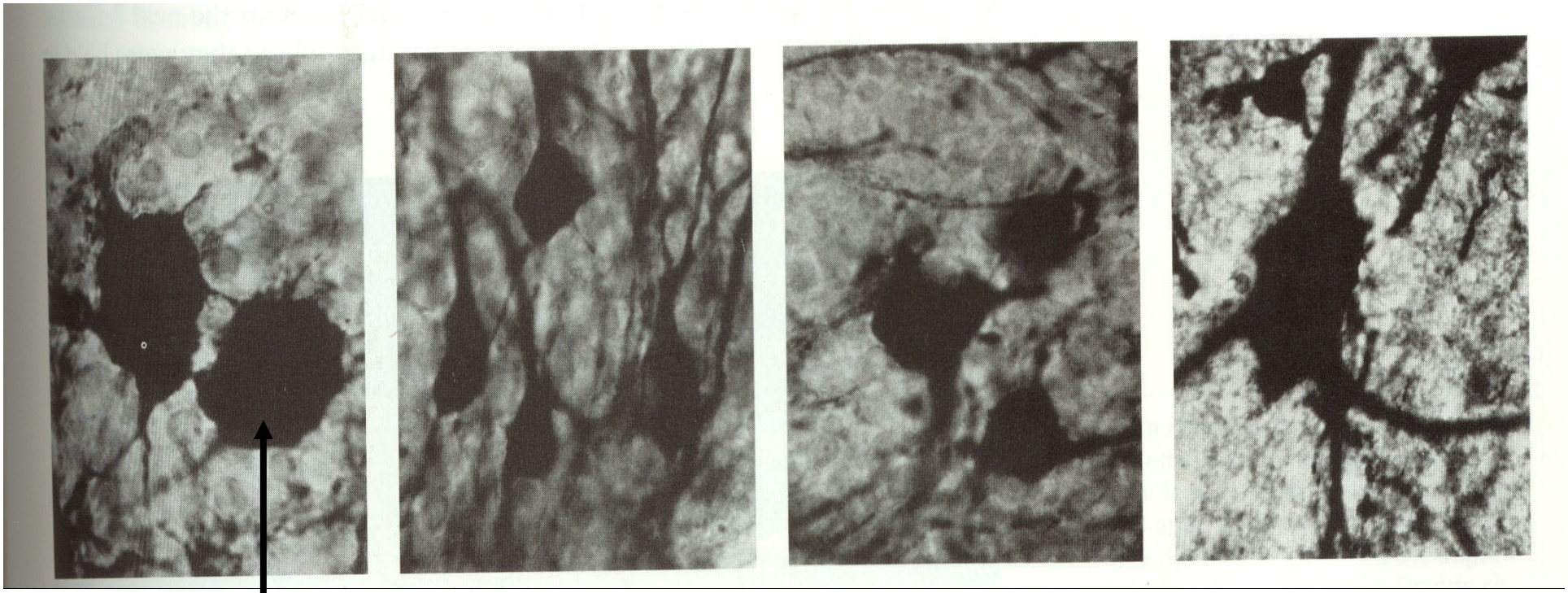
2. Social rank determines morph

3. Researchers examined GnRH neurons in forebrains of two morphs

Environment and behaviour

territorial male

satellite male



territorial male
that has recently
lost his territory

satellite male that
recently acquired
a territory

GnRN neurons

White et al (2002) J Exp Biol 205:2567

(Identical) twin studies

Caribbean

German

Separated at birth, 47 years apart

“Both liked sweet liqueur, collect elastic bands around their wrists, read magazines back to front, and dip buttered toast into coffee.”

Category	IQ	
	Genes	Measured correlation
1. Identical twins reared together	1.0	0.85
2. Identical twins reared apart	1.0	0.67
3. Fraternal twins reared together	0.5	0.58
4. Siblings reared apart	0.5	0.45
5. Parent-genetic offspring	0.5	0.39
6. Parent-adoptive offspring	0.0	0.18

Summary

1. There is a genetic basis to all behaviours

2. Some behaviours have a stronger genetic component than others

3. Behaviour is almost never *fully* "genetically determined"

4. Environment is very important too

5. Behaviour is typically determined by both "nature" AND "nurture"

Other literature

On adaptive significance and evolution of honeybee dances:

Dornhaus A & Chittka L. (2004) Why do honeybees dance? Behavioural Ecology & Sociobiology 55: 395-401

Dyer FC (2002) The biology of the dance language. Annual Review of Entomology 47: 917-949.

On the evolution of sexual colour preference in sticklebacks:

Smith, C, Barber I, Wootton RJ & Chittka L. (2004) A receiver bias in the origin of threespine stickleback mate choice. Proceedings of the Royal Society - B 271: 949-955.

On the evolution of learning:

Moore BR (2004) The evolution of learning. Biological Reviews 79: 301-335

Dukas R (2004) Evolutionary biology of animal cognition. Annual Review of Ecology Evolution & Systematics 35: 347-374