PRIMER ON MEIOSIS

Mammals – sexual reproduction

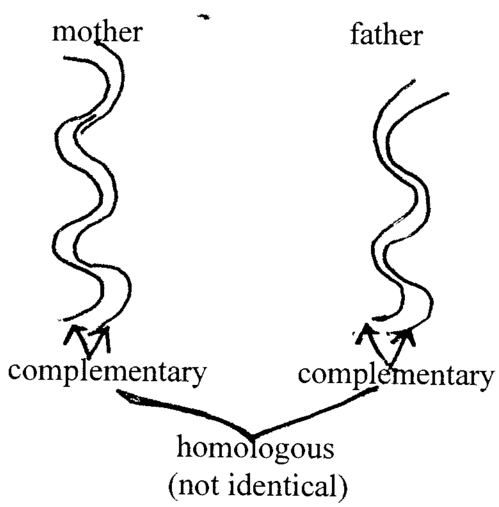
2 components: meiosis and fertilization

Some non-mammalian vertebrates reproduce via parthenogenesis – no fertilization, but still meiosis

Some species have no ♂ – more later in course

Meiosis – occurs in gonads – starts pre-birth ♀ mammal and at puberty ♂

Nomenclature – mitosis and meiosis



After the S phase, this all duplicated sister chromatids – identical

Cells that will undergo meiosis – meiocytes

Produced by mitosis from gonial cells

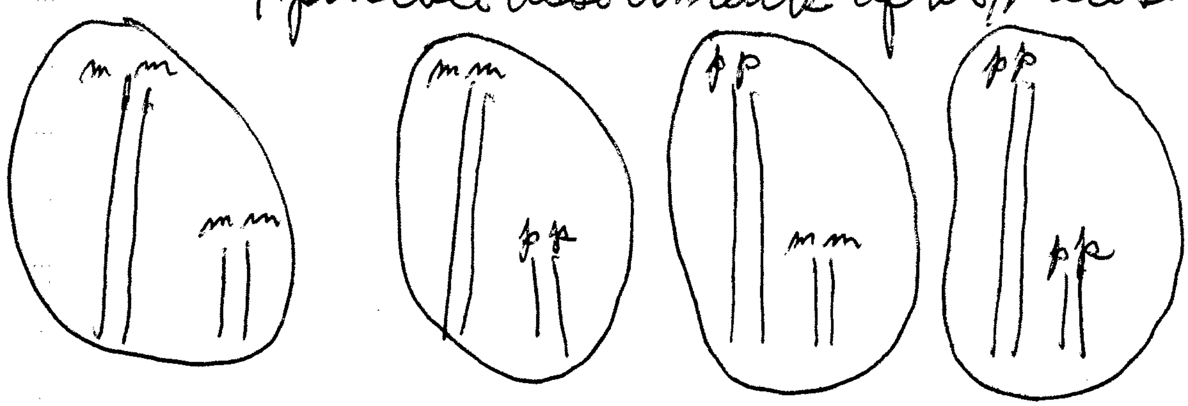
Gonia	➜	1° meiocyte	➜	2° meiocyte	➜	tid
2N ➜ 4N		2N ➜ 4N		2N		N

Random Assortment

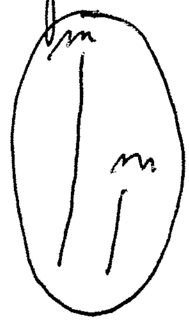
New combinations of alleles (without crossing over) for N = 2 chromosomes (long and short)

After S:

