Name: _____ Date: _____ Period: ____

Genetics: Punnett Squares Practice

Most genetic traits have a stronger, dominant allele and a weaker, recessive allele. In an individual with a heterozygous genotype, the dominant allele shows up in the offspring and the recessive allele gets covered up and doesn't show; we call this **complete dominance**.
However, some alleles don't completely dominate others. In fact, some heterozygous genotypes allow both alleles to partially show by blending together how they are expressed; this is called **incomplete dominance**. Other heterozygous genotypes allow both alleles to be completely expressed at the same time like spots or stripes; this is called **codominance**. Examples of each are listed below.
Write what each type would be if they were heterozygous.

1. Complete dominance = If a Red (RR) and White flower (rr) were crossbred, resulting in 100% Rr, what phenotype would been seen according to the rules of COMPLETE dominance?

2. Incomplete dominance = If a Red (RR) and White flower (rr) were crossbred, resulting in 100% Rr, what phenotype(s) would been seen according to the rules of IN-complete dominance?

3. Codominance = If a Red (RR) and White flower (WW) were crossbred, resulting in 100% RW, what phenotype(s) would been seen according to the rules of CO-dominance?

Incomplete dominance practice Problems

4-6. Snapdragons are incompletely dominant for color; they have phenotypes red, pink, or white. The red flowers are homozygous dominant, the white flowers are homozygous recessive, and the pink flowers are heterozygous. Give the genotypes for each of the phenotypes, using the letters "R" and " r " for alleles:

a. Red snapdragon genotype: _____

b. Pink snapdragon genotype: _____

c. White snapdragon genotype: _____

Show genetic crosses between the following snapdragon parents, using the punnett squares provided, and record the genotypic and phenotypic %s below:

a. pink x pink

Genotypic %: _____
Phenotypic %: _____

b. red x white

Genotypic %: _____
Phenotypic %: _____

c. pink x white

Genotypic %: _____
Phenotypic %: _____

7-9. In horses, some of the genes for hair color are incompletely dominant. Genotypes are as follows: brown horses are BB, white horses are bb and a Bb genotype creates a yellow-tannish colored horse with a white mane and tail, which is called "palomino". Show the genetic crosses between the following horses and record the genotypic and phenotypic percentages:

a. brown x white b. brown x palomino c. palomino x palomino

Genotypic %: _____ Phenotypic %: _____

Genotypic %: _____ Phenotypic %: _____

Genotypic %: _____ Phenotypic %: _____

10. Can palominos be considered a purebred line of horses? Why or why not?

11. Which two colors of horse would you want to breed if you wanted to produce the maximum numbers of palominos in the shortest amount of time?

12. In Smileys, eye shape can be starred (SS), circular (CC), or a circle with a star (CS). Write the genotypes for the pictured phenotypes

_____ _____ _____

13. Show the cross between a star-eyed and a circle eyed.
What are the phenotypes of the offspring? _____
What are the genotypes? _____

14. Show the cross between a circle-star eyed, and a circle eyed.
How many of the offspring are circle-eyed? _____
How many of the offspring are circle-star eyed? _____

15. Show the cross between two circle-star eyed.
How many of the offspring are circle-eyed? _____
How many of the offspring are circle-star eyed? _____
How many are star eyed? _____

15 Points

Codominance Worksheet (Blood types)

Name_____
Period _____ Date _____

Human blood types are determined by genes that follow the **CODOMINANCE** pattern of inheritance.
There are two dominant alleles (A & B) and one recessive allele (O).

Blood Type (Phenotype)	Genotype	Can donate blood to:	Can receive blood from:
O	ii (OO)	A,B,AB and O (universal donor)	O
AB	I^AI^B	AB	A,B,AB and O (universal receiver)
A	I^AI^A or I^Ai (I^AO)	AB, A	O,A
B	I^BI^B or I^Bi (I^BO)	AB,B	O,B

1. Write the genotype for each person based on the description:
   a. Homozygous for the "B" allele _____
   b. Heterozygous for the "A" allele _____
   c. Type O _____
   d. Type "A" and had a type "O" parent _____
   e. Type "AB" _____
   f. Blood can be donated to anybody _____
   g. Can only get blood from a type "O" donor _____

2. Pretend that Brad Pitt is homozygous for the type B allele, and Angelina Jolie is type "O." **What are all the possible blood types of their baby?** *(Do the punnett square)*

   _____

3. Complete the punnett square showing all the possible blood types for the offspring produced by a type "O" mother and an a Type "AB" father. **What are percentages of each offspring?**

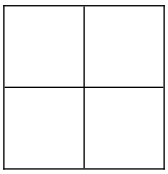
   _____

4. Mrs. Essy is type "A" and Mr. Essy is type "O." They have three children named Matthew, Mark, and Luke. Mark is type "O," Matthew is type "A," and Luke is type "AB." Based on this information:
   a. Mr. Essy must have the genotype _____
   b. Mrs. Essy must have the genotype _____ because _____ has blood type _____
   c. Luke cannot be the child of these parents because neither parent has the allele _____.

5. Two parents think their baby was switched at the hospital. Its 1968, so DNA fingerprinting technology does not exist yet. The mother has blood type "O," the father has blood type "AB," and the baby has blood type "B."
   a. Mother's genotype: _____
   b. Father's genotype: _____
   c. Baby's genotype: _____ or _____
   d. Punnett square showing all possible genotypes for children produced by this couple.

e. Was the baby switched? _____

6. Two other parents think their baby was switched at the hospital. Amy the mother has blood type "A," Linville the father has blood type "B," and Priscilla the baby has blood type "AB."



   a. Mother's genotype: _____ or _____

   b. Father's genotype: _____ or _____

   c. Baby's genotype: _____

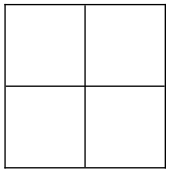
   d. Punnett square that shows the baby's genotype as a possibility

   e. Could the baby actually be theirs? _____

7. Based on the information in this table, which men **<u>could not</u>** be the father of the baby?

   *(hint… look at the baby's blood type only…)*_____
   You can use the Punnett square if you need help figuring it out.

