Forum: Science & Society

Animating platelet production adds physiological context

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Animating complex biological processes contextualizes them within their underlying physiology, identifies gaps in our mechanistic understanding, affirms the importance of continued research, and provides a bridge between academic scientists and the general public. Here, two videos illustrate the clinical value of and translate state-of-the-art research in platelet production.

The value of illustrating science by video

Biomedical research at academic institutions is mostly funded by federal agencies such as the National Institutes of Health and National Science Foundation that are themselves supported entirely by tax-payers' money. Although scientists are required to justify their research programs to a committee of peers to secure grants, few efforts are made to communicate this research to the general public that fund them. The result is a disconnect between science and its benefit to society [1,2], where most people have a very limited grasp of the state-of-the-art in a given research discipline and the advances in that field that they help support. This inevitably has long-lasting implications on how society approaches short- and long-term policy decisions, and affects the state of science funding in the USA [1,2]. Academic scientists could traverse the present disconnect between themselves and the general public by producing videos describing their scientific projects. These videos should translate complex biological concepts and affirm the importance of continued biomedical research. As proof-of-concept, we have produced a video series on the topic of platelet production to highlight its clinical value (Video 1) and review the state-of-the-art (Video 2).

Producing a scientific video

Science is done on behalf of society and it is important for academic researchers to communicate the value of their work to society in a manner that will be understood. To translate scientific concepts effectively, it is recommended that scripts be kept simple, clear, and concise. Stories should be told using context, and points should be organized and presented as individual sections that can stand alone. Animation helps engage the audience, and researchers should develop relevant visuals that support the message. Whiteboard animation provides an ideal platform for scientific presentations to lay audiences due to its high contrast, clean imagery, and medium detail of illustration, and should be considered when preparing such work. Allan Paivio's dual-coding theory supports the use of engaging the viewer with multiple mediums – by providing narration alongside animation to maximize information processing and memory retention [3]. Although there are many free or low-cost software packages available that individuals can use to create their own presentations, these programs have limited capabilities, limited cross-platform stability, are 'buggy', and are not intuitive to use. It is recommended that researchers seek out professional animators, who are experts in illustration, design, storytelling, and animation. Finally, videos should be published in open-access journals or on academic department (university), public health organization, or grant organization websites using professional video-hosting resources such as YouTube or Vimeo.

Videos to communicate with the general public

Video 1 represents an example of a professional whiteboard animation developed for lay audiences on the clinical value of platelet research. Whereas figures illustrate a single concept, videos combine multiple concepts to tell a story and are valuable in contextualizing information to describe how individual concepts are interrelated. The order in which figures appear, their relative positioning and distance from one another, and the length of time they are shown are the vehicles that transition the viewer from one figure to the next. Video 1 exemplifies this point by taking individual figures and tying them together in sequence to explain what platelets are, where and how they are made, and what role they play in human health and disease.

In this video we show that, worldwide, more than 14 million platelet units are transfused annually to treat bleeding complications resulting from pregnancy and birth, trauma, surgery, HIV infection, and cancer treatment [4]. Blood vessels are an interconnected network of pipes that transport oxygen from the lungs throughout the body and platelets are the engineers that keep the blood

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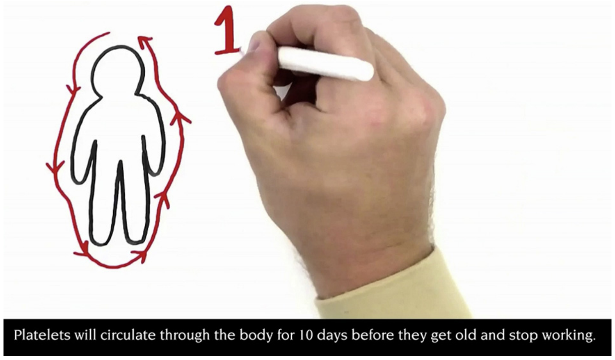
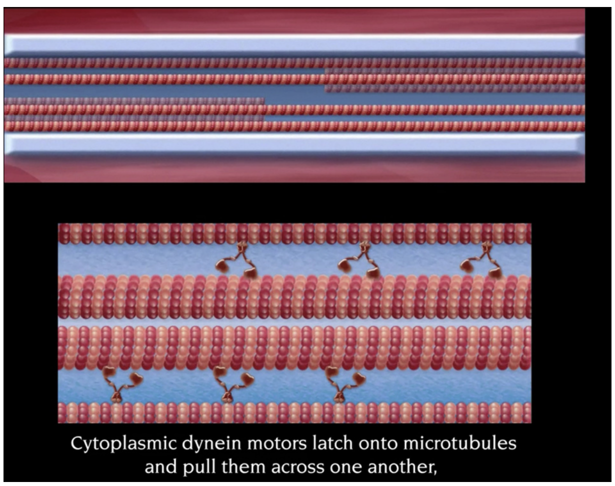


Video 1. Clinical importance of platelet research. This video highlights the process of platelet production and summarizes the value of platelet research within the larger context of human health. This video was produced in collaboration with TruScribe® (http://www.truscribe.com/).



