4-H Project Connections
- Beef
- Dairy
- Dog
- Goats
- Horse
- Sheep
- Swine
- Veterinary Science

4-H Science Abilities:
- Categorize/Order/Classify
- Collect Data
- Compare/Contrast
- Infer
- Interpret/Analyze/Reason
- Predict
- Question

4-H Life Skills:
- Critical Thinking
- Learning to Learn
- Marketable Skills
- Planning/Organizing
- Problem Solving

Colorado Science Standards:

Eighth Grade
- 2LS1. Organisms reproduce & transmit genetic information (genes) to offspring, which influence individuals ' traits in the next generation.

Fifth Grade
- 2LS1. All organisms have structures & systems with separate functions.

Fourth Grade
- 2LS1. All living things share similar characteristics, but they also have differences that can be described & classified.

Colorado Mathematics Standards:

Sixth Grade
- 1.1 Quantities can be expressed & compared using ratios & rates.

Fifth Grade
- 3.1 Visual displays are used to interpret data.

Fourth Grade
- 3.1 Visual displays are used to interpret data.

National Science Standards:

Life Science
- H.C.1 The cell
- M.C.2 Reproduction and heredity
- H.C.2 Molecular basis of heredity
- H.C.3 Biological evolution

Science in Personal and Social Perspectives
- H.F.6 Science and technology in local, national and global challenges

STEM Connections

Colorado State University Extension

Connecting Science, Technology, Engineering, and Math concepts to our everyday lives.

Introduction: All living things express **traits**. A trait is a distinct inherited feature or quality. The way that a trait is shown externally is called **phenotype**. For instance, wool crimp would be a trait expressed in sheep. People have known for a long time that offspring look like their parents. So, ewes and rams with really crimpy wool are likely to have lambs that also have crimpy wool. Animals store information about traits on things called **genes**. Parents each donate one gene to their offspring, making a pair of genes. These genes can be **dominant** or **recessive**. A dominant gene is expressed regardless of the other gene in the pair. That means that if there are two dominant genes in a pair, called co-dominance, both genes are expressed. Usually dominant genes are symbolized by a capital letter. A recessive gene is only expressed if both genes in the pair are recessive. Usually recessive genes are symbolized by a lower case letter. Animals can have a recessive gene that they do not express. If both genes in the pair are dominant or recessive they are called **homozygous** (homo = alike). However, if the animal has one recessive gene and one dominant gene, they are called **heterozygous**. The genetic makeup of an animal is called **genotype**. Genotypes are valuable in predicting various traits and can predict disease. For instance, scrapies can be prevented based on genotype. Scientists use a tool called a **Punnett Square** to predict the genotype of offspring between two parents. In the following activities, we will use Punnett Squares to calculate the likelihood of various phenotypes and genotypes. Then we will use genetic information to build a sheep.

Who was the first person to discover genes? His name was Gregor Mendel and he was a monk in Austria who worked almost 150 years ago. He cross bred different kinds of pea plants over many generations. He used math (particularly fractions and probability) to find the likelihood of a plant to have various traits. Mendel tested lots of kinds of traits such as seed color, the way the seed looked (round or wrinkled), plant height and many more traits!

Ages:
- 4th—8th grades

Time Required:
- 30—45 minutes

Materials:
- Balloons (Black & White)
- Black Permanent Marker
- Brown Paper Bags (small)
- Bugles ® (type of snack)
- Craft eyes (optional)
- Felt/Craft Foam/ Cardstock
- Pen/pencil
- Pipe cleaners
- Scissors
- Stick Glue/ Rubber Cement
- Tape
- Worksheets at the end of the lesson
- Yarn, Wool or Cotton Balls

Power Words
- co-dominance—two genes are equally expressed
- dominant— a gene that is expressed regardless of the other gene in the pair
- gene—the basic unit that determines a trait
- genotype— the genetic makeup of an animal
- heterozygous - the genotype has one recessive and one dominant gene
- homozygous - the genotype has two recessive or two dominant genes
- phenotype - the expression of genetic traits
- Punnett Square— a tool used to predict an offspring's phenotype
- recessive - a gene that is only expressed if both genes in the pair are recessive
- traits—a distinct inherited feature or quality

Experience / "What to Do"

A: Learning How to Use a Punnett Square

Punnett Squares are used to predict the genotype of offspring. The female's genotype is always placed on the x-axis and the male's genotype is always placed on the y-axis. From here, one gene from each parent is distributed to each theoretical offspring. An example is shown below.

In this example, we want to determine if the offspring will be polled or horned. Polled is dominant and horned is recessive.

The female and male are both homozygous polled.

1. What is the female's genotype? Homozygous polled = PP
2. What is the male's genotype? Homozygous polled = PP
3. Put the correct characters in each of the boxes:

Male \ Female	P	P
P		
P		

4. Distribute one gene to each offspring:

Male \ Female	P	P
P	PP	PP
P	PP	PP

5. At this point we decide what percentage of the population is homozygous dominant and polled. What about homozygous recessive and horned? Heterozygous? Since all of the offspring are PP, they are all homozygous dominant or 100% polled. Follow this same process for the remainder of the worksheet. (See Answers that Follow.)

B: Use Genetics to Build a Sheep

1. Cut out the Punnett Squares on page 4. Glue the Punnett Squares to the outside of a brown paper bag. Inside the bag place the cut-out genotypes that correspond to the trait. Repeat for each trait.
2. Place the bags in order in which youth should build their sheep. It's important that the colored face trait goes first (so they have something to tape/glue the rest of the traits to) and that the scrapies trait goes last.
3. Match the corresponding trait to the correct "body part". Black and white balloons should be available for the head (with black permanent markers for speckles), Bugles ® should be available for the horns, ears should be prepared (see cutouts), yarn, wool or cotton balls for the wool cap, noses should be shaped from pipe cleaners and cut outs represent the scrapies gene.
4. Youth should be able to go through the various traits and "build" a sheep. A couple of hints:

⇒ The probability will only work if the genotypes are returned to the bag after every youth has a turn.

⇒ You should be able to use the key on the bottom of the sheep building workshop to identify dominant and recessive traits.

⇒ Youth should use markers to draw eyes on their head or use craft eyes

⇒ Since both black and white are dominant traits, (called co-dominant) youth with the heterozygous BW will have speckled faces (since both traits are expressed.) They should get a white balloon and draw on black spots.

⇒ When the sheep are all built check to make sure that their genotypes and phenotypes match

⇒ When the sheep are all built, you should explain to the group that those with scrapies QQ are susceptible to scrapies. Tell youth that the "herd" has been exposed to scrapies. All youth with the QQ gene get scrapies and die. They have to pop their balloon.

⇒ An additional genotype worksheet is included where youth can record their genotypes to determine if they got their phenotype correct.

Share/Reflect/Generalize/Apply: What is the probabilities for the various traits? For instance, what is the likelihood that the sheep is black faced? Did you know it is possible to cross multiple traits at once using the Punnett Square? For more information go to: http://www.anaracavaliers.com/punnett_squares_and_probability.htm. For more activities check out: http://www.agclassroom.org or biology.clc.us.edu/courses/bio105/geneprob.htm. For virtual activities and to learn much, much more about genetics go to: htpp://learn.genetics.utah.edu.

Career Connections: Genetic Counselor, Cytogenetic Technologist, Biomedical Engineer, Functional Genomics, Embryologist, Bioinformatics, Anthropological Genetics, Human Geneticist

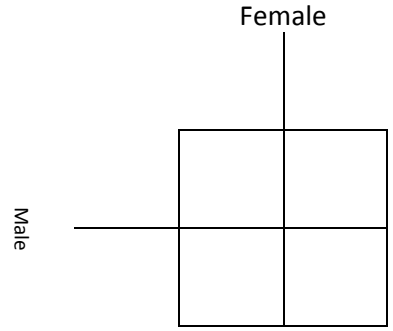
References: Thayer, S. L., Glauer, D., & Snook, N. (2011). *Sheep Resource Handbook*. (2 ed., pp. 123-129). Ohio State University. Klug, W. S., & Cummings, M. R. (2006). *Concepts of Genetics*. (8th ed.). Upper Saddle River, NJ: Prentice Hall. Sheep on hill photo from www.freedigitalphotos.net

This STEM Connection was developed by Claire Dixon. To find out more about 4-H STEM activities, contact your local county Extension office. http://www.ext.colostate.edu/cedirectory/countylist.cfm More activity sheets can be found at http://www.colorado4h.org/k12/activity_sheets/activity.php

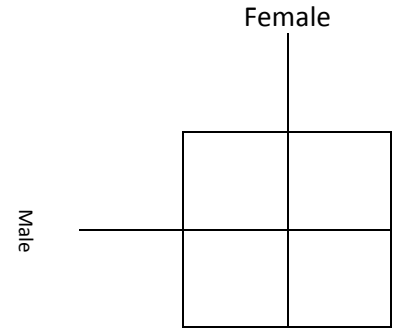
Maaaaastering Genetics - Punnett Squares

