

# Fantastic fibrin

You never know when and where a blood vessel might be hurt. So all the parts needed to fix a hole must be available anytime and everywhere in our blood. But we need sticky fibers only near a damaged vessel. Blood vessels clogged at other places would stop red blood cells from bringing enough oxygen to the brain or heart. So the blood must clot at exactly the right time and at the right place: at a wound.

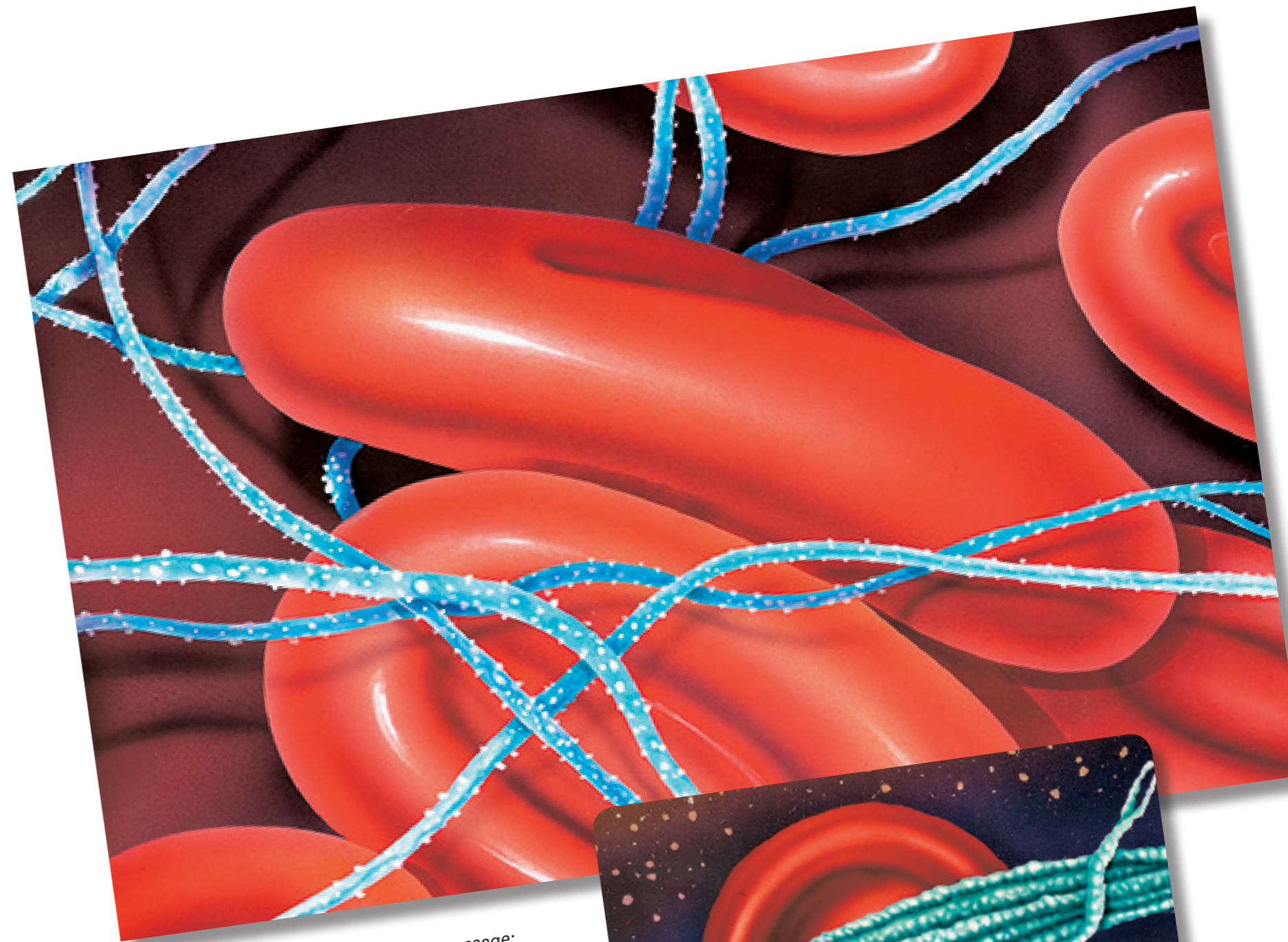
Now comes a fantastic trick. As long as everything is okay we have proteins floating in our blood that help to clot blood but they are sleeping. One is called fibrinogen —or fibrin maker, and a dozen more are there to control it.

Once alarmed by damaged blood vessel cells, our thrombocyte cells send out signals telling the fibrinogen to become fibrin and to form a dense mesh of fibers. This will trap blood cells and turn liquid blood into a solid mass called a blood clot.

