FEATURE: How Blood Keeps You Alive – Paul Brand & Phillip Bishop, M.D.

VOICE: An ambulance rushed a girl to a hospital emergency room. She looked dead.

PROF.: A few minutes later, she was so alive that a man changed his career plans.

FORMAT: THEME AND ANNOUNCEMENT

VOICE: The emergency-room cart rolled into the hospital. As a student observing the scene, Paul Brand thought the girl on the gurnee was dead.

PROF.: Seeing her restored to health inspired Brand to become a medical doctor. He became a surgeon and spent much of his life at the Christian Medical College and Hospital in Vellore [vel-OR], India.

VOICE: Tell me about the incident that changed Dr. Brand's life.

PROF.: He wasn't planning to be a physician. He was taking a short course in healthcare for people who were planning to work in areas where there weren't any doctors. He recalled, "In an emergency ward of a small hospital, I saw a young woman brought in, in terrible shock from blood loss. …I couldn't feel her pulse, and there was no sign of life."

He continued, "Somebody came rushing and hooked up a bottle of blood...to her. She still looked dead white. But then ***I saw that girl come alive!*** A little flush came into her cheeks, and then I began to feel the pulse. Then I saw her open her eyes and look at me and ask for a drink!"

VOICE: Are you implying that this experience influenced him to abandon his previous career plans and become a medical doctor?

PROF.: Yes. And it impressed on him the extreme importance of the several functions that ***blood*** performs in our bodies.

Shortly before his death, Dr. Brand told a lecture audience, "When I was a student, I was working on many interesting pieces of research. I had many different kinds of pain inflicted on me [as part of the experiments]. One of the most severe kinds…was the pain of ischemia [is-KEM-ee-uh]…"

VOICE: Isn't ischemia a stoppage of blood flow in part of the body?

PROF.: That's right. His teachers would take a tourniquet and put it around his upper arm to stop the flow. Then they would exercise the flexor and extensor muscles and use barbells and various exercise equipment.

They would do it until he felt an overwhelming sense of weakness. Then his instructor would say, "Go on, do some more" and would measure how much force the student could produce.

Then suddenly Dr. Brand's entire arm experienced the intense pain of a muscle cramp. The instructor would tell him to continue exercising, but it was impossible.

VOICE: After a few minutes without fresh blood, his arm was powerless in pain.

PROF.: Yes. He remembered, "But I'll never forget the agony of that pain. The pain of ischemia occurs because you're exercising your muscles, and you're working with ***no energy, no oxygen***. And the lactic acid and the other metabolites are accumulating in your muscles and causing this terrible cramp and spasm and pain."

VOICE: What a relief it must have been when they ***released*** the tourniquet!

PROF.: Definitely! The arterial blood flowed in, filled with oxygen. His whole arm returned to its normal color. He exclaimed, "Oooh! Absolute bliss! The bliss of the cleansing blood – the blood that washes away the lactic acid and all the products of our physical work."

VOICE: Someone said the bloodstream is like a freight train that delivers food while simultaneously taking away the garbage.

PROF.: That's an excellent analogy. The circulatory system transports oxygen and nutrients to all the cells in the body, while removing waste products.

And it does it ***without stopping*** the train to do the pickup and delivery!

VOICE: How does it achieve that?

PROF.: By a combination of chemistry and geometry. First, let's discuss the chemistry.

VOICE: Isn't hemoglobin the major chemical component of blood?

PROF.: Yes. Dr. Phillip Bishop is a professor of exercise physiology at the University of Alabama and has served as a visiting scientist at NASA. He describes hemoglobin as an organic compound that accurately performs the functions of shipping agent, accountant, delivery driver, and recycler. It contains more than 9,000 molecules. More than half of them are hydrogen, more than a quarter are carbon – and oxygen, nitrogen, sulfur and iron make up the rest.

VOICE: How does hemoglobin perform the various functions of "shipping agent, accountant, delivery driver, and recycler"?

PROF.: Part of the answer is the way the blood transports oxygen. When a red blood cell passes through the lungs, it picks up oxygen by oxidizing. When it passes through the other organs of the body, it delivers its life-giving substances by ***de***-oxidizing.

VOICE: It sounds like a very rapid series of chemical reactions – all performed without stopping the flow.

PROF.: Yes. And while it's doing that, it does other chemical reactions to pick up waste products from throughout the body. It knows which organs should receive which substances – including delivering carbon dioxide to the lungs and taking other waste products to the kidneys.

PROF.: Dr. Bishop adds, "Consider the engineering and management tasks that have to be solved. Oxygen has to be extracted from the air, carried across the lung wall, across the capillary wall, through the blood plasma, across the wall of the red blood cell, and attach to the hemoglobin. Which is to say, the hemoglobin must be attractive to oxygen at the lung. The hemoglobin then must hold on to the oxygen until the blood reaches a location in the body where oxygen is needed."

VOICE: Hemoglobin is attractive to oxygen, so oxygen bonds rapidly to it.

PROF.: Yes, ***some*** of the time. But here's where Dr. Bishop says something that surprised me. In his words, "Then, at that one point in time, hemoglobin must ***lose its attraction for oxygen***."

VOICE: (SURPRISED) So that it can deliver the oxygen to the body's cells?

PROF.: Yes. Dr. Bishop elaborates that oxygen must somehow be transported through the wall of the red cell, through the plasma, through the wall of each cell that's receiving it, and through several other objects. Inside the mitochondria wall, in his words, "it is combined with hydrogen to make the energy necessary for beating hearts, contracting muscles, and working brain cells."

VOICE: So hemoglobin attracts oxygen when it is picking it up in the lungs. But it loses its attraction for oxygen when it reaches the organs that need to unload oxygen from it.

PROF.: That's right. The organs need more oxygen when they have a higher temperature or a higher-than-normal acidity level. He observes that under those conditions, "Most remarkably, as the demand for oxygen increases…, the hemoglobin's distaste for oxygen intensifies."

VOICE: So it downloads the oxygen faster, to meet the increased need.

PROF.: Yes. Dr. Bishop comments, "This is one truly remarkable molecule!"

VOICE: We mentioned a moment ago that the bloodstream is like a freight train that delivers food while simultaneously taking away the garbage. It transports oxygen and nutrients to all the cells in the body, while removing waste products.

How does it achieve that, without mixing the good ingredients and the waste materials – and ***without stopping*** the train to do the pickup and delivery? You said chemistry is part of the answer. What else makes the process work?

PROF.: There are still some details we don't know. But geometry is part of the answer.

If you look at a red blood cell through a microscope, it resembles a donut. But the middle of it doesn't contain a ***hole***, but it is much ***thinner*** than the edge.

VOICE: Why is that?

PROF.: Scientists who have analyzed it with a computer have discovered that this unusual shape is the most efficient geometric form for the job a red blood cell must do. It provides a large surface area for the hemoglobin to capture the nutrients rapidly and transport them to the body's cells, and to remove the waste products rapidly from the cells. That unusual shape provides a large surface area, while keeping the cell small enough to flow freely through the arteries, veins and capillaries.

VOICE: When Dr. Brand was preparing patients for surgery, did he tell them about how the blood would help to make their surgery succeed?

PROF.: Yes. He explained, "I sometimes stroke a vein of a patient's hand and push the blood out of it and let it come back. I say, 'You know, you've got wonderful blood. I'm going to operate on you, but right there is the fluid that is circulating through all [of] the operation wound.[1] If any infection occurs, your body is a healing body'."

VOICE: So infection is another of the things that the bloodstream removes from our bodies.

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1 The wound that will be caused temporarily by the operation.

PROF.: That's right.

VOICE: The circulatory system performs so many functions that are indispensible to life, that someone called it “The Red River of Life.”

PROF.: That's why Dr. Brand concluded, “In the grace of God and in the design of the Creator, all of my body's cells which are metabolizing are being constantly, continually cleansed.”

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