GENETICS AND MENDEL



How is each group the same?
How is each group different?

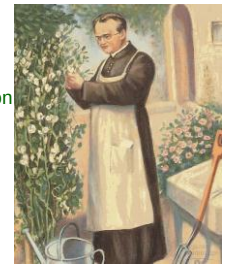


Heredity
transmission of traits from parents to offspring

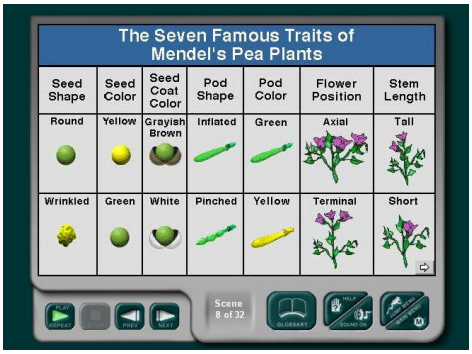
Genetics
study of heredity

HISTORY OF DISCOVERERY OF HEREDITY

- Up to 1800's: theory of blending inheritance
- 1851: Gregor Mendel, father of heredity
  - studied pea plants
  - prevented self pollination
  - used cross pollination



Mendel's Experiment



Genetic Terms

Alleles: different forms of the same gene
ex: tall / short
green seed / yellow seed
smooth / wrinkled
curly hair/ straight hair

Dominant: stronger trait which is expressed, written as a capital letter
ex: T

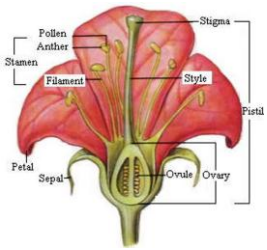
Recessive: weaker trait which is not expressed when paired with a dominant trait, written as a lower case letter
ex: t

Homozygous/Pure: appearance of 2 identical alleles of a gene on a chromosome
ex: TT, tt

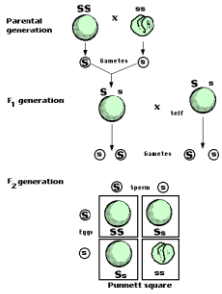
Heterozygous/Hybrid: appearance of 2 different alleles of a gene on a chromosome
ex: Tt

Genetic Terms

- **self pollination:** fertilization of plant's egg by pollen of same plant
- **cross pollination:** fertilization of plant's egg by pollen of another plant



Mendel: Experiment 1



Mendel: Experiment 1

1. he crossbred purebred plants of opposite traits (**parental/P generation**)
2. resulting offspring were **first filial (F1 generation)**
3. he self pollinated F1 generation
4. resulting offspring were **second filial (F2 generation)**
5. he performed 100's of crosses and documented results

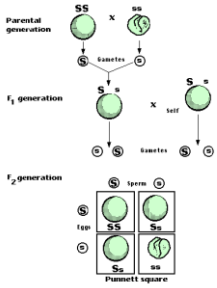
Results: Experiment 1

P
100% homozygous dominant: **SS**

F1
100% heterozygous dominant: **Ss**

F2
3:1 ratio dominant to recessive traits
smooth : wrinked

THIS WORK FORMED BASICS OF GENETICS AND HOLDS TRUE TODAY !



Mendel: Experiment 1

Mendel's Three Laws of Heredity

I. Law of Dominance and Recessiveness

One factor (gene) in a pair may mask the other factor (gene) preventing it from having an effect.

dominant: allele codes for a protein that works

recessive: allele codes for a protein that doesn't work

genes always occur in pairs

ex: TT, Tt : tall
tt: short

Mendel's Three Laws of Heredity

II. Law of Segregation

The two factors for a trait **segregate** (separate) during the formation of egg and sperm and each reproductive cell (gamete) receives only one factor for each trait

ex: male would give one trait : T or t
female would give one trait: T or t

offspring could have these combinations:
TT, Tt, tt

Mendel's Three Laws of Heredity

III. Law of Independent Assortment

Factors (genes) for different traits are distributed to reproductive cells (gametes) independently of each other.