Name	Blood Type
Mother	Type A
Baby	Type B
The mailman	Type O
The butcher	Type AB
The waiter	Type A
The cable guy	Type B



8. The sister of the mom above also had issues with finding out who the father of her baby was. She had the state take a blood test of potential fathers. Based on the information in this table, why was the baby taken away by the state after the test?

   *(hint… look at the baby's blood type only…)*_____

Name	Blood Type
Mother	Type O
Baby	Type AB
Bartender	Type O
Guy at the club	Type AB
Cabdriver	Type A
Flight attendant	Type B

BLOOD TYPE & INHERITANCE

In blood typing, the gene for type A and the gene for type B are codominant. The gene for type O is recessive. Using Punnett squares, determine the possible blood types of the offspring when:

1. Father is type O, Mother is type O

_____% O
_____% A
_____% B
_____% AB

2. Father is type A, homozygous; Mother is type B, homozygous

_____% O
_____% A
_____% B
_____% AB

4. Father is type A, heterozygous; Mother is type B, heterozygous

_____% O
_____% A
_____% B
_____% AB

5. Father is type O, Mother is type AB

_____% O
_____% A
_____% B
_____% AB

6. Father and Mother are both type AB

_____% O
_____% A
_____% B
_____% AB

GENETICS: X LINKED GENES

In fruit flies, eye color is a sex linked trait. Red is dominant to white.

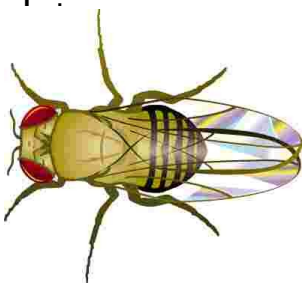
1. What are the sexes and eye colors of flies with the following genotypes:

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

2. What are the genotypes of these flies:

white eyed, male _____ red eyed female (heterozygous) _____
white eyed, female _____ red eyed, male _____

3. Show the cross of a white eyed female $X^r X^r$ with a red-eyed male $X^R Y$.



4. Show a cross between a pure red eyed female and a white eyed male.
What are the genotypes of the parents:

_____& _____

How many are:
white eyed, male___
white eyed, female ___
red eyed, male ____
red eyed, female ____

5. Show the cross of a red eyed female (heterozygous) and a red eyed male. What are the genotypes of the parents?

_____ & _____

How many are:
white eyed, male___white eyed, female ___
red eyed, male ____ red eyed, female ____

Math: What if in the above cross, 100 males were produced and 200 females. (think about the percentage of the total #) How many total red-eyed flies would there be?
6. _____

7. In humans, hemoph disease. Males will either have the disease or not (but they won't ever be carriers)

$X^H X^H$ = female, normal

$X^H X^h$ = female, carrier

$X^h X^h$ = female, hemophiliac

$X^H Y$ = male, normal

$X^h Y$ = male, hemophiliac

Show the cross of a man who has hemophilia with a woman who is a carrier.

8. What is the probability that their children will have the disease? _____

9. A woman who is a carrier marries a normal man. Show the cross. What is the probability that their children will have hemophilia? What sex will a child in the family with hemophilia be?

10. A woman who has hemophilia marries a normal man. How many of their children will have hemophilia, and what is their sex?

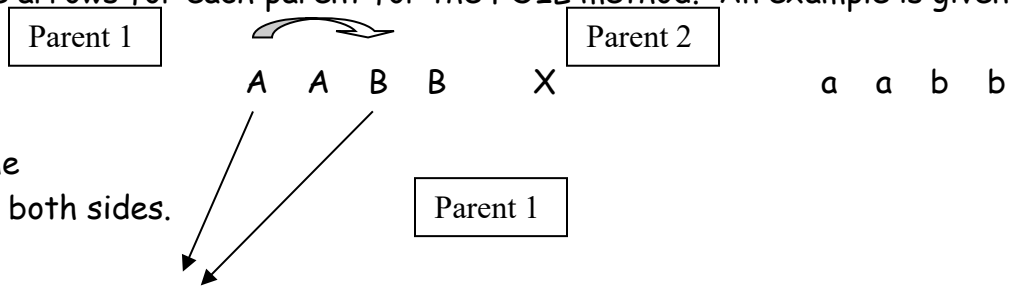
How to set up dihybrid crosses

A) Figure out the genotypes of both traits for both parents.

B) Write out the parents' genotypes together ex. AABB X aabb

C) Use the F i r s t O u t s i d e I n s i d e L a s t method to set up the test cross

1) Draw the arrows for each parent for the FOIL method. An example is given below.



2) Set up the cross for both sides.

	AB			
Parent 2				

3) Practice filling in the probable offspring below.

	AB	AB	AB	AB
ab	AaBb			
ab				
ab				
ab				

4) To figure the phenotypic ratio, count the number of individuals with either the dominant or recesssive phenotype for both traits! Then that ratio would be something like 4:4:4:4 or 9:3:3:1

PTC-taster- TT, Tt	Attached earlobes- EE, Ee	Can roll tongue- RR, Rr
Non-PTC taster – tt	Free earlobes – ee	Can't roll tongue - rr
Hitchhikers thumb- HH, Hh	Straight pinky- PP, Pp	
Straight thumb – hh	Bent pinky- pp	
Hair on mid-digit – MM, Mm	Widow's peak- WW, Ww	
No hair on mid-digit- mm	No widow's peak- ww	

Now practice!