4 possible assortments after meiosis I



After meiosis II, each of above produces 2 sperm



etc

With 2 chromosomes -
4 kinds of sperm

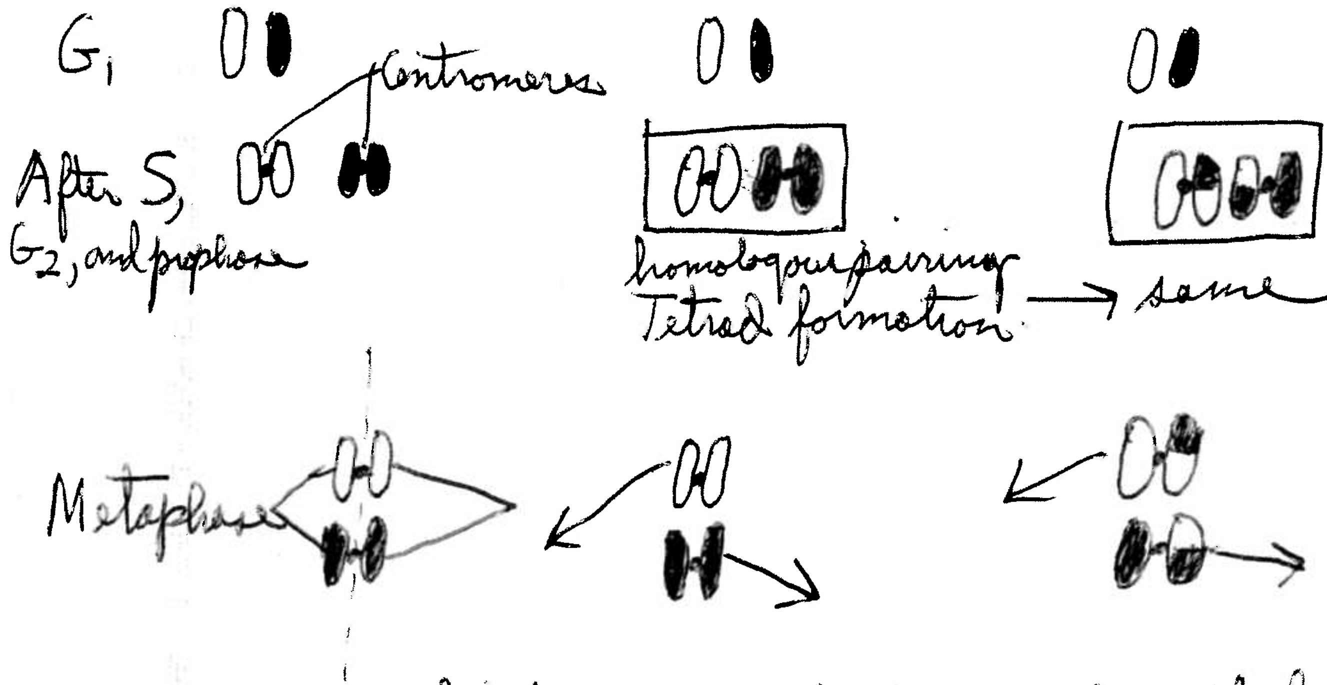
3 chromosomes
8 kinds of sperm

10 = 1024 kinds
20 = many millions

Crossing over is superimposed on this

Chromosome Movement in Mitosis vs. Meiosis
(One set of homologous chromosomes)
Maternal = white ; Paternal = black

Mitosis	Meiosis – no cross over (theoretical)	Meiosis with cross-over



Centromeres divide

one copy of each homolog to each cell

Centromeres do not divide

two copies of one homolog to one cell ; two copies of the other homolog to the other cell

each 2 complementary

Meiotic divisions vs mitotic:

1. 2 divisions w/only 1 DNA syn
2. No or very short G_2 after S phase, MI
3. Chromosomes move differently and independently
4. Very long cell cycle – weeks common, years sometimes

Have classical stages when cell divides as in mitosis – interphase, prophase, metaphase, anaphase, telophase, interphase

Repeated for meiosis II

Also sequences similar to mitosis; appearance of chromosome, breakdown nuclear envelope, migration centrioles, disappearance of nucleolus

So the sequence of relevance is:

last	G_2	
mitosis	M	
gonial cells	G_1	] longish
	S	]
	G_2 absent	
Meiosis I	M	
	] Prophase] metaphase, etc.	This prophase very prolonged – divided into 5 parts

Classically – Prophase described on basis of light microscopic observations

leptotene = adj.
zygotene
pachytene
diplotene
diakinesis

Start with preleptotene meiocyte – at this point chromatin diffuse – strands clumped

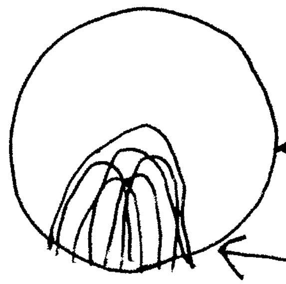
Then prophase divided into 5 stages (artificial, man-made stages for continuum)