- Mendel also crossed plants that differed in two characteristics
  ex: height, coat color
- He found that traits from dominant factors did not appear together
- Factors for each trait were not connected

MENDEL'S 4TH LAW

PRINCIPLE OF ZERO POPULATION GROWTH

"If your parents had no offspring, chances are 3:1 you won't either"

Mendel was very innovative because he applied math (probability) to Biology.

Probability
Possibility that an event will occur

Probability = $\frac{\text{\# one kind of event}}{\text{\# of all events}}$

Genetic Crosses

Punnett Square
Chart used to predict probabilities of genetic crosses (RC Punnett)

Phonotype: external appearance of an organism
Genotype: actual genetic makeup of an organism

Punnett Square steps:
1. determine which trait is dominant or recessive
2. determine genotype (remember – genes come in pairs)
3. write down letters to represent the gene pairs
4. write down the cross
5. make a square with 4 sections
6. put one pair across top (male), one pair down the side (female)
7. fill in boxes with the gene pairs

Mother's Genes	Father's Genes: b	Father's Genes: b
B	Bb	Bb
b	bb	bb

Monohybrid Cross
Crossing of one set of traits.

Practice Problems

Test Cross
Procedure where an individual of unknown genotype is crossed with a homozygous recessive individual.

Practice Problems

Dihybrid Cross
Crossing of two sets of traits.

Traits

Y	yellow	R	round
y	green	r	wrinkled

P generation
homozygous round, yellow X homozygous wrinkled, green

RRYY x rryy

P Generation

rryy

RRYY

	ry	ry	ry	ry
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy

F1 generation: 100% RrYy heterozygous round yellow
(only genotype possible)

Cross F1 generation: **RrYy**

RrYy

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

F2 generation: phenotype ratio

9 : 3 : 3 : 1
yellow round : yellow wrinkled : green round : green wrinkled

When crossing two hybrids- phenotype ratio will always be 9:3:3:1

Product Rule

Chance of one event X chance of another event =
chance of two events occurring at same time.

(A x B = AB)

Chance of brown eyes x chance of blonde hair = chance of blue eyes and happening together



Theories of Heredity

1902: **Walter Sutton**, Columbia University
- Observed that genes are located on chromosomes.
- Chromosomes carry genetic information

1903: **Chromosome Theory of Heredity**
1. Genes are located on chromosomes and each gene occupies a specific place (locus) on a chromosome.
2. Genes can exist in several forms. (alleles)
3. Each chromosome contains only one of the alleles for each of its genes.

Sutton – believed that genes move in sets on a chromosome.

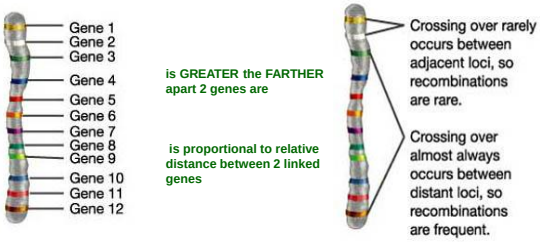
Theories of Heredity, cont.

1902/03: Thomas Hunt Morgan , Columbia Univ.
- proved gene linkage

Gene linkage: attachment of certain genes to each other on a chromosome

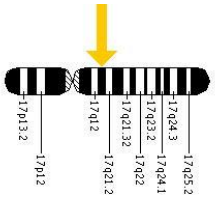
Linkage groups: group of genes on one chromosome usually inherited together
(they do not undergo independent assortment)

Exchange of chromatids pieces of a homologous pair during synapsis at a chiasma...



Sturtevant (worked with Morgan)

- responsible for discovering **crossing over**
- crossing over occurs at random along linkage groups and close together alleles rarely cross, farther distance alleles cross over more often
- used crossing over to make gene maps
- **gene map** diagram of allele positions on a particular chromosome



Sex Determination

1905: Nettie Stevens –

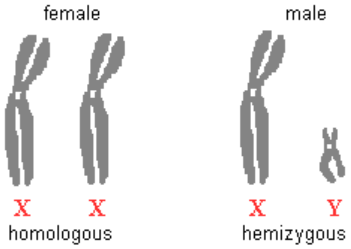
- discovered sex chromosomes

** **autosomes** – non sex chrom. matched
** **sex chromosomes** – mismatched pair

- female chromosomes - X
- male chromosomes - Y

- during meiosis, 4 resulting gametes have either only an X or Y
- 1:1 ratio of male to female offspring (50% probability in mating)

Which sex determines sex of offspring?