Dihybrid Crosses. Set up the crosses using the rules and the letters from the other page.

1. If a woman who is a non-PTC taster (recessive) with heterozygous hitchhikers thumb has children with a man who is a heterozygous PTC taster with straight thumbs (recessive), what is the probability of them having each of the following types of children? (Fill in the Punnett Square and the blanks).

   Parents' genotypes _____ X _____

   a. How many PTC taster, Hitchhikers thumb_____
   b. How many PTC taster, straight thumb_____
   c. How many Non-PTC taster, Hitchhikers thumb_____
   d. How many Non- PTC taster, straight thumb_____
   e. What is the phenotypic ratio?_____

2. If a woman who has no hair on her mid-digit (recessive)and is homozygous attached earlobes (dominant) has children with a man who has hair on his mid-digit and has attached earlobes (heterozygous for both traits), what is the probability of them having each of the following types of children? (Fill in the Punnett Square and the blanks).

   Parents' genotypes _____ X _____

   a. How many hair, attached earlobes_____
   b. How many hair, not attached earlobes_____
   c. How many hairless, attached earlobes_____
   d. How many hairless, not attached earlobes_____
   e. What is the phenotypic ratio?_____

3. John Doe and Jane Doe want to have children and are thinking about how their childrens' hands might look. What would their children look like if they are both heterozygous for straight pinky and hitchhikers thumb? (Fill in the Punnett Square and the blanks).

   Parents' genotypes _____ X _____

   a. Straight pinky, hitchhikers thumb_____
   b. Straight pinky, Straight thumbs_____
   c. bent pinky, hitchhikers thumb_____
   d. bent pinky, Straight thumbs_____
   e. What is the phenotypic ratio?_____

4. Dohn Joe and Dane Joe want to have children and are thinking about how their children's hair line and tongues will turn out. They are both circus performers and want their children to follow in their footsteps. Their circus only accepts people with a Widow's Peak and who can roll their tongues. What would their children look like if Dohn is heterozygous for both Widow's peak and tongue rolling, and Dane is homozygous dominant for Widow's peak and heterozygous for tongue rolling? (Fill in the Punnett Square and the blanks).

   Parents' genotypes _____ X _____

   a. Widow's Peak, Tongue Roller_____
   b. Widow's Peak, non tongue roller_____
   c. Straight hair line, Tongue Roller_____
   d. Straight hair line, non tongue roller_____
   e. What is the phenotypic ratio?_____
   f. What are the chances of their child being able to join the circus?_____

This problem will involve both a test cross and a Dihybrid Punnett Square
Background information:

1. You are a pigeon breeder. In order to make the most money as a pigeon breeder, you must sell mainly checkered winged, red feather pigeons. Lucky for you checkered wings and red feathers are dominant in pigeons (plain wings and brown feathers are recessive). To breed as many checkered winged, red feather

pigeons as possible, you need to breed homozygous checkered winged, red feather pigeons with each other (because all of the offspring would be checkered winged, red feather pigeons). You know you have a female homozygous checkered winged, red feathered pigeon (you bred her yourself!) She is so beautiful that she has won prizes in several pigeon beauty contests.

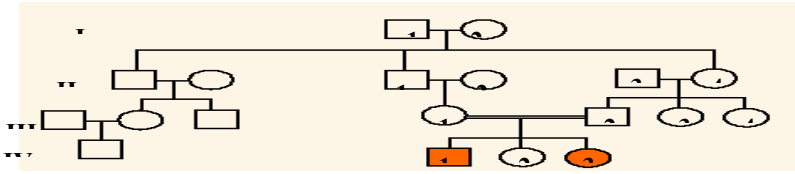
a. The Problem: You recently purchased a male pigeon that has checkered wings and red feathers from a shady pigeon dealer, who claimed it was homozygous. Before you breed this male with your prize winning female, you want to be sure that it is homozygous for both traits. Describe how you will be able to tell what the genotype for both traits of your pigeon in 1 generation. (test cross here) **5 points**

b. Illustrate the probable outcomes if your pigeon IS homozygous for both traits. (using a Punnett Square) **5 points.**

Pedigree Worksheet

Use the given pedigrees to answer the following questions:

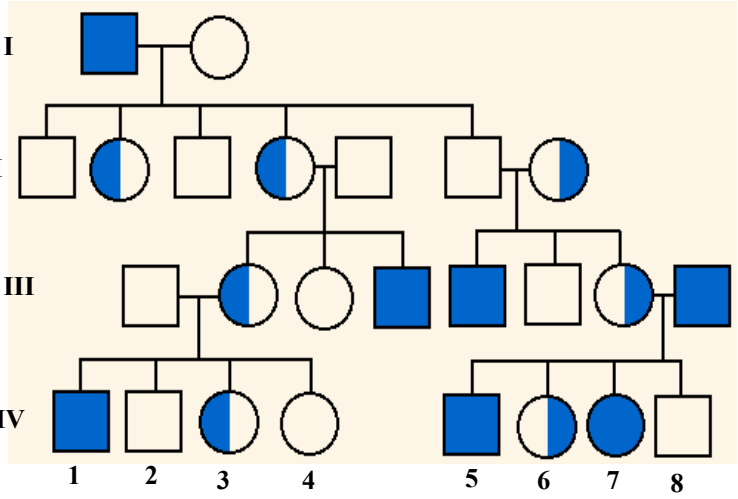
The pedigree to the right shows the passing on of straight thumbs (recessive) and Hitchhiker's Thumb (dominant) in a family. Shaded shapes mean the person has a straight thumb