Name _____ Club _____

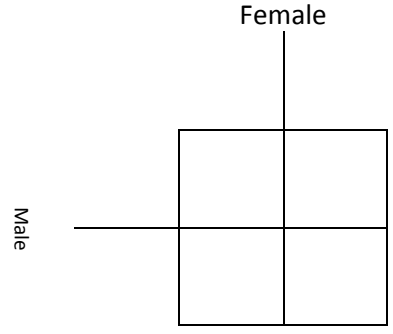
1. Polled is dominant over recessive horned. Both parents are homozygous dominant. Polled is represented by P and horned is represented by p. What percentage of the offspring is polled? _____(Hint: 1. What is the female's genotype? _____ 2. What is the male's genotype? _____ 3. Put the correct genotypes in the Punnett Square below. 4. Distribute one gene to each offspring. 5. Count the number with the phenotype - polled.)



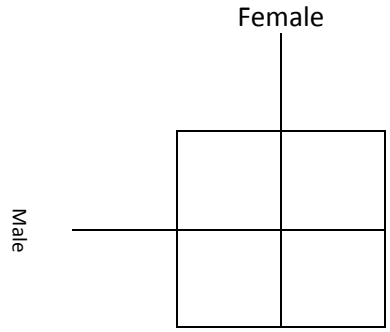
2. Both parents are homozygous recessive. What percentage of the offspring is polled? _____



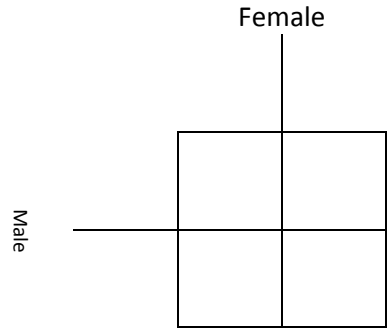
3. Both parents are heterozygous. What percentage of the offspring is polled? _____



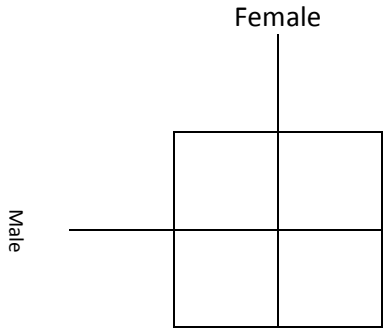
4. The female is heterozygous. The male is homozygous polled. What percentage of the offspring is polled?____



5. The female is homozygous horned. The male is homozygous polled. What percentage of the offspring is polled?____



6. The female is homozygous horned. The male is homozygous horned. What percentage of the offspring is polled?____



Do you feel you've mastered the Punnett Square? Let's try building a sheep to apply what you've learned!

Maaaaastering Genetics - Use Genetics to Build a Sheep—Page 1

1. Black Face or White Face?

Male \ Female	B	W
B	BB	BW
W	BW	WW

BB	BW
BW	WW

2. Polled or Horned?

Male \ Female	P	p
p	Pp	pp
p	Pp	pp

Pp	pp
Pp	pp

3. Short Ears v. Long Ears?

Male \ Female	ℓ	ℓ
L	L ℓ	L ℓ
L	L ℓ	L ℓ

Lℓ	Lℓ
Lℓ	Lℓ

Key:

Black Face: B (dominant)
White Face: W (dominant)
Polled : P (dominant)
Horned: p (recessive)
Short Ears: L (dominant)
Long Ears: ℓ (recessive)
No Wool Cap: W (dominant)
Wool Cap: w (recessive)
Triangle Nose: T (dominant)
Square Nose: t (recessive)
Scrapies Resistant: R (dominant)
Scrapies Susceptible: Q (recessive)

**Note: These traits are not necessarily accurate in terms of dominance and recessiveness These examples have been simplified for this exercise.

4. Wool Cap?

Male \ Female	w	w
w	ww	ww
w	ww	ww

ww	ww
ww	ww

5. Triangle v. Square Nose?

Male \ Female	T	T
T	TT	TT
T	TT	TT

TT	TT
TT	TT

6. Scrapies Resistant?

Male \ Female	R	Q
R	RR	RQ
Q	RQ	QQ

RR	RQ
RQ	QQ

Key:

Black Face: B (dominant)
White Face: W (dominant)
Polled : P (dominant)
Horned: p (recessive)
Short Ears: L (dominant)
Long Ears: ℓ (recessive)
No Wool Cap: W (dominant)
Wool Cap: w (recessive)
Triangle Nose: T (dominant)
Square Nose: t (recessive)
Scrapies Resistant: R (dominant)
Scrapies Susceptible: Q (recessive)

**Note: These traits are not necessarily accurate in terms of dominance and recessiveness These examples have been simplified for this exercise.

