Biology

Chemistry

Investigating blood types

In this experiment, simple liquids that mimic blood are used to demonstrate blood typing.

Image courtesy of Nicola Graf

By Tim Harrison

The topic of blood types is often taught in school science lessons but experimenting with real blood may not be possible for many good reasons—because of the concerns of parents, the need for comprehensive risk assessments to prevent infection or the transmission of blood-borne disease, or the reluctance of students to use their own blood.

In this practical activity, simple chemical solutions are used to simulate blood types. The activity can be used in lessons, for a science club or as part of a forensic science day for students of many ages.

The science of blood

Blood is a sticky red fluid containing several kinds of cell suspended in a watery liquid called plasma: red blood cells, white blood cells and platelets (figure 1). Many chemicals are also suspended or dissolved in the plasma, including proteins, sugars, fats, salts, enzymes and gases. Each person's blood has certain inherited

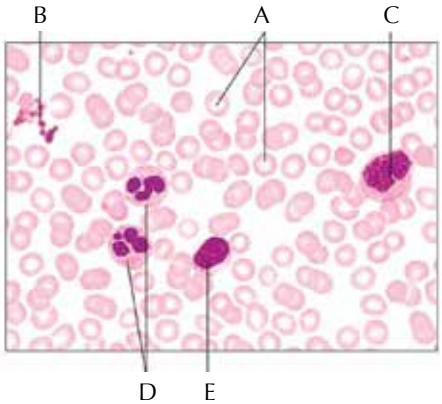

Image courtesy of Magdalena Wajrak

Figure 1: Photomicrograph of a human blood smear showing red blood cells (A) platelets (B) and white blood cells (C, D and E).

Anti-A agglutinin + blood: clumping	Anti-B agglutinin + blood: clumping	Blood type
Yes	No	A
Yes	Yes	AB
No	Yes	B
No	No	O

Table 1: Deducing ABO blood type using antigens

Image courtesy of Magdalena Wajrak

Using the dimple tray

characteristics that distinguish it from the blood of other people.

Until the 1980s, blood was primarily differentiated by ABO blood typing, which relies on the presence of three substances on the outside of red blood cells, called antigens. Although for forensic purposes, this technique has since been replaced by other methods such as DNA fingerprinting, for clinical purposes, ABO blood typing is still used before giving someone a blood transfusion to prevent complications such as rejection.

The presence or absence of A and B antigens on red blood cells determines a person's ABO blood type. This leads to the identification of four main blood types: A, B, AB (when both antigens are present) and O (when neither antigen is present), as shown in figure 2. A third important blood antigen is the Rhesus (Rh) factor, or D antigen. People with the D antigen are Rh positive, and those who lack it are Rh negative.

In order to type a person's blood, antibodies (called agglutinins and sometimes referred to as antiserums) are added to a few drops of blood. These agglutinins bind to the antigens on the surface of the red blood cells, causing the cells to aggregate or clump. If clumping occurs in a blood sample, then that associated antigen is present. Once all antigens have been tested, the blood type can be deduced (table 1).

ABO blood typing experiment

Safety note: Wear safety glasses and gloves. See also the general safety note on the *Science in School* website.

REVIEW

- **Biology**
- **Chemistry**
- **Blood**
- **Immunology**
- **Agglutination reactions**
- **Displacement reactions**
- **Ages 14–19**

This interesting practical activity addresses a basic topic of biology: blood types. Although the theory may be familiar to students, experiments on blood are normally avoided for reasons explained by the author. This, however, is an easy simulation to try in the laboratory using a simple chemical reaction.

The subject of this article could be related to other important topics such as immunology in biology, displacement reactions in chemistry, and even civil rights in ethics. The experiment could also be useful for awakening students' interest in the need to investigate new materials and technologies that allow us to make safer and faster transfusions.

Suitable comprehension questions could include:

1) What is the importance of knowing your blood type?
2) Why does clumping occur? What is the relationship between antigen and antibody?
3) Do you know an example of blood typing other than ABO?
4) What is the difference between agglutination and displacement reactions?
5) Why is it important to investigate new sources of universal donor blood?

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Materials

Each group will need:

- Two spotting tiles (dimple trays)
- Two pipettes, one for each blood sample
- 2.0 mol dm^{-3} hydrochloric acid solution in a dropping bottle labelled 'Anti-A'
- 2.0 mol dm^{-3} sulfuric acid solution in a dropping bottle labelled 'Anti-B'
- Identified 'blood samples' (aqueous solutions made thicker with glycerol and dyed with food colouring to resemble blood), labelled by blood type:
  - 'O' = distilled water
    'A' = 0.1 mol dm^{-3} silver nitrate solution
  - 'B' = 0.1 mol dm^{-3} barium nitrate solution
  - 'AB' = a 50:50 mixture of 0.1 mol dm^{-3} silver nitrate and barium nitrate solutions
- Unidentified blood samples, made from the same solutions as the identified blood samples, labelled 'victim 1', 'victim 2', etc.

