Name ANSWER KEY

Date _____

AP Biology 2021

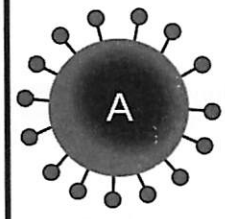
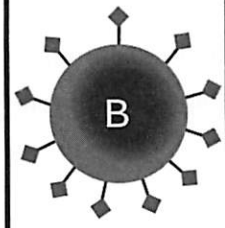
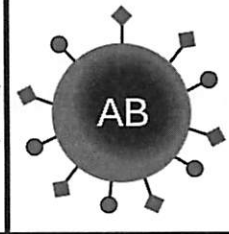
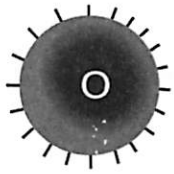
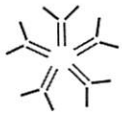
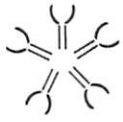
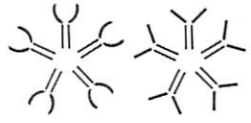
Block _____

The Case of the Long-Lost Son

ckground Information:

There are four main blood types: Type A, Type B, Type AB and Type O. The blood type of an individual is named for the type of antigen(s) (a specific protein) found on the surface of their red blood cells. The same individual will create and carry antibodies in their blood plasma which will bind to foreign antigens and cause agglutination (also known as clumping). See the ***Table 1*** showing the corresponding antibodies and antigens for each blood type.

Table 1: Plasma Antibodies and Antigens Present for Each Blood Type (A, B, AB & O)

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in red blood cell	 A antigen	 B antigen	 A and B antigens	None

Red blood cells have many different antigens on their surfaces – more than just A or B. Another important antigen on the surface of a RBC is called the Rh factor. You may have heard of a blood type as being *positive* or *negative*. This is referring to the Rh factor. If you have this protein, you are said to be Rh positive; if you don't have this antigen you are considered Rh negative. The allele Rh^+ is dominant to Rh^-.

Blood types are controlled by multiple alleles (I^A, I^B, i). The alleles I^A and I^B are codominant and when inherited together, they are both expressed equally (i.e. the blood cells will have both A and B antigens on their surface). I^A and I^B are both dominant to i. The genotypes and corresponding phenotypes are shown in the table of Human Blood Types.

Human Blood Types	
Phenotype	Genotype
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B
O	ii

The Case Study:

Eccentric millionaire, Mr. Cash, died last month from a heart attack at the age of 93. According to his will, all of his estate, an estimated 30 million dollars, was to go to his toy poodle, Fluffy. In a startling turn of events, today two men came forward to contest the will. Both Mr. Donald Green and Mr. Jack Smith came to claim to be Mr. Cash's long-lost son, Marvin. Until today, Marvin was believed to have died in a tragic rafting accident in Africa some 20 years ago. Marvin Cash's raft disappeared in Zimbabwe while he and a group of friends were viewing Victoria Falls. He and friends were believed to have been eaten by a crocodile. However, remains of the bodies were never found.

Judge Marian Hall, who is handling the estate, has ordered blood tests for both Mr. Green and Mr. Smith. She has also requested that blood tests be done on Mr. Cash's remains, as well as on his estranged wife, Cathy Cash.

Objectives:

- Determine the blood type of four simulated blood samples
- Use blood types to determine the relationships between individuals involved

Materials:

4 blood typing slides	Anti-A Serum	Toothpicks
4 simulated blood samples	Anti-B Serum	

Procedure:

Part A – Determining Blood Types

1. Place 4 blood typing slides on a piece of paper. Label above each of your blood typing slides as follows:

   Slide 1 = Mr. Cash/Sample 3 **Slide 3** = Mr. Green/Sample 4

   Slide 2 = Mrs. Cash/Sample 1 **Slide 4** = Mr. Smith/Sample 2

2. Place 1 drop of Mr. Cash's blood (sample 3) in each of the A and B wells of Slide 1
3. Place 1 drop of Mrs. Cash's blood (sample 1) in each of the A and B wells of Slide 2
4. Place 1 drop of Mr. Green's blood (sample 4) in each of the A and B wells of Slide 3
5. Place 1 drop of Mr. Smith's blood (sample 2) in each of the A and B wells of Slide 4
6. Add 1 drop of the Anti-A Serum in each A well on all four slides
7. Add 1 drop of the Anti-B Serum in each B well on all four slides
8. Stir each sample of serum and blood. Be sure to use a clean toothpick with each sample.
9. Record your observations in ***Table 1***. A positive test is indicated by a clumping of cells within a sample.

Table 1: Data from Clumping Reaction

	Anti-A Serum (+/-)	Anti-B Serum (+/-)	Blood Type (A, B, AB, O)
Slide 1: Mr. Cash	+	+	AB
Slide 2: Mrs. Cash	+	−	A
Slide 3: Mr. Green	−	−	O
Slide 4: Mr. Smith	−	+	B

10. Compare your observations with ***Table 2*** below and determine the blood type of each individual. Record the blood types in ***Table 1***.