Maaaaastering Genetics - Use Genetics to Build a Sheep - Genotype Page

Name _____ Club_____

1. Black Face or White Face?

record your genotype here

2. Polled or Horned?

record your genotype here

3. Short Ears or Long Ears?

record your genotype here

4. Wool Cap?

record your genotype here

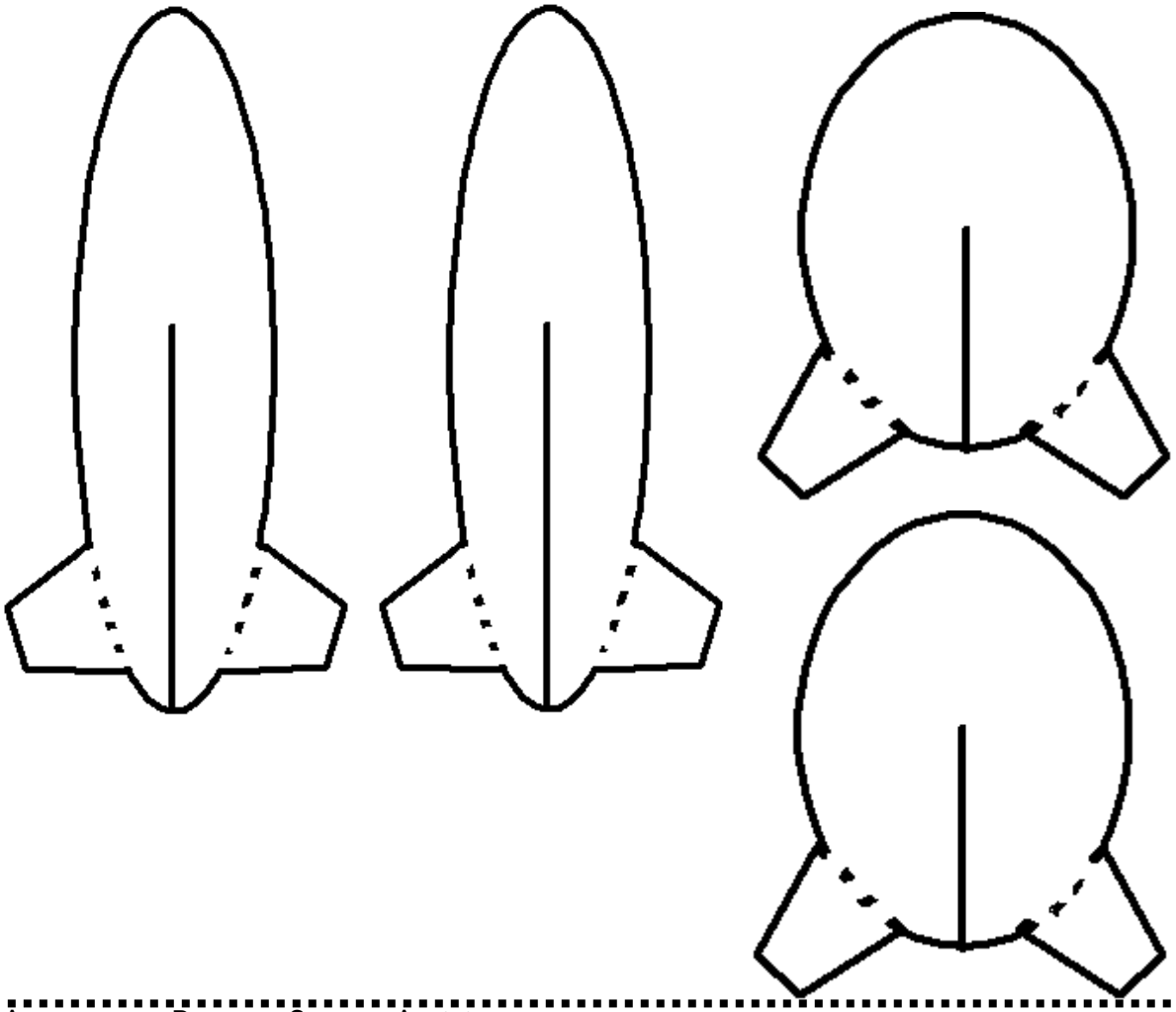
5. Triangle or Square Nose?

record your genotype here

6. Scrapies Resistant?

record your genotype here

**Note: These traits are not necessarily accurate in terms of dominance and recessiveness These examples have been simplified for this exercise.