Procedure

Explain the scenario to your students: there has been an accident and you need to know the ABO blood type of the victims before they can be given blood transfusions. It is the students' job to use the blood samples

Image courtesy of Magdalena Wajrak

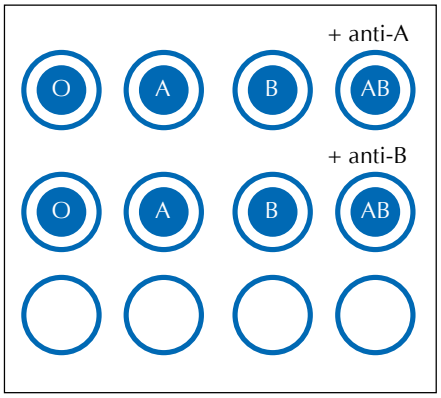


Figure 2: Blood samples on a dimple tray

Image courtesy of Magdalena Wajrak

Recording observations

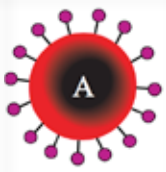
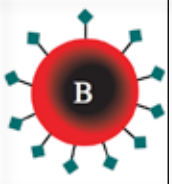
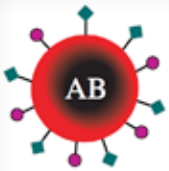
	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and anti-A
Antigens in red blood cells	 A antigen	B antigen	 A and B antigens	None

Image courtesy of InvictaHOG ; image source: Wikimedia Commons

ABO blood typing

BACKGROUND

More types of artificial blood

The need to identify the blood type of patients before blood transfusion may soon be a thing of the past. Recently, UK-based researchers at the University of Edinburgh announced that they had made type O negative red blood cells from stem cells. If scaled up successfully, this method could lead to a new source of universal donor blood, and there are plans for a small-scale clinical trial in 2016.

Furthermore, researchers are developing products based on haemoglobin (the oxygen-carrying protein in blood), for example in a polymerised and powdered form, that can be stored for months at room temperature, unlike blood, which has to be refrigerated.

and work out the type of blood each victim has.

1. Using a clean pipette, put one drop of one of the identified blood samples into each of the first wells of the first two rows of your dimple tile. Complete the rows with the other blood samples, as shown in figure 2.
2. Add a drop of anti-A antiserum to each dimple in the first row and record your observations in table 2. If you're not sure of a result, add another drop of anti-A antiserum.
3. Add a drop of anti-B antiserum to each dimple in the second row and record your observations, also in table 2. If you're not sure of a result, add another drop of anti-B antiserum.
4. Use your results to conclude how each blood type (O, A, B and AB) reacts to the antibodies.
5. Take a clean dimple tray and test the victims' blood using the same method. Record your observations in table 3.
6. Use your results to assign the correct blood type to each victim

About what happens

These tests mimic how different blood types react with agglutinins, by using simple chemistry. With older students you may wish to discuss this chemistry, pointing out the differences between the antibody-antigen reaction which is being modelled and the simple displacement reaction that is actually happening.

In this experiment, instead of clumping blood cells, the (white) precipitates make the solutions clump in the spotting tiles.

Barium nitrate(aq) + sulfuric acid(aq) → barium sulfate(s) + nitric acid(aq)

Silver nitrate(aq) + hydrochloric acid(aq) → silver chloride(s) + nitric acid(aq)

The clumps that form are dark red, instead of white, because of the food colouring present.

Blood type	Observations with anti-A. Did clumping occur?	Observations with anti-B. Did clumping occur?
A		
B		
AB		
O		

Table 2: Record the clumping behaviour of the identified samples.

Victim	Observations with anti-A. Did clumping occur?	Observations with anti-B. Did clumping occur?	Blood type
1			
2			
3			
4			

Table 3: Test the unidentified blood samples (found at the accident scene).

Acknowledgement

This activity was developed by Magdalena Wajrak of Edith Cowan University in Perth, Australia. The solutions used in this version came from a group of science technicians from the Association of Science Technicians in Independent Schools in Western Australia (LABNETWEST)[w1].

Web reference

w1 – To learn more about LABNETWEST, see: http://labnetwest.asu.au

Resources

While A, B, AB and O are the most common blood types, there are other rarer blood types, as this article in *Mosaic* explores: http://mosaicscience.com/story/man-golden-blood

From the same website, why not explore why we have blood types at all? Visit: http://mosaicscience.com/story/why-do-we-have-blood-types

For further *Science in School* articles about forensic science projects, see:

Wallace-Müller K (2011) The DNA detective game. *Science in School* **19**: 30-35. www.scienceinschool.org/2011/issue19/detective

Gardner G (2006) The detective mystery: an interdisciplinary foray into basic forensic science. *Science in School* **3**: 35-38. www.scienceinschool.org/2006/issue3/detective

Tim Harrison works at the University of Bristol, as the school teacher fellow at the School of Chemistry. This is a position for a secondary-school teacher that was created to bridge the gap between secondary schools and universities, and to use the resources of the School of Chemistry to promote chemistry regionally, nationally and internationally.