Overview of Lecture: Sex & Reproduction.
Read: Text ch 46 (review ch 13)

Bullet Points:
• Sex & Reproduction
• Why Have Sex?
• Parthenogenesis
• Sexual Selection
• Sexual Conflict
• Human Mating Systems
• Signaling & Mate Choice
• Evolutionary Psychology
• Parental Care
‘Few subjects pervade our everyday thinking more than sex, and few urges are more insistent.’ (Raven et al. 2005)

By ‘sex’ the authors mean the:

Fitness depends on **reproductive success**.
Many proximate aspects of animal form and function (and thought)
  can be viewed as adaptations
  contributing to ultimate reproductive success.

There are two principal modes of animal reproduction.
**Asexual reproduction** is the **cloning** of one parent.
In most cases, just mitotic cell division w/o meiosis & syngamy.
  
  \{fission, fragmentation, budding, parthenogenesis \ldots\}

**Sexual reproduction** is the creation of offspring
  by the fusion of haploid gametes to form a diploid zygote.
Haploid gametes are formed by meiosis.
The female gamete, the **ovum** (unfertilized egg),
  is usually a relatively large and nonmotile cell.
The male gamete, the **spermatozoon**, is a small, motile cell.

**Sexual reproduction**
  by generating unique combinations of genes inherited from two parents.
Sexual reproduction may enhance the \{long-term\} reproductive success of parents
  when environment changes or offspring disperse or pathogens evolve.
  \{but there are short-term costs of sexual recombination: males & meiosis\}
In a population of parthenogenetic females cloning selves: the pop. can produce babies faster – everyone’s a mom; & each baby reproduces 100% of a mom’s genes, not 50%;
But babies, families & the pop genetically more homogeneous; less variable ecology, more vulnerable to coevolving parasites

This implies the operation of selective forces that confer an advantage to sexuality and genetic recombination, at either the population or individual level.

The effect of **sex and recombination** (combining isolated beneficial mutations at) different genetic loci, which:
is likely to be a major factor favoring their evolution and maintenance.

*With sex, isolated mutations at diff loci in diff individuals can be combined in one individual: beneficial mutations can interact synergistically & deleterious mutations can be purged in batches – both processes can speed adaptation and select for sexual recombination.*

**Sex releases the speed limit on evolution.**
Colegrave N. NATURE 420 (6916): 664-666 DEC 12 2002
…I show that sex can increase the rate of adaptation {to novel nutrient conditions} in the facultatively sexual single-celled chlorophyte Chlamydomonas reinhardtii …
Why Sex?
In evolutionary terms, sex is more important than life itself. Sex fuels evolutionary change by adding variation to the gene pool. The powerful urge to pass our genes on to the next generation has likely changed the face of human culture in ways we're only beginning to understand.

Show 5: Why Sex?

About the Program
Preview: QuickTime or RealPlayer
Buy the Video (entire series)

Help television evolve.
Make a pledge to your PBS station.

related web activities:

Is Love in Our DNA?
Did evolution shape your taste in a mate? Take our poll.

Sex and the Single Guppy
Learn how exhibitionism has an evolutionary payoff.
(Shockwave required)

The Mating Game
Help our contestants find the perfect date.
(Flash required)

The Advantage of Sex
Why did sex evolve? The likely answers may surprise you.

Questions about evolution? Check out the Evolution FAQ.
Animals may reproduce asexually or sexually exclusively, or they may alternate between the two modes.

In aphids, rotifers, and the freshwater crustacean **Daphnia**, each female can produce eggs of two types, depending on environmental conditions such as the time of year.

**Asexual reproduction occurs** early in the season. Females produce clonal parthenogenetic female offspring.

**Sexual reproduction occurs** during food shortages & end of season.

Some males develop from parthenogenetic eggs and some females produce darker eggs that require fertilisation by the males.

{**males made only when times are tough & sex-recombination is apparently a good idea!**}

The fertilized eggs form dormant “resting eggs”: may remain viable in sediment for years - disperse through time & space.

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**Differentiation in sex investment by clones and populations of Daphnia.**

Tessier AJ, Caceres CE  ECOLOGY LETTERS 7 (8): 695-703 AUG 2004

...document an ecological gradient in dormancy that is manifest as a genetic gradient in clonal variation **for the propensity to engage in sex.**
Researchers in Japan have shown for the first time that female mice can reproduce without help from the other half of the species.

**Birth of parthenogenetic mice that can develop to adulthood.**

Bi-parental reproduction is necessary because of parent-specific epigenetic modification of the genome during gametogenesis.

Here we show the development of a viable parthenogenetic mouse from a reconstructed oocyte containing two haploid sets of maternal genome, ...made possible by the appropriate expression of the... *making one egg nucleus act like a sperm nucleus by increasing the activity of the & repressing one*.

The parthenote developed to adulthood with the ability to reproduce offspring. These results suggest that **paternal imprinting prevents parthenogenesis**, ensuring that the paternal contribution is obligatory for the descendant.
If evolution by natural selection adapts animals to their environments, why are males & females so different?

Environment includes social env as well as ecological env. Males & females are in different social (mating) env’s.

Sex is a game (speaking technically, of course) with asymmetries that lead to

Mating systems begin with sex but differentiate around
Bateman’s Principle: - the “battle of the sexes”

There appears to be stronger selection on females than on males to mate more than once.

Fruit flies:

Sexual stereotypes

But! - in a diploid sexual species, in each generation, neither sex wins ‘battle of the sexes.’

If one male has relatively more offspring, this is a zero-sum game within the male sex; males don’t have more offspring on average, just greater variance.

Parental investment, sexual selection and sex ratios
Kokko H, Jennions MD 2008 JEB 21: 919-948
Sex role divergence is therefore still an evolutionary conundrum.
Mating is costly for males.


... courtship alone was sufficient to reduce male life span. Mating itself and production of seminal fluid and sperm, on the other hand, did not seem to be costly ...

Mounting attempts may be an indicator of an altered metabolic rate or hormonal status \{stress?\} that renders the males more susceptible to death.
Mating can be costly to females too

**Cost of mating** in *Drosophila-melanogaster* females is mediated by male accessory-gland products
Chapman et al. 1995 NATURE 373: 241-244.

**Female *Drosophila melanogaster* with** environmentally or genetically elevated rates of mating
This cost of mating is not attributable to receipt of sperm from the main cells of the male accessory gland are responsible for the cost of mating in females, *toxic semen*!
and that increasing exposure to these products increases female death rate.
Main-cell products are also involved
in elevating the rate of female egg-laying,
in reducing female receptivity to further matings and

The cost of mating to females may therefore represent a side-effect of evolutionary conflict between males


Neuroscience: Love hangover. *identifies receptor to sex-peptide*

We evaluated the influence of ... sexual selection upon male reproductive traits in a naturally promiscuous species, D. melanogaster. Sexual selection was removed in two replicate populations through enforced monogamous mating with random mate assignment or retained in polyandrous controls. {lots of males & females per bottle} Monogamous mating eliminates ... mate competition, mate discrimination, sperm competition, cryptic female choice and, hence, sexual conflict. Levels of divergence between lines in sperm production and male fitness traits were quantified after 38-81 generations of selection. ...

... the fitness of monogamous males and their mates was greater when reproducing in a non-competitive context: females mated once with monogamous males produced offspring at a faster rate and produced a greater total number of surviving progeny than did females mated to control males. The results indicate that sexual selection favours the production of increased numbers of sperm in D. melanogaster and ...
Sexual conflict occurs when the two sexes have conflicting optimal fitness strategies concerning reproduction ...


Mating systems are frequently shaped by conflicts over reproductive interests between males and females. Sexual cannibalism can be an especially dramatic manifestation of such conflicts.

Cannibalism may be in the interest of both sexes when females consume males to improve fecundity and/or males sacrifice their bodies to increase fertilization success.

... in the orb-web spider N. plumipes 60% of males do not survive copulation. Males that mate w/ mated females increase fertilization success by being cannibalized. Cannibalized males generally mate for longer, but longer copulations correspond with increased paternity.

Females should always cannibalize a male but males only gain from cannibalism.
Intrasexual selection for dominance & access in one sex selects for **sexual dimorphism** within species.

Does size dimorphism in humans suggest anything about ancestral mating systems?

Across primates, harem size is correlated with dimorphism, suggesting humans evolved dominance.
Y chromosomes reveal founding father -
Did conquest and concubines spread one man's genes across Asia?
Charlotte Schubert NEWS Published online: 24 October 2005

About 1.5 million men in northern China and Mongolia may be descended from a single man, according to a study based on Y chromosome genetics. Historical records suggest that this man may be Giocangga, who lived in the mid-1500s & whose grandson founded the Qing dynasty. The analysis is similar to a controversial study in 2003, which suggested that approximately 16 million men alive today are descended from the Mongolian conqueror Genghis Khan & his brother Don w/ same Y.

... the Y chromosome passes along steadily from father to son, providing a relatively fixed marker for clues about ancestry {Y can't crossover w/ X}.

BBC. 1.5m Chinese 'descendants of one man'
Over 1.5 million served.
Not by McDonalds but Giocangga, the grandfather of the founder of the Qing dynasty.
Recent genetic research suggests that over 1.5 million Chinese men are the direct descendants of this one single man.
... the average Chinese man at the time of Giocangga would only have around 20 descendants living today.
**Chimps** are not size dimorphic; males do not control access to harem.

**Humans** slightly dimorphic; slightly polygynous; do guard mate(s).

Inverse correlation between size dimorphism vs testicle size; Human mating system seems to have evolved w/ some competition for access to copulation; what about sperm competition?

Increasing size dimorphism correlated with increasing male-male competition for copulation.

**Gorillas** are very dimorphic; hyp: the more males compete for & control access to copulation,

Human sperm competition: testis size, sperm production and rates of extrapair copulations. Simmons et al. 2004. Anim Behav. 68:297-302. … rates of extrapair paternity are in the region of 2% … suggest that the risk of sperm competition in humans is

Big mystery:
Allometry of female breasts

Males find ‘shapely’ breasts attractive.

Hyp: Large breasts advertise youth, health & high repro. potential.

Angier (1999) claims male obsession w/ breasts is maladaptive

Consider female choices:

Venus Envy: A History of Cosmetic Surgery
Often animals choose mates by selecting for big signals or costly advertisements: "Status symbols" that are correlated with some unobservable quality of value.

Status symbols advertise ‘Goods’ to be delivered:

"I mean, hell, sure, Superman is cute, but Batman looks like he's got money."

Fitness of a signaler depends on survival & reproduction

The survival cost of advertising is compensated by
MACHINE MEASURES BEAUTY OF FACE (Feb, 1933)

Blinded By Science The Math Behind Beauty
A plastic surgeon computes the perfect face.
by Bruno Maddox
From the June 2007 issue, published online June 1, 2007

Marilyn Monroe (1957) by Milton H. Greene
Image courtesy of Merquidity Beauty Analysis

Even beauty may now be reduced to cold, hard figures, according to the inventors of a device that is said to record the contours of a face with thousandth-of-an-inch accuracy. Beauty shops might use the device, the inventors say, to learn how to change their customers' features. In the inventors' opinion, the following measurements are ideal: nose, same length as the height of forehead; eyes, separated by a space the width of one eye.
Psychological evidence suggests that sex differences in morphology have been modified by sexual selection so as to attract mates (intersexual) or intimidate rivals (intrasexual selection):

**Women** compete with each other for high quality husbands by exaggerating morphological indicators of, such as a small nose and small feet and pale, hairless skin. Sexually attractive in women ...

**Men's** physical appearance tends to communicate social dominance, which has the combined effects of intimidating reproductive rivals and attracting mates. The male beard is not obviously related to phenotypic quality ...

**Darwinian aesthetics: sexual selection and the biology of beauty.**
Waist-hip ratio in women is often considered a key feature in physical attractiveness. Measured directly from this image, the frontal WHR of the model in this image is approximately 0.69.


Waist-to-Hip Ratio across Cultures: Trade-Offs between Androgen- and Estrogen-Dependent Traits
E Cashdan 2008 Current Anthropology 49: 1099-1107

... women with a WHR of about 0.7 are more fecund, are less prone to chronic disease, and (in most cultures) are considered more attractive.

Optimal Waist-to-Hip Ratios in Women
Hormone levels predict attractiveness of women.
02 November 2005 NewScientist.com news service

Researchers ... have found that women’s facial attractiveness

ML Smith & colleagues photographed 59 women, aged 18-25, every week for six weeks. ... they provided a urine sample for hormone analysis and gave information on their menstrual cycle. None wore make-up, nor took the contraceptive pill. The photographs were rated by 14 men and 15 women, for attractiveness, health and femininity. The group also rated two composite face images of the 10 women with the lowest peak-oestrogen levels & the 10 women with the highest levels (see image).

“There was a very strong correlation between and how attractive, healthy and feminine they were found to be [by men & women]

{note skin color in photos & consider function of makeup}
Science in the Lap of Luxury

What a lapdancer's tips can tell scientists about female oestrus ...

As anyone who has ever kept a female dog knows, at certain times of the year she becomes the focus of affection for any male canine within sniffing distance. It’s because she is “on heat”, which is another name for the mammalian oestrus, a time when animals advertise their fertility and attractiveness to the opposite sex.

So does this happen to us? Geoffrey Miller and his colleagues hypothesised that if women do subconsciously advertise their peak fertility in some subtle way, then men ought to find them most attractive at this time.

To test their theory ... recruited 18 lap dancers & asked them to keep track of their tips ... the women recorded the stage of their menstrual cycles ...

The earnings of the normally-cycling (non pill-using) lap dancers

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Science says lap dancers send 'signals,' rake in cash

Ovulatory cycle effects on tip earnings by lap-dancers:
Economic evidence for human estrus?

Male facial attractiveness - Evidence for hormone-mediated adaptive design.
This study ... examine the facial preferences of 42 female volunteers at two different phases of their menstrual cycle.
Preferences were measured using a 1200 frame QuickTime movie that was designed to systematically modify a facial image from an extreme male (0) to an extreme female configuration (1200).
{masculine face (& 2/4th digit length) associated w/ testosterone}

High salivary testosterone is linked to masculine male facial appearance in humans.

The results indicate that females exhibit
(1) a preference for a male face on the masculine side of average,
(2) a shift toward a more masculine male face preference during the high-risk phase of their menstrual cycle {-29 frames}
The results are interpreted as support for a hormonal theory of facial attractiveness, whereby perceived beauty depends on an interaction between displayed hormone markers {masculinity} and the hormonal state of the viewer.