Ears

Use these as a template for ear cut out of felt, craft foam or card stock. Cut along the black solid lines (careful—don't cut off the tabs!) Glue the two sides of the inside cut together to give the ear a conical shape. Fold down on the tab's dotted line and glue tabs to the ears to the balloon head.

Answers to Punnett Square Activity

1. 100% Female

Male \ Female	P	P
P	PP	PP
P	PP	PP

2. 0% Female

Male \ Female	p	p
P	Pp	Pp
P	Pp	Pp

3. 75% Female

Male \ Female	P	p
P	PP	Pp
p	Pp	pp

4. 100% Female

Male \ Female	P	p
P	PP	Pp
P	PP	Pp

5. 100% Female

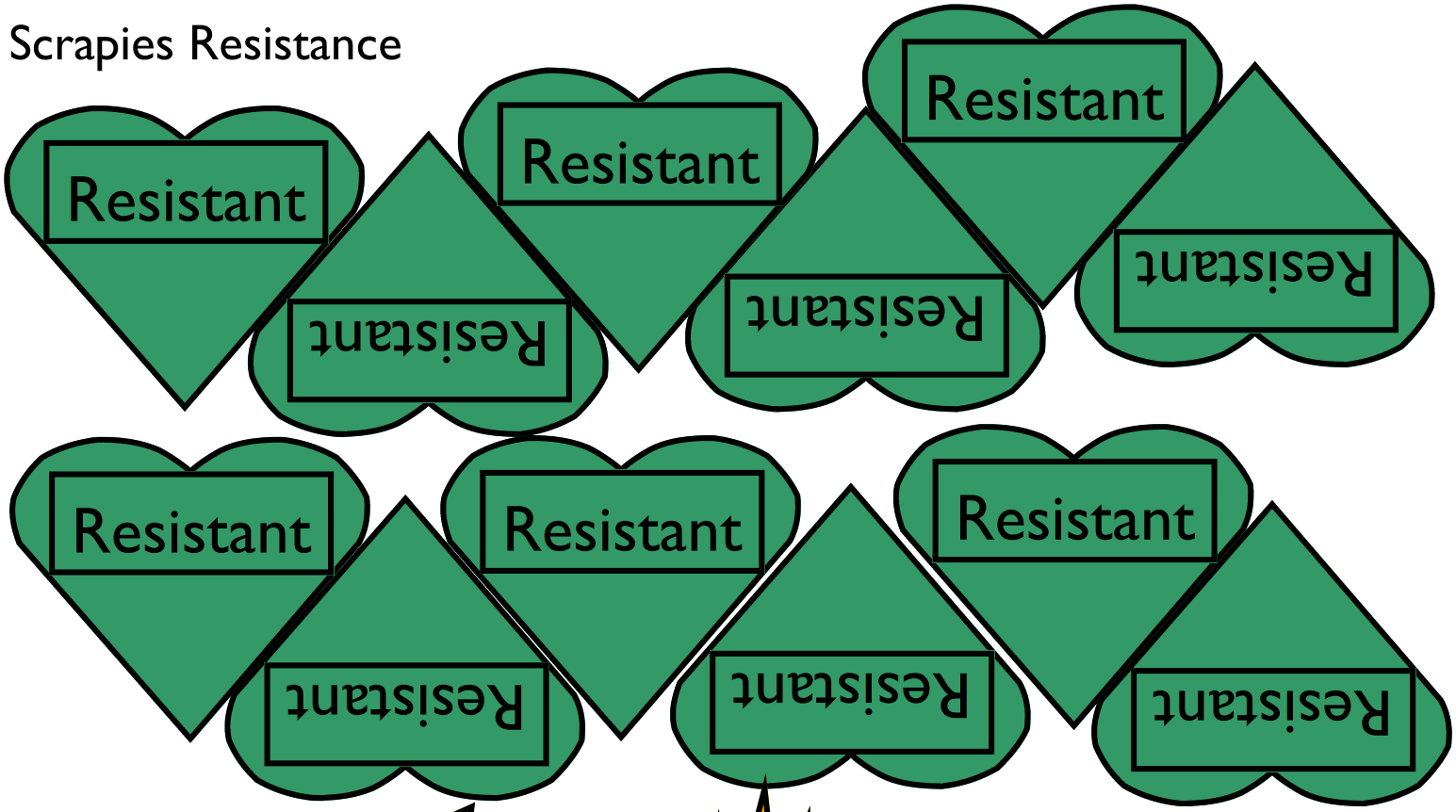
Male \ Female	P	P
P	Pp	Pp
P	Pp	Pp

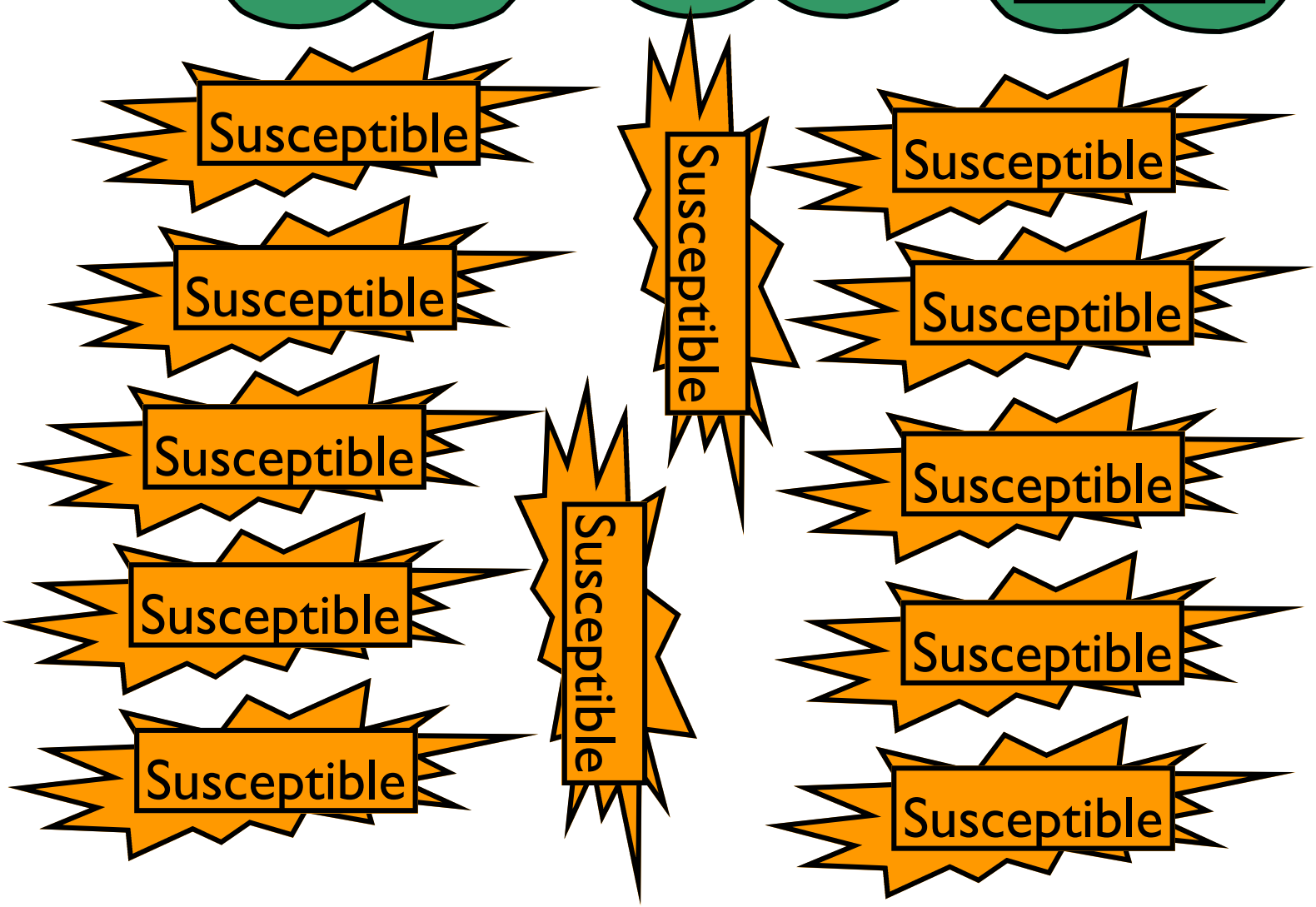
6. 0% Female

Male \ Female	p	p
p	pp	pp
p	pp	pp

**Note: These traits are not necessarily accurate in terms of dominance and recessiveness These examples have been simplified for this exercise.

Scrapies Resistance





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