1. **leptotene** (Greek leptos for thread) – see highly attenuated, long, thin thread-like chromosomes

all light microscopy view

Keyword = thread

Late leptotene – chromosomes seem to stick to one side



in plants synizetic knot
attach nuclear membrane near centriole

2. **zygotene** (Greek for yoke, adjoining, pair) – homologous chromosomes come together in zipper-like fashion point-for-point pairing (each of homologous chromosomes is a pair chromatids), can't recognize chromatids with light microscope at this stage

Keyword = pair

Nothing like this occurs in mitosis

3. **pachytene** (Greek for thick) – thickening & apparent coiling of chromosomes

Keyword = thick

4. **diplotene** (Greek for 2) – see that each homologous chromosome is actually a pair chromatids, [Tetrad] also see chiasmatas – morphological correlate of genetic crossing over – each homologous pair: at least 1 chiasmata or apoptosis

Keyword = doubling
↑
Is apparent, actually doubled much earlier

Homologs seem to repel each other except at chiasmata

Chromosomes go through diffuse stage many species (dyctiatate or dyctiotene)

Lampbrush chromosomes in some species

5. **diakinesis** (Greek for across) – tetrads coil, thicken, shorten, terminilization of chiasmata
nuclear envelope disappears
centrioles begin migration
nucleolus disappears

prometaphase (prophase, metaphase, anaphase, telophase) somewhat like mitosis

nuclear membrane forms at completion of MI in some species

quick interkinesis – no S phase, G_1 and G_2 are one phase and cells go through the rapid cell division of MII

In prophase, nuclear membranes disappear, centrioles migrate

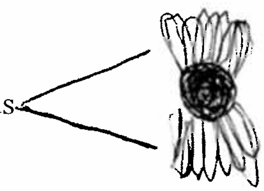
In telophase, nuclear membranes formed, etc.
great variation in actual details of process species to species

At this point, have established LM sequence of events

The electron microscope view is more interesting

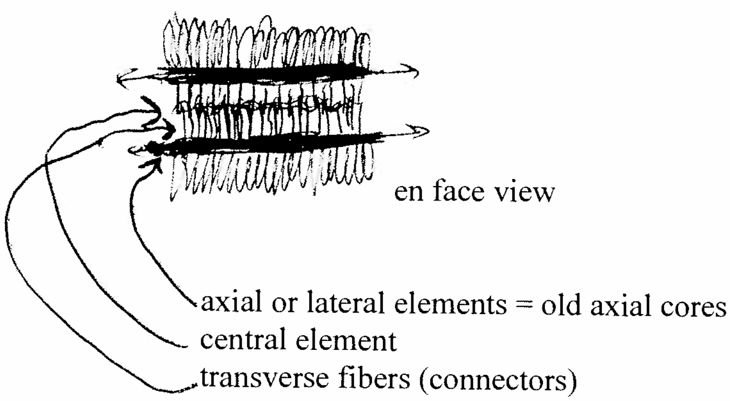
In leptotene find structures not seen with light microscope appearing called axial cores – 400 Å thick – made protein – 100 Å chromatin fibers radiate from

interpretation is that these are sister chromatids

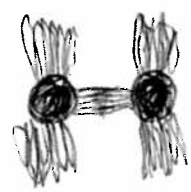


By pachytene, see new structure with electron microscope termed the synaptonemal complex

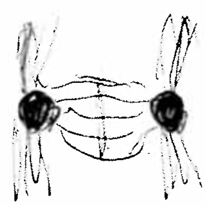
This is really the axial cores coming together as homologs pair



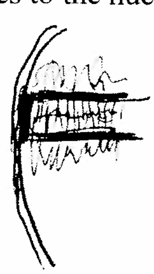
en face view


end view

Some species very elaborate variations on this



The synaptonemal complex attaches to the nuclear membranes as a telomere



Pairing of axial cores usually start ends of chromosomes on nuclear membrane, bouquet formation ends at chromosomes where they attach nuclear membrane

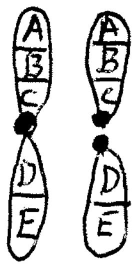
Is great debate over pairing of homologous chromosomes – how it occurs

See pairing light microscope at zygotene, but it may occur earlier
Some authors differentiate pairing from synapsis – latter is more intimate version

Some base pairing involved

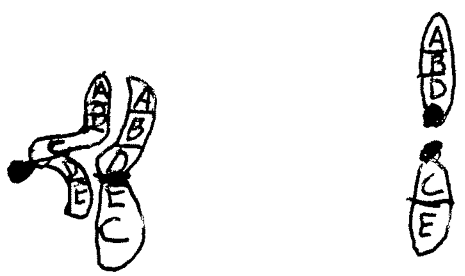
Why some hybreds are fertile and others (e.g. mules) sterile, even with different chromosome numbers in both cases.