If only one of the dozen different proteins controlling fibrinogen is not working, fibrinogen cannot turn into fibrin and a wound will never close. This is what happens to kids with hemophilia. Their cells lack the right blood-clotting gene, and so these kids never stop bleeding.

## WHAT CAN DOCTORS DO ABOUT IT?

One way is to take out the missing protein from blood donated by healthy people, and inject it into the bleeding kids. Or we let bacteria produce the protein that people with hemophilia need so badly and give to kids. Another tricky way is to give sick cells the right genes, or recipes, so they can make the right blood-clotting protein themselves. These are the tricks genetic engineers can play. But first let us look at how cells actually work.



The fibrin makers got the message: Fibrin clings together to form sticky fibers. Wrong: fibrin fibers are just made of fibrin. The other proteins are there to control fibrin formation.

Now the fibers catch red blood cells to turn liquid blood solid. The clotted blood will clot stop bleeding.



# Ingenious genes



All this happens in the incredibly tiny world inside our cells. If we pulled the DNA thread out of the nucleus, it would look like a twisted ladder with rungs made of two parts. When the cell is about to divide, the whole DNA will split to give a copy to each fresh cell.

Above is a single thread called messenger RNA. It has copied a particular portion of the DNA inside the nucleus, a single gene. Now it will take it to the protein factories. This is how ribosomes get the recipe for making a particular protein.

Cells get the instructions what to do from their genes: recipes for making proteins, written in a chemical language on an incredibly thin thread called DNA. Without genes a cell wouldn't know what to do. It would run out of fresh proteins and die.

Almost all of our cells have the same complete set of genes, called a genome: recipes for the many thousands of kinds of proteins. We actually have a double set, so if one gene happens to be faulty, the reserve gene can take over.

But of course liver cells and skin cells have different jobs and make different proteins. So each kind of cell will only read the genes for the very kind of proteins it is supposed to make. However, there is some housekeeping work to be done by liver cells, skin cells and all other cells: they all divide or produce energy, so all cells also turn on the same housekeeping genes.

## WHERE DO CELLS GET THEIR GENES FROM?

From the very first cell from which they all came: the fertilized egg cell in the mother's womb. When the egg cell divides over and over again to become an embryo, all new cells get an identical copy of the genome, and always the same double set.

Egg cells are very special. The cells that divide to make an egg cell give them only a single set of genes. So it cannot divide on its own, until the father's sperm cell delivers his unique set of genes. This is called fertilization. Only now can the egg cell grow, and the baby will have a set of genes from both parents.



# How to make

# clones

Clones are living beings with exactly the same set of genes. Almost all our body cells are clones since they all have the same genes and come from one fertilized egg cell. Our liver cells are different from our skin cells not because they have other genes. They only turn on different ones.

## ARE THERE ALSO HUMAN CLONES?

Yes, think of identical twins. They come from one fertilized egg that accidentally splits into two cell clumps early on, so they have identical genes. They still look different from their parents, because all of us have a mixture of genes coming from both paren. So, no kid can naturally ever be a clone of its parents.

## BUT AREN'T THERE ANIMAL CLONES?

That is a different story. Remember the sheep whose milk contains a blood-clotting human protein? Wouldn't it be useful to have a flock of sheep clones all making protein medicine the same way?

Veterinarians know for many years how to make farm animal clones. They take fertilized egg cells out of the mother that have already divided into a clump of a few dozen cells. They split the cell clump into single cells and let each cell develop into a new cell clumps each one developing into identical animal clones. Then they put them put back into mother animals which give birth to clones like identical twins.

However, genetic engineers have discovered a new way to make animal clones. Not from an egg cell, but from an adult animal. And no father is needed!

This is the trick: Remove the nucleus with all its DNA from a fertilized egg cell. Then take the nucleus with all its genes from a skin cell of another sheep. Put it into the empty egg cell. Now the egg cell has again a full set of genes but this time from the animal that gave the skin cell. The resulting animal will be a clone, or identical twin. The first sheep ever cloned this way was called Dolly. And Dolly was the very first animal ever that had no father.



Cloned sheep Dolly has two mothers.

Here we have mother nr. 1. She will give her genes to Dolly in the end.



This is mother nr. 2. She will produce an egg cell without genes.



Let's take out a skin cell.



Take out the egg cell.

Take the nucleus with all its genes out of the skin cell.



Remove the nucleus. We don't need it.



Now we have an empty egg cell.

Put the nucleus into the empty egg cell of mother nr. 2.



Put the genetically engineered egg cell back into mother nr. 2.



She will give birth to Dolly: a clone of mother nr. 1.



And here we have little Dolly.