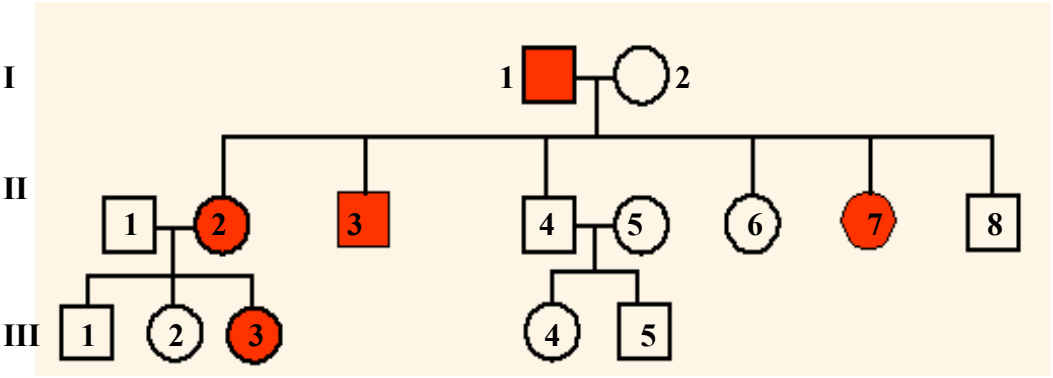


1. What is the genotype of IV-1?_____
2. What is the genotype IV-3?_____
3. What is the genotype of III-1? _____
4. What is the genotype III-2?_____
5. What is the genotype II-3?_____
6. Is it possible for individual IV-2 to be a carrier? _____ Why?_____

_____

7. The pedigree to the right shows the passing on of colorblindness (a recessive, ***sex-linked trait***). Fill in the numbers for each generation (generation IV is done for you).
8. What do the half shaded circles mean?_____
_____
9. What is the ONLY sex carriers of colorblindness can be?
_____
10. Which individuals are colorblind?_____
_____
11. What is the genotype of person II-2?_____
12. What is the genotype of person I-1?_____
13. What is the genotype of person III-3?_____
14. If person IV-1 marries a female who is not colorblind and is not a carrier, what are the chances of their male offspring being colorblind?_____What about their female offspring?_____





= Sickle Cell Anemia

<u>NOTE</u>- carriers are not shown on this pedigree although Sickle Cell Anemia IS A RECESSIVE DISORDER.

15. Which members of the family above are afflicted with sickle cell anemia? _____
16. How are individuals III-4 and III-5 related?_____
17. How are individuals I-1 and I-2 related?_____
18. How are individuals II-7 and III-2 related?_____
19. How are individuals I-2 and III-5 related? _____
20. How many children did individuals I-1 and I-2 have? _____
21. How many girls did II-1 and II-2 have? _____ How many have sickle cell anemia? _____
22. Label the possible genotypes for all individuals in the pedigree. One person can have more than one possible genotype

data base question [38 marks]

1a. *[1 mark]*

Ebola virus disease (EVD) is the disease in humans and other primates that is caused by the Ebola virus. Fruit bats are the reservoir for the virus and are able to spread the disease without being affected. Humans can become infected by contact with fruit bats or with people infected by the virus, their body fluids or equipment used to treat them.

The table shows data for four African countries that were affected by the 2014–2015 Ebola outbreak.

Country	Total population / millions	Population density / inhabitants km^{-2}	Number of Ebola cases	Number of deaths	Death rate (as a percentage of Ebola cases) / %
Liberia	4.5	40	10672	4808	45.1
Sierra Leone	6.3	79	13250	3949	29.8
Guinea	12.3	53	3783	2512	66.4
Mali	16.3	14	8	6	75.0

[Source: adapted with permission, from Ebola Situation Report, figure 1, http://apps.who.int/ebola/current-situation/ebolasituation-report-2-march-2016, March 2016, and from Successful treatment of advanced Ebola virus infection with T-705 (favipiravir) in a small animal model, Oestereich, L. *et al*, 2014, under CC BY 3.0]

Identify the country with the largest number of Ebola cases.

1b. *[1 mark]*

Identify the country with the largest number of deaths.

1c. *[1 mark]*

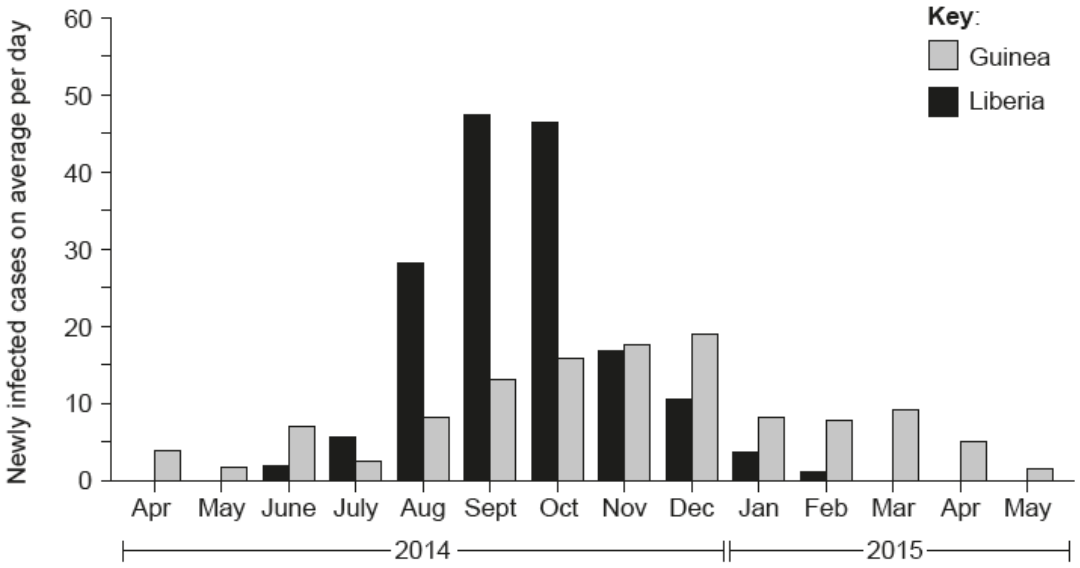
Analysis of the data suggests that the number of deaths from EVD is not related to the total population size. State **one** piece of evidence from the data that would support this analysis.