1. Minimal rearrangement when a large metacentric chromosome breaks into two telocentric chromosomes to produce a second species



2 chromosomes can pair with 1 (large from the other species) at Meiosis

2. Too much rearrangement of DNA after the above occurs.



Same genes but in different linear order.

These cannot pair homologously. They try, but distort chromosomes so much that meiosis cannot proceed

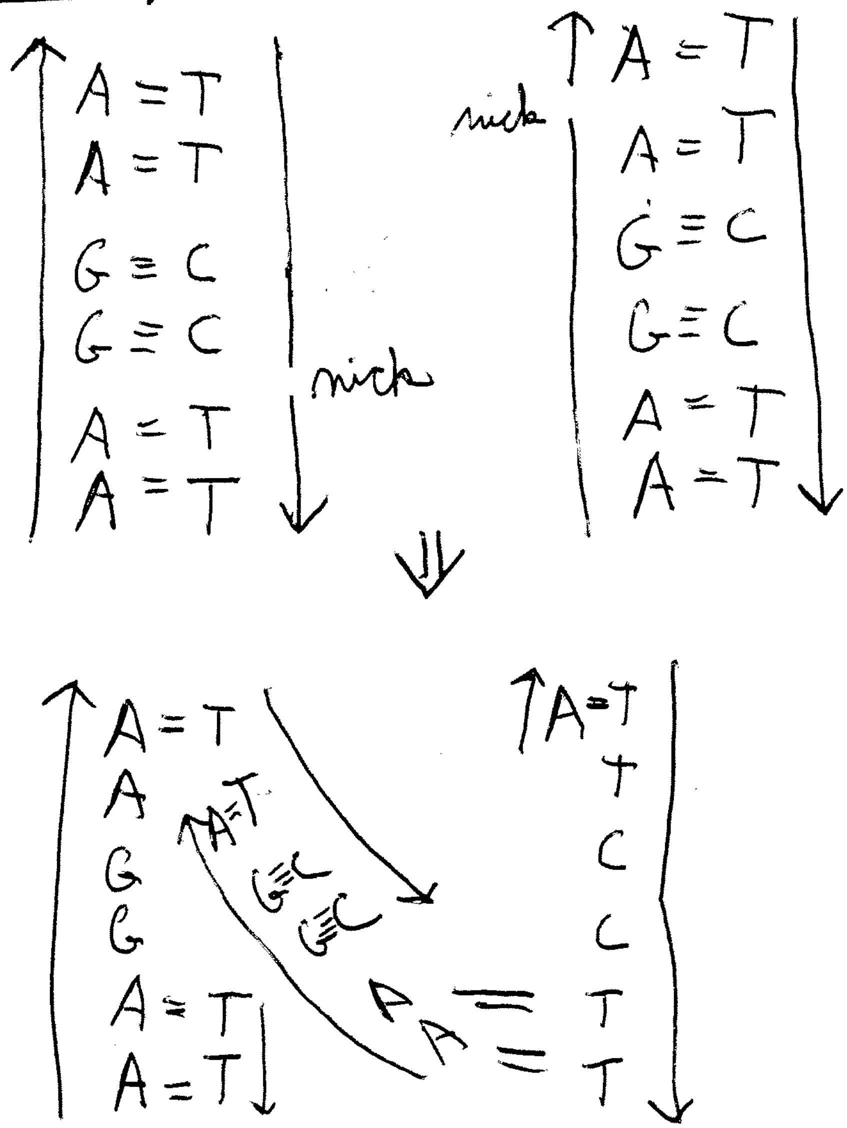
Holliday model of molecular aspects of crossing over — Mechanism similar to homologous recombination used to make transgenic animals

Enzymes: endonuclease nicks DNA, maybe 100,000 cuts

Get Holliday Junctions

Exonuclease gets rid of extraneous DNA

DNA polymerase fills in.



identical sequence portion of homologous chromosomes