Video 2. Proplatelet production and platelet release. This video reviews the state-of-the-art of thrombopoiesis within the physiological context of human bone marrow. This video was produced in collaboration with Alice C. Kitterman (http://www.aliceychen.com/), and created in Adobe Illustrator CS 6.0, Adobe Photoshop CS 6.0, Adobe After Effects CS 6.0, and iMovie (v.9.0.4).

vessels in working order. All three cell types in the blood are created inside the marrow of large bones [5]. Here, stem cells make copies of themselves that can transform into any other kind of cell in the body. To produce platelets, stem cells transform into large cells called megakaryocytes and move next to blood vessels [6]. Here, megakaryocytes extend long projections through the spaces between cells that line the blood vessels to release many new platelets into the blood [7]. Platelets will circulate through the body for 10 days before they get old and stop working [8]. When this happens, white blood cells will collect them and dispose of them so that new platelets can keep blood vessels functioning. Platelets stop bleeding by patching blood vessels that are injured or faulty [8]. When any part of this process breaks down people get sick and can die. When a person has too few platelets they will not be able to stop bleeding. This is of particular concern during childbirth or surgery. If a person has too many platelets this can cause blockages in the heart and brain, which can lead to heart attack or stroke. This type of video is most valuable for communicating general scientific concepts to the general public and justifying a research program's *raison d'être*. It is recommended that all publically funded basic research departments produce a video highlighting their focus and showcase it on their departmental website.

Videos to communicate sophisticated scientific information

Although intermediate stages in complex biological processes such as platelet production are often studied independently to resolve their underlying mechanistic drivers, these must eventually be reassembled and contextualized within a physiological setting to provide a complete picture. Doing so not only helps identify important mechanistic contributors implicated by the surrounding environment but can help highlight existing gaps in our current understanding. Animation is useful to simplify complex interactions and illustrate dynamic processes that cannot be conveyed with static images. The relative size, position, and distance of components are useful in communicating scale, and the animation speed can be used to communicate rate information. Static figures and videos of actual processes (when available) should be included alongside animations to facilitate the viewer in placing the highlighted mechanism within its physiological context. Video 2 exemplifies this point by combining individual studies of key steps in platelet production and replacing them within their true physiological context.

Video 2 shows that, during platelet formation, megakaryocytes (large platelet progenitors found mainly in the bone marrow of the ribs and thighs) extend pseudopodia-like proplatelet extensions into adjacent blood vessels [9–11]. Blood shear rates of 500–2500 s^{-1} induce megakaryocytes to elongate proplatelets, which form bulges along their length and platelet-size swellings at their tips [12]. Proplatelets can be thought of as the 'assembly lines' of platelet production and, as proplatelets pinch off, they release large circular preplatelet intermediates into the blood that undergo further divisions to form platelets [13]. Proplatelet production is a microtubule-driven process. During proplatelet elongation individual microtubules slide past one another causing the proplatelet shaft to narrow and eventually pinch off [14]. Cytoplasmic dynein motors latch onto microtubules and pull them across one another, driving microtubule 'telescoping'. Multiple microtubule coils are formed within the platelet-size swellings at the proplatelet tips. Kinesin motors carry alpha-granules (storage vehicles for platelet molecular cargo) along microtubule tracks that are retained at the platelet-size swellings [15]. Circular preplatelets released into the bloodstream propagate new platelets by twisting into a 'figure 8' conformation, elongating along the long axis, pinching at the shaft's midpoint, and dividing in two [12]. Residual tails ostensibly coil back into the platelet body. It is currently unknown whether terminal platelet production happens in the general circulation, bone marrow, or within the microcapillaries of the lung or spleen. Platelet formation is a highly dynamic process where the bone marrow microenvironment directs intricate cytoskeletal reorganizations in megakaryocyte progenitors to drive production of platelet intermediates and, ultimately, functional platelet release. With so many factors influencing the different components of this process in time, 2D animation can advance our understanding of this mechanism by modeling it in a step-wise, linear manner. This type of video is most valuable for communicating specific scientific concepts to students and peers, and should be used as a teaching tool, in professional meetings, and for grant submissions where an educated audience may not be familiar with the details of the investigator's subspecialty.

Concluding remarks

As the pace of scientific progress quickens, the growing divide between publicly funded basic research and the general public that subsidizes this work has made all but the most significant scientific achievements inaccessible to the average person. To bridge this gap and justify the underlying value of publicly funded basic research programs, scientists must become proactive in how they communicate their research to society. Animation provides this vehicle, and should be embraced as a powerful tool with which to engage the public and translate complex principles into easy to understand concepts. Government support of basic research has never been lower and while basic research is the major vehicle for technological and healthcare advancement in our nation it is up to researchers to justify its value.

Conflicts of interest

J.N.T and J.E.I. declare no competing financial interests. A.C.K. is an employee of A.Y. Chen Illustration and Design.

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