1d. *[1 mark]*

Based on the mode of transmission of the Ebola virus, suggest a possible reason for the relationship between population density and the number of Ebola cases in these four countries.

1e. *[3 marks]*

The graphs show the progress of the EVD epidemic in Guinea and Liberia for the period April 2014 to May 2015.



[Source: Ebola Situation Report 2 March 2016 and data from *International Journal of Infectious Diseases*, 38,
Ligui Wang *et al*, Epidemiological features and trends of Ebola virus disease in West Africa, 52-53.,
Copyright 2015, with permission from Elsevier]

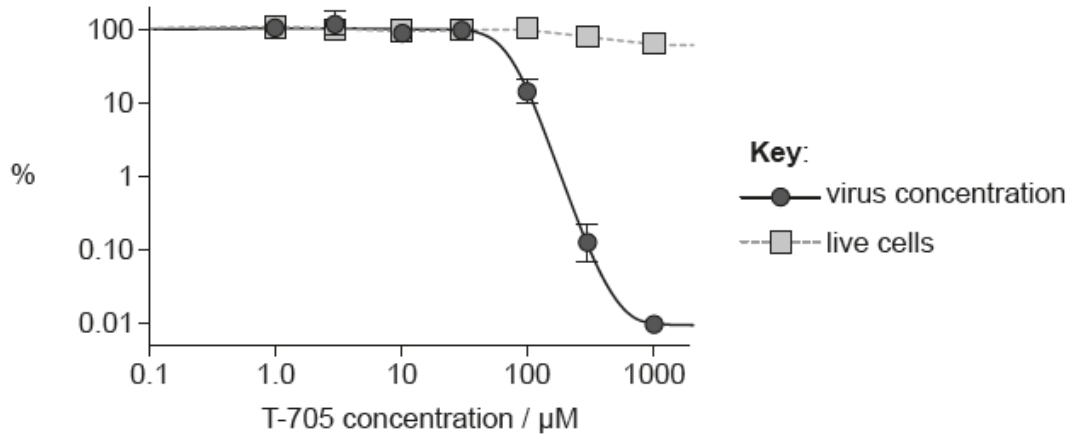
Based on the data, compare and contrast the progress of the epidemic in Liberia and Guinea.

1f. *[2 marks]*

Suggest **two** possible reasons for the drop in the daily numbers of newly infected cases after October 2014 in Liberia.

1g. *[2 marks]*

An antiviral drug, T-705, was tested in order to establish whether it has potential to treat EVD. The graph shows the data from an in vitro trial of T-705 on cells that had been infected with Ebola virus five days previously. Virus concentration and live cells are shown as percentage of the control.



[Source: Oestereich, Lisa & Rieger, Toni & Neumann, Melanie & Bernreuther, Christian & Lehmann, Maria & Krasemann,
Susanne & Wurr, Stephanie & Emmerich, Petra & de Lamballerie, Xavier & Ölschläger, Stephan & Günther, Stephan. (2014).
Evaluation of Antiviral Efficacy of Ribavirin, Arbidol, and T-705 (Favipiravir) in a Mouse Model for Crimean-Congo
Hemorrhagic Fever. *PLoS neglected tropical diseases*. **8**. e2804. 10.1371/journal.pntd.0002804.]

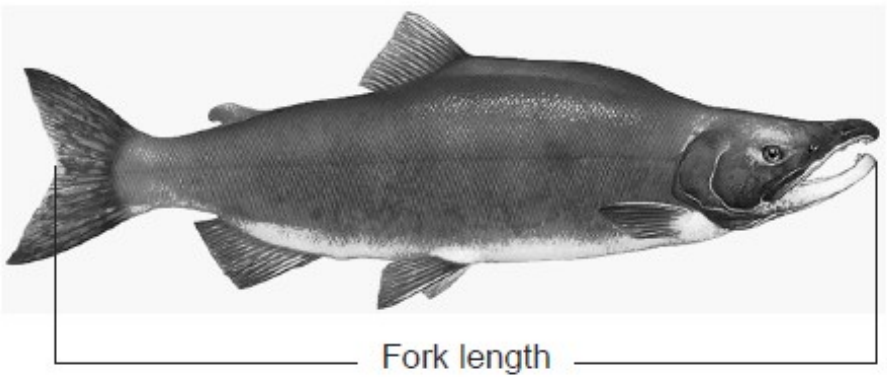
Based on these data, outline the evidence that T-705 has potential to be used as a treatment for EVD.

1h. *[1 mark]*

District administrators combatting the 2014 Ebola epidemic in West Africa were assisted by international organizations such as the World Health Organization, who provided data on the progress of the epidemic. Suggest **one** other way in which international organizations can assist with combatting an epidemic of Ebola.

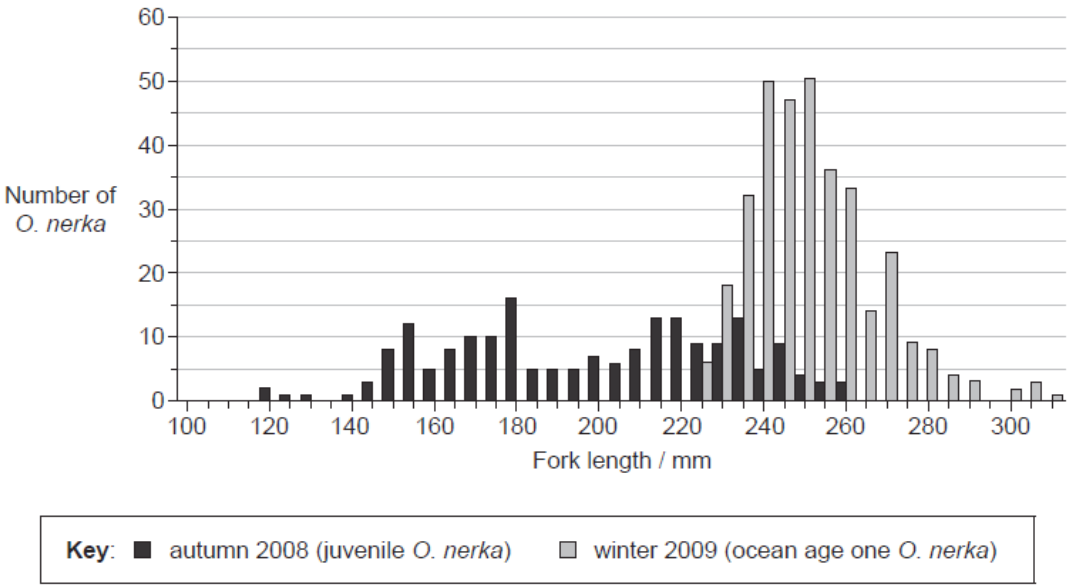
2a. *[1 mark]*

Sockeye salmon (*Oncorhynchus nerka*) spend the first years of their lives in the freshwater lakes of Alaska before migrating to marine waters. Their first months in marine waters are spent foraging and growing near the shore line. They then move to offshore regions of the North Pacific Ocean for 2 to 3 years.



[Source: adapted from http://pnwfolklore.org]

The graph shows fork length frequency of juvenile *O. nerka* caught during their first months in marine waters in autumn 2008 and ocean age one *O. nerka* caught 15 months later during winter 2009 in the North Pacific Ocean.



[Source: adapted from E V Farley, *et al.*, (2011), *ICES Journal of Marine Science*, **68** (6), pages 1138–1146]

Identify the most frequent fork length for *O. nerka* caught during autumn 2008 and winter 2009.

Autumn 2008:

Winter 2009:

2b. *[2 marks]*

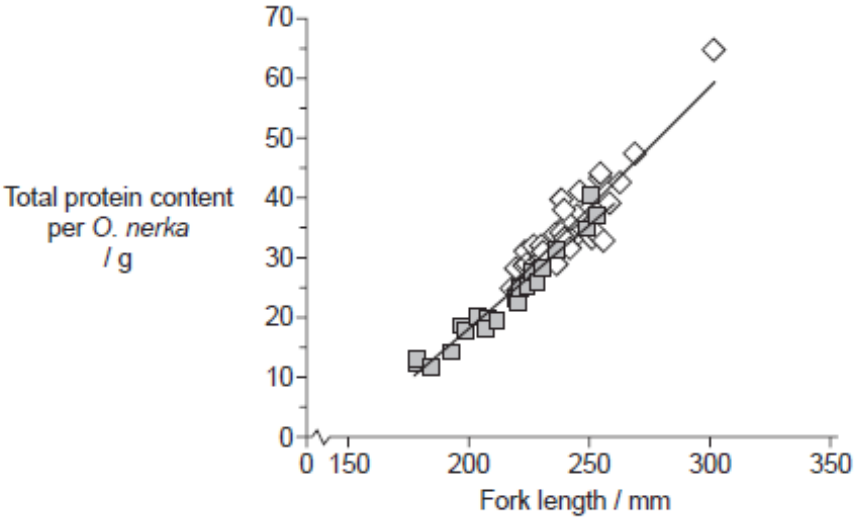
Distinguish between the fork lengths of *O. nerka* in autumn 2008 and winter 2009.

2c. *[1 mark]*

Suggest a reason for the variation in fork length of ocean age one *O. nerka*.

2d. *[2 marks]*

Protein content in *O. nerka* was measured to evaluate possible differences during their first 15 months at sea. The graph shows the relationship between fork length and total protein content per *O. nerka* caught during autumn 2008 and winter 2009.



[Source: adapted from EV Farley, *et al.*, (2011), *ICES Journal of Marine Science*, **68** (6), pages 1138–1146]

Compare the protein content for *O. nerka* caught during autumn 2008 and winter 2009.

2e. *[1 mark]*

Outline the difficulty in predicting the age of *O. nerka* from fork length.

2f. *[1 mark]*

Using the data, suggest **one** reason for the relationship between protein content and fork length.

2g. *[2 marks]*

Scientists measured mercury levels in different fish. The table shows the results.

	Mercury / μg g^{-1}				
	Mean	Standard deviation	Minimum	Maximum	Number of samples
Cod	0.111	0.066	0.001	0.989	115
Monkfish	0.181	0.075	0.056	0.289	9
Shark	0.979	0.626	0.001	4.540	356
Trout	0.071	0.025	0.001	0.678	35

Compare the results shown in the table for monkfish and shark.

2h. *[1 mark]*

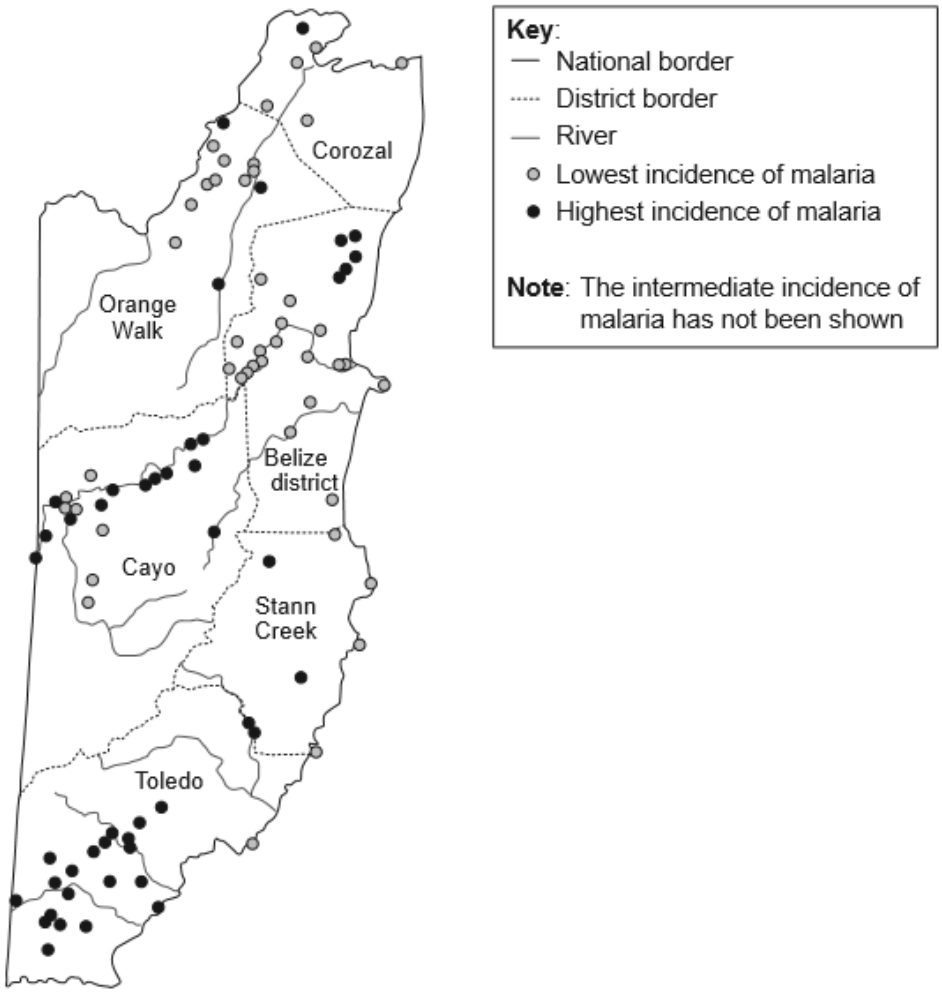
Suggest additional information that would be helpful in evaluating these data.

2i. *[1 mark]*

State which type of fish shows the most variation.

3a. *[1 mark]*

Malaria is a mosquito-borne disease caused by a unicellular organism, *Plasmodium*. *Plasmodium* is a parasite that spends part of its life in a mosquito and part in a human. The mosquito transmits the *Plasmodium* to a human when it feeds on human blood. Mosquitoes hatch in water and are flying insects as adults. In the country of Belize, where malaria is a serious problem, studies have been made to determine what environmental factors affect the incidence of the disease. 156 villages were studied over a ten-year period.



[Source: adapted from S. Hakre *et al.* (2004) *International Journal of Health Geographics*, **3** (6). Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Shilpa Hakre, Penny Masuoka, Errol Vanzie and Donald R. Roberts © 2004 Hakre *et al*; licensee BioMed Central Ltd]

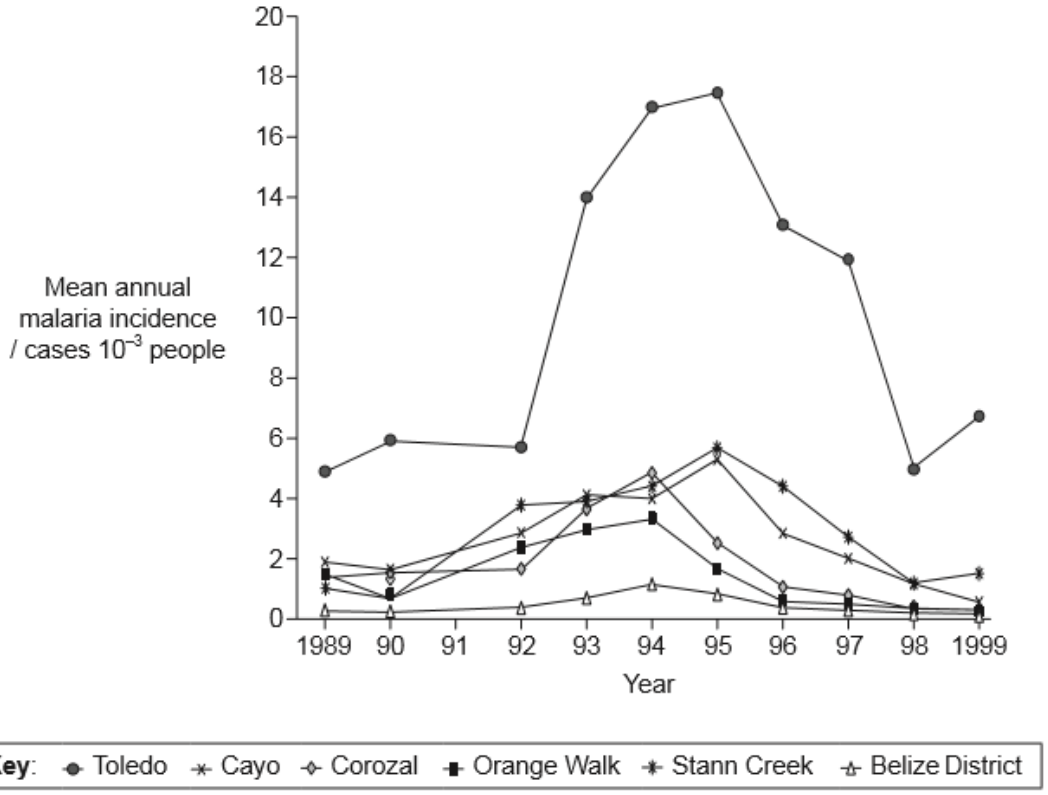
State the district where there is the highest number of villages with the highest incidence of malaria.