Sex Linkage

- 1909: discovered by Morgan (worked with drosophila)

Experiment:
- in a large batch of red eyed flies, they found 1 white eyed fly (actually a mutation)

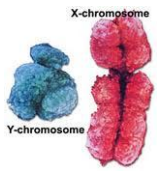
BIG DISCOVERY - NO FEMALES HAD WHITE EYES
ONLY MALES HAD WHITE EYES

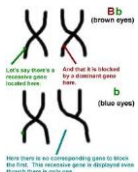
MORGAN DISCOVERED A SEX LINKED TRAIT

How is the gene for white eyes related to sex???

Sex Linked Genes (X linked)

- genes carried by either sex chromosome (generally carried on X chrom, missing on Y chromosome)





Lets revisit the experiment by Morgan

P $X^R X^R$ x $X^r Y$
red female white male

F1 $X^R X^r$ or $X^R Y$ (all red eyes)
red red
hetero hemizygous
female male

Hemizygous: dominant gene present and expressed, recessive gene missing

Cross F1: $X^R X^r$ x $X^R Y$

F2 3 red : 1 white (phenotype)

	X^R	Y
X^R	$X^R X^R$	$X^R Y$
X^r	$X^R X^r$	$X^r Y$

1 homo red female
1 hetero red female (carrier) (genotypes)
1 hemi red male
1 hemi white male

This is known as **"criss cross inheritance"**

P → F1 → F2
male female male
(express) (carrier) (1/2 sons express)

What would happen in F3 if hybrid red female was crossed with expressing male?

$X^R X^r$ x $X^r Y$

F3

	X^r	Y
X^R	$X^R X^r$	$X^R Y$
X^r	$X^r X^r$	$X^r Y$

1 carrier female
1 normal male
1 male expresses
1 female expresses

- Why is this important?

- sex linked traits not limited to drosophila
- occur in all species including humans

REGULATION OF GENE EXPRESSION

Gene expression (protein expression)
Process by which a gene's information is converted into the structures and functions of a cell.

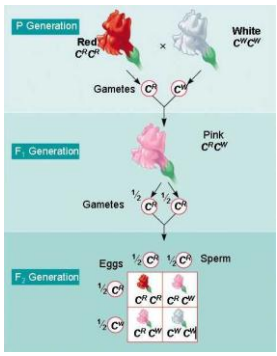
dominance: protein works
recessiveness: protein does not work

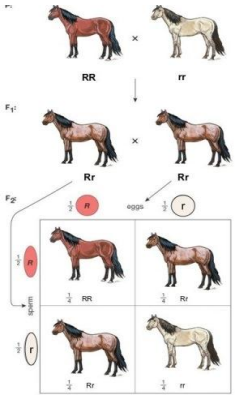
Gene Interactions

1. **Incomplete dominance**
Active allele does not entirely compensate for inactive allele.

- heterozygous phenotype is between two homozygous phenotypes
- only one dominant allele is active

****3rd phenotype is mixture of phenotypes****





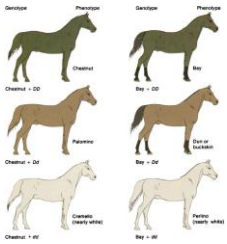
2. Codominance

Both alleles of a gene are expressed.

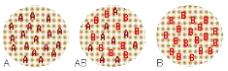
- both alleles are active and expressed
- very common in many organisms

****third phenotype has original phenotypes****

Incomplete dominance



Co-dominance

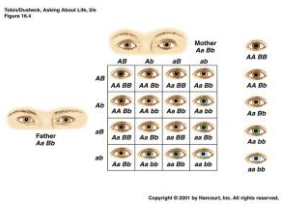


3. Polygenic inheritance

Two or more genes responsible for a single trait.

Ex: skin color
(4-7 genes)

eye color
(at least 8 genes)



Study for the test!!!