I. WRITTEN COMPREHENSION : Read the following text and answer the questions underneath.

The Curious Wavefunction

Musings on science, history, philosophy and literature

On Patrick Blackett, the ideal experimental physicist, and what it takes to excel at interdisciplinary research

By Wavefunction on Wednesday, June 29, 2016

The grandly named Patrick Maynard Stuart Blackett was the Cambridge physicist on whose desk Robert Oppenheimer purportedly left a poisoned apple. The veracity of this yarn will likely never be determined, and it's rather unfortunate that Blackett has been enshrined in the public's mind through this story, most notably by writer Malcolm Gladwell in his book "Outliers".

This selective and sensationalized reporting is unfortunate because Blackett was the one of the most versatile and accomplished experimental physicists of the twentieth century. Not only was he an outstanding scientist who won the Nobel Prize for his research into cosmic rays and particle physics, but he was also a brave and decorated naval officer, a highly successful military scientist who pioneered operations research during World War 2, a vigorous campaigner for arms disarmament, and a writer of clear and engaging books advocating common sense thinking about weapons and warfare. This underappreciated scientist and government official deserves much more recognition than as the recipient of a possibly poisoned apple.

Athletic and handsome as a movie star with a finely sculpted face, Blackett saw raw action in the Battle of Jutland in World War 1. Between the war years he worked at the famed Cavendish Laboratory where he did much of his prizewinning work on cosmic rays. He and his colleague Giuseppe Occhialini

discovered the positron (predicted by Paul Dirac) at the same time as American physicist Carl Anderson, but because the two wanted to confirm their discovery and were slow in publishing it, Anderson was the one who received the Nobel Prize for it (although Blackett was awarded his own prize for other work in 1948). The 'poisoned apple' incident emerges from this period. The story goes that Oppenheimer who was unsuccessfully trying his hand at experimental physics and suffering severe mental health problems as a result left the apple on Blackett's table out of sheer jealousy at Blackett's multifaceted personality and accomplishments. Even if the story is true it speaks to the kind of admiration Blackett could evoke.

During the war Blackett was one of the founders of the branch of mathematics and management science called operations research. He used this technique productively in trying to protect convoys against U-Boat attacks. After the war Blackett became an enthusiastic and sensible proponent of arms disarmament. As early as 1949 he wrote a book named "Fear, War and the Bomb" which argued against the efficacy of strategic bombing and the lure of nuclear weapons as instruments of warfare. In a time when the atomic bomb was seen as the linchpin of geopolitical strategy, this was a remarkably prescient and courageous position to adopt. Subsequent events have only vindicated Blackett's core thesis.

Blackett ended his career as a decorated scientist and public servant, having gathered many honors for his efforts and advice. Fortunately there are at least three books that vividly describe his life and times; volumes by Mary Jo Nye (2004), Peter Hore (2002) and most recently Stephen Budiansky (2013).

Blackett's own writings on science and politics are worth reading, but here I want to highlight his views on what it takes to be an accomplished experimental physicist. It strikes me that Blackett's take applies not just to experimental physicists but to any scientist who wants to straddle the boundary between two disciplines or modes of thinking. Here's what he has to say (italics mine):

> The experimental physicist is a jack-of-all-trades. A versatile, amateur craftsman he must blow glass and turn metal, carpenter, photograph, wire electric circuits and be a master of gadgets of all kinds. He may find invaluable his training as an engineer and can profit always by utilizing his gifts as a mathematician. In such activities will he be engaged for three quarters of his working day. During the rest he must be a physicist, that is he must cultivate an intimacy with the physical world, *but in none of these activities taken alone need he be preeminent*; certainly not as a craftsman, and not even in his knowledge of his own special field of physics need he, or indeed perhaps can he, surpass the knowledge of some theoretician…
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> *The experimental physicist must be enough of a theorist to know what experiments are worth doing, and enough of a craftsman to be able to do them. He is only preeminent in being able to do both.*

Blackett's words are worth remembering for many reasons. First of all, he emphasizes the wide variety of tools that an experimental physicist needs to be

proficient at. In fact Blackett says that good experimental physicists may end up spending most of their time not learning physics but building tools. Most notable among these are tools that are actually not experimental but theoretical. It's not sufficient for an experimental physicist to be good at building magnetometers, wiring circuits or writing software; she also needs to understand the theory that her efforts are going to test, as well as the limitations of her efforts in validating essential features of the theory.

There are a handful of experimental physicists in the 20th century who straddled this boundary with ease. Supreme among these was Enrico Fermi, whose achievements in both theory and experiment were unparalleled. The historian of science C P Snow paid Fermi the ultimate tribute when he remarked that, had Fermi been born twenty years earlier, he could have seen him first discovering Rutherford's atomic nucleus and then inventing Bohr's theory of the hydrogen atom. That's as high as praise can get. However there were other physicists who were also quite accomplished in both domains. One example was Isidor Rabi who knew enough theory to interpret the results of his Nobel Prize winning magnetic beam experiments. Another was Willis Lamb, a student of Robert Oppenheimer whose precision experiments on the energy levels of electrons in hydrogen atoms led to observation of the so-called Lamb Shift. The Lamb Shift was the starting point for a revolution in physics that led to the theory of quantum electrodynamics.

In other sciences too it is important for practitioners to understand enough of other tools and ideas to have an impact. Chemistry being a more experimental science compared to physics, it's especially important for chemists to remember Blackett's motto. For instance a biochemist might be exceedingly accomplished in setting up assays to test the activity of a drug, but he might likely misinterpret results or not follow up on interesting ones if he is unaware of kinetics, thermodynamics and the principal features of intermolecular interactions. Similarly, a synthetic chemist setting up a reaction needs to be proficient in understanding molecular conformation and the determinants of molecular reactivity. Simply being able to set up low temperature reactions, handle flammable reagents and record NMR spectra won't be enough.

Perhaps the most important message from Blackett's musings is that one does not need to truly excel in one domain or another in order to excel in their combination. This principle applies to other fields too. For instance Oliver Sacks, while a very good neurologist, was not one of the top neurologists in the world. Similarly, although an excellent writer, he was perhaps not at the very top of the pantheon of prose stylists. But as Andrew Solomon says in his review of Sacks's wonderful autobiography, what made him truly unique was the fact that he was a very good neurologist who was also a very good writer. It was this killer combination that made him world-class.

In this era of highly interdisciplinary research, Blackett's message should be especially pertinent. With the constant river of diverse data flowing toward us at superhuman speed, it's probably a bad strategy to try to excel in multiple fields all at once. Instead, just like Blackett's ideal experimental physicist, it's far better

to aim for being pre-eminent in knowing those fields in the first place, and knowing enough of each to be useful and not dangerous.

II. Answer the questions :

1) What legend or story made Patrick Blackett famous ?

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2) Why do you think Oppenheimer left a poisoned apple on Blackett's desk according to you ?

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3) Why does Patrick Blackett deserve more recognition than a mere allusion to the legend of the poisoned apple ?

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4) What