Table 2: Clumping Reactions of Blood-Typing Serums

Reaction		Blood Type
Anti-A Serum	**Anti-B Serum**	
Clumping	No Clumping	Type A
No Clumping	Clumping	Type B
Clumping	Clumping	Type AB
No Clumping	No Clumping	Type O

Part B – Determining Relationships

1. Complete a Punnett square showing the Cash's possible children if Mrs. Cash's genotype is homozygous

	I^A	I^A
I^A	I^AI^A	I^AI^A
I^B	I^AI^B	I^AI^B

Genotype Ratio: $2I^AI^A : 2I^AI^B$ Phenotype Ratio: 2 type A : 2 type B

2. Complete a Punnett square showing the Cash's possible children if Mrs. Cash's genotype is heterozygous

	I^A	i
I^A	I^AI^A	I^Ai
I^B	I^AI^B	I^Bi

Genotype Ratio: $1I^AI^A : 1I^Ai : 1I^AI^B : I^Bi$ Phenotype Ratio: 2 type A : 1 type AB : 1 type B

3. (a) What are Mr. Green's possible genotypes? ii only

   (b) Is Mr. Green the Cash's long-long son? How do you know? **Explain**:

   He can't be their child because it isn't possible to have a type O child from an AB and A parents

4. (a) What are Mr. Smith's possible genotypes? I^BI^B or I^Bi only possible if Cashes are his parents

   (b) Is Mr. Smith the Cash's long-lost son? How do you know? **Explain**:

   He could be since a type B child is possible with their blood types

Extension & Application:

1. Rh factors are proteins that were first discovered in the blood of Rhesus Monkeys, but humans have them too. If you are Rh positive, it means that there are Rh type proteins on your blood cells. If you are Rh negative, there are no Rh type proteins on your blood cells. The positive allele is dominant over negative, so heterozygous individuals are Rh positive. Problems with a pregnancy (Rh incompatibility) can arise when an Rh negative female becomes pregnant with a fetus who is Rh positive such as fetal anemia, jaundice and even spontaneous miscarrage. Why? Why does the situation get worse for future pregnancies? (BTW, there's now a treatment for this - if you are Rh- and become pregnant you will receive a Rh Immunoglobulin injection.)

2. The male biological parent of two children is type O+, and the female biological parent is type A+. The offspring are O- and A+. Given this information, what can you say about the genotypes of the father and mother?

3. Two individuals (Type AB+ and type O-) have offspring. What are the predicted genotypic and phenotypic ratios of the cross? (The parent who is AB+ is heterozygous for Rh value).

4. Two individuals (Type A+ and type B+) have offspring. What are the predicted genotypic and phenotypic ratios the cross? (Both parents are homozygous for blood type and heterozygous for Rh value.

Extension + Application - Blood type lab

① the Rh incompatibility worsens with each pregnancy bc the antibodies build up with each exposure (pregnancy). Similar to antibody build up each time you are exposed to a virus for a 2nd or 3rd time (AND the reason we are giving 2 doses of the new mRNA COVID vaccines!).

② male: ii Rh^+ $\underline{Rh^-}$
- both parents must be Rh^+ Rh^- (heterozygous) bc they have an Rh^- child

female: $I^A\underline{i}$ Rh^+ $\underline{Rh^-}$
↳ must be heterozygous for A bc they have an O child

	I^A Rh^+	I^A Rh^-	i Rh^+	i Rh^-
i Rh^+	I^Ai Rh^+Rh^+	I^Ai Rh^+Rh^-	ii Rh^+Rh^+	ii Rh^+Rh^-
i Rh^-	I^Ai Rh^+Rh^-	I^Ai Rh^-Rh^-	ii Rh^+Rh^-	ii Rh^-Rh^-

A+ O-

(3) AB^+: $I^AI^B\,Rh^+Rh^-$ x $ii\,Rh^-Rh^-$

	$i\,Rh^-$		
$I^A\,Rh^+$	$I^Ai\,Rh^+Rh^-$	1	A^+
$I^B\,Rh^+$	$I^Bi\,Rh^+Rh^-$	1	B^+
$I^A\,Rh^-$	$I^Ai\,Rh^-Rh^-$	1	A^-
$I^B\,Rh^-$	$I^Bi\,Rh^-Rh^-$	1	B^-

Genotype | Phenotype

4. A^+: $I^AI^A\,Rh^+Rh^-$ B^+: $I^BI^B\,Rh^+Rh^-$

	$I^B\,Rh^+$	$I^B\,Rh^-$
$I^A\,Rh^+$	$I^AI^B_{+/+}$	$I^AI^B_{+/-}$
$I^A\,Rh^-$	$I^AI^B_{+/-}$	$I^AI^B_{-/-}$

Genotype: 1 $I^AI^B\,Rh^+Rh^+$: 2 $I^AI^B\,Rh^+Rh^-$: 1 $I^AI^B\,Rh^-Rh^-$

Phenotype: 3 AB^+ : 1 AB^-