Weird animal genomes and sex chromosome evolution

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Embryonic diapause: blastocyst goes into suspended animation for up to 11 months.
Premature birth of underdeveloped Young: limb, organ development still going on. Provides opportunities for observation and manipulation of development that are impossible in mouse.

Lactation complex: big changes in milk composition between newborn and 3 months pouch young. Premmies? Control?

There are 26 species of kangaroo.
We chose the tammar wallaby as our model kangaroo. Small, easy to handle, most of the classic work on marsupial physiology is done on this species.
Inter-island crosses like *M. musculus* x *M. spretus* because they are very different.
- Lots of markers: microsatellite (variable numbers of repeats).
- Have loads of phenotypic differences including in reproductive characters like diapauses.

**Gorgeous kangaroo chromosomes...**

**Kangaroo physical map**
- choose conserved gene, search in trace archives
- design overgos from kangaroo sequence
- use to screen kangaroo BAC library
- FISH to kangaroo chromosomes

**Kangaroo linkage map**
- island populations
- many genetic differences
- hybrids, backcrosses
- map construction
Mono and tammar differ by about 10 interchromosomal rearrangements.

**Carnivorous marsupials (Dasyuridae)**

**Tasmanian tiger**
Thylacinus cynocephalus

Dunnart
“Marsupial mouse”
Sminthopsis crassicaudata

Extinct
1936

**Tasmanian Devil**
Facial Tumour Disease: Tumour cells transmitted by biting

Normal

Tumour

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- Sequence all vertebrates (66,000 species)
- Both sexes!!
- Map at least one species in group

Genes on the X and Y chromosomes

- PAR
  - Shared by X and Y
  - Contains 18 genes

X
- Many different functions
- Well conserved in mammals
- 1669 genes

Y
- Only 27 genes specific to Y
- Male-specific functions
- Poorly conserved

Sex chromosomes

- Problems at meiosis
- Dosage problems
- Sex-linked diseases
- Sex-reversal syndromes

Why so weird?

- so they work optimally?
- evolutionary accident?

Dumb design!

XY evolution
- Once the X and Y were an ordinary pair

proto-XY
- One partner acquires a male-determining gene

- Other male-advantage genes accumulate
  - recombination suppressed

Y degraded by deletion, mutation
- And degraded and degraded

And could even disappear

X
- Y is a degraded X

Degeneration of the sex-specific element (Y or W) from an original autosome, with examples of animal species which exhibit this level of differentiation.
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Evidence
human X-Y homology

Suggests progressive gene loss from Y

Origin of human sex chromosomes

X conservation in placental mammals

Evolutionary blocks on the X

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Evolution of sex chromosomes

- Frogs
- Many fish
- Humans
- Mice
- Kangaroos
- Turtles
- Alligators
- Bold snakes
- Colubrid snakes
- Ratite birds
- Vipers
- Carinate birds

X Y

ZZ:ZW

Sex in dragons
- Microdissect Z, W
- Use ZW DNA to screen BAC library
- Sequence BACs
- Identify orthologous region in chick genome
- Read off candidate sex determining genes

Ezaz, Georges, Sarre

Snake ZZ/ZW

# Bird ZW

Macroevolution

Marine turtles

No sex chromosomes
Temperature-dependent sex (TSD)

Turtle chromosomes
Painted with chick Z

Sex chromosome variation in reptiles

Gekko Z = Bird Z!!

Bird ZW is ancestral?

Origin of human sex chromosomes

Reptiles and birds
Monotremes
Marsupials
Placents
Amphibians
Fish
Tetrapods

Platypus sex chromosomes?
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Genes on platypus sex chromosomes

No homology to human X
Homology to chicken Z

Origin of human sex chromosomes

Evolution of vertebrate sex determination

Evolution of the X

- lots of genes
- many different functions
- conserved in mammals (because of XCI?)

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Nice examples of neofunctionalization (SRY, RBMY) and subfunctionalization.
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Y loss in XO spiny rat
Could it happen in humans?

SRY replaced by ??
Spermatogenesis genes relocated

What if

New hominid species?

War of the sex genes
Infertility

- species divergence

Hope for men!
Japanese spiny rats have survived loss of Y

Kuroiwa et al, 2010

Conclusions

Vertebrate genome is very conserved
Different regions may become sex chromosomes
Biased gene content, degeneration

This article should be referenced as such: