Week 1

AnS 331 lecture note outline – Part 1

What is animal reproduction?

Composite field:
- genetics
- embryology/developmental biology
- anatomy
- physiology
- endocrinology
- animal husbandry/management

Animal reproduction

- early comprehensive writing on reproduction by Greek philosopher Aristotle (384-322 B.C.): "Generation of Animals"
- next major treatise was in 1910: "The Physiology of Reproduction" by F.H.A. Marshall
- between the writings of Aristotle and Marshall, most of what was published was speculation rather than true knowledge of reproductive biology

Two schools of thought

preformationists: completely "pre-formed" miniature beings present in sperm or eggs; offspring formed by simple growth/enlargement

epigenists: tissues, organs, etc. formed from the egg

Senger text Fig 1-2

Add: 1827: von Baer described "ovulum" (150 years after discovery of sperm!)

Genetic aspects of reproduction

1865: Austrian monk Gregor Mendel formulated:

a) law of segregation
- unit of inheritance is a gene; genes exist in pairs within cells; members of a gene pair segregate into sex cells

b) law of independent assortment
- genes controlling separate traits segregate independently

1880: Flemming observed chromosomes in cell nuclei

1883: van Beneden recognized haploid nature of germ cells, restoration of diploid condition at fertilization

1902: McClung reported sex chromosomes

1908: Sutton identified that chromosomes carry hereditary material

1908: Bateson & Punnett discovered sex linkage

sex-linked traits: genes reside on the X chromosome

holandric traits described later by others

(Holandric Traits – genes found on the Y chromosome)

1953: Watson & Crick discovered structure of DNA

Basic review of genetics

somatic cells contain a nucleus

(Somatic Cells are any cell in the body other than sex cells)

each cell nucleus contains 2 sets of homologous chromosomes:

- 1 set from the mother (via the egg)
- 1 set from the father (via the sperm)

somatic cells are diploid [2n; contain 2 sets of homologous chromosomes]

mammalian gametes (i.e., sperm & eggs) are haploid [1n; contain only 1 set of homologous chromosomes]

species differ in the number of homologous chromosomes per cell

(Homologous chromosomes have the same appearance and structure. One from the mother and one from the father.)

Chromosome numbers

Species	2n (diploid)	1n (haploid)
humans	46	23
cats	38	19
pigs	38	19
sheep	54	27
goats	60	30
cows	60	30
donkeys	62	31
horses	64	32
Prezwalski	66	33
dogs	78	39
chickens*	78	39
turkeys*	82	41

* also have microchromosomes

species similarities in chromosome numbers:

- cats & pigs: 38 chromosomes/cell
- goats & cows: 60 chromosomes/cell
- dogs & chickens: 78 chromosomes/cell

Neighborhood Chat:

Can mating of different species (same number of chromosomes per cell) result in successful reproduction (defined as birth of live offspring)?

(Depends upon the species.)

Hybridization

successful mating of two different species
may have the same or different number of chromosomes per cell
example:
- donkey (2n=62) X horse (2n=64) = mule (2n=63)

Idaho Gem

Mule gives birth?
- Collbran, Colorado mule named Kate gave birth to foal "Winterhawk's Kule Mule Amos" in 2007
- Morocco (2002), China (1988), Morocco (1984)
- Roman phrase "cum mula peperit" (when a mule foals)

Hybridization (continued)
- mitochondrial DNA studies → hybridization is fairly common among many closely related species in the wild
- problem for species survival plans (SSPs) [example: snow leopard which are hybrid animals]

Basic review of genetics (continued)
within each nucleus, two types of chromosomes exist:
1) autosomes
   - typically one pair less than the total number of pairs of chromosomes
   - genes encode vast majority of traits
   - two doses of genes (one maternal & one paternal) are typically necessary for normal trait expression
2) sex chromosomes
   - carry genes that determine:
      - genetic sex
      - traits unrelated to genetic sex
   - usually one pair (2 chromosomes)
      - can see in karyotype
      - sex chromosome exception: duckbill platypus (10 sex chromosomes; 2 sets of 5 chromosomes)
         - XXXXXXXXXY
         - XXXXXXXXXX

a) mammals
   - XX (homogametic sex) are female
   - XY (heterogametic sex) are male

Sperm sexing uses knowledge of heterogametic sex
Senger text Fig 10-15
X chromosome larger than Y
X chromosome absorbs more DNA-specific dye
Fluorescent emission higher for X than Y
Flow cytometer

Flow cytometric sorting of whitetail deer spermatozoa (Kjelland et al. (2011) J Anim Sci 89:3996-4006)
(For trophy hunting they did this for the whitetail deer for people who want to hunt large bucks.)

Sex determination (cont'd)
1990: SRY gene discovered
Sex-determining **R**egion on **Y** chromosome
protein encoded by SRY gene is a DNA transcription factor
transcription factors activate (turn on) other genes
SRY transcription factor activates genes that cause testes to form
- autosomal genes: SF-1, SOX9, DMRT-1, FGF-9, etc

b) avians
ZZ (homogametic sex) are male
ZW (heterogametic sex) are female

sex-determining gene is DMRT1
- located on Z chromosome
  - 2 copies of DMRT1 = male
  - < 2 copies of DMRT1 = female

Neighborhood chat
Can a flow cytometer be used to successfully sort rooster spermatozoa as a means to pre-determine offspring genetic sex?

(There is no variation in sex chromosome composition in rooster sperm cells- they all have a Z chromosome)

Basic review of genetics (cont'd)
in mammals, only one dose of genes from each sex chromosome is used
- male (XY): all genes on X chromosome are used; all genes on Y chromosome are used
- female (XX) genes from only **<u>one</u>** X chromosome per cell are used

What happens to the other X chromosome per cell?
Barr body
- condensed chromatin resulting from the random inactivation of one X chromosome per cell in mammalian females

<u>Application of knowledge:</u>
Tortoisehell coat color in cats
locus on X chromosome with two alleles: X_B (black) X_b (orange)
some cells express black; some cells express orange
calico expresses white also

queens with tortoiseshell, calico, and "torbie" coat color patterns were more aggressive with the orange allele "blamed" for cat aggression. (Stelow et al (2016) J. Appl. Anim. Welfare Sci. 19(1):1-15)