3b. *[2 marks]*

Analyse the data in the map to find whether there is an association between rivers and the incidence of malaria.

3c. *[3 marks]*

Each of the six districts of Belize was studied from 1989 to 1999. The graph shows the mean number of people in each district to be affected by malaria per year per 1000 people.



[Source: adapted from S. Hakre *et al.* (2004) *International Journal of Health Geographics*, **3** (6). Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Shilpa Hakre, Penny Masuoka, Errol Vanzie and Donald R. Roberts © 2004 Hakre *et al*; licensee BioMed Central Ltd]

Compare the trends in incidence of malaria for Toledo and Corozal.

3d. *[1 mark]*

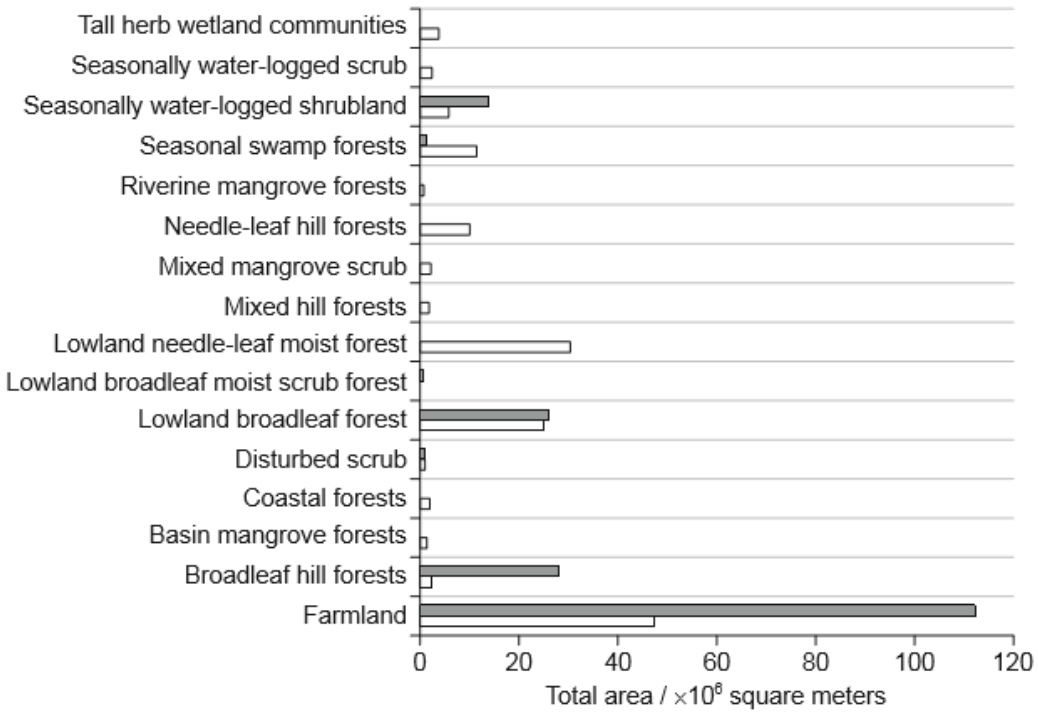
Suggest a reason for the decreases in the incidence of malaria from 1995 to 1999.

3e. *[1 mark]*

Suggest a reason why the incidence of malaria is so low in the Belize District.

3f. *[1 mark]*

The country of Belize has many different ecosystems. These ecosystems are shown in the bar chart. The white bars indicate the total area within each ecosystem with the lowest incidence of malaria. The dark grey bars indicate the total area within each ecosystem with the highest incidence of malaria. The total area with an intermediate incidence of malaria is not shown.



[Source: adapted from S. Hakre *et al.* (2004) *International Journal of Health Geographics*, **3** (6). Spatial correlations of mapped malaria rates with environmental factors in Belize, Central America. Shilpa Hakre, Penny Masuoka, Errol Vanzie and Donald R. Roberts © 2004 Hakre *et al*; licensee BioMed Central Ltd]

Besides farmland, identify which two ecosystems have the greatest total area with a high incidence of malaria.

3g. *[1 mark]*

Predict with a reason, using the data, which district has most farmland.

3h. *[4 marks]*

Discuss whether malaria could be reduced by replacing farmland with natural ecosystems and replacing broadleaf hill forest with mixed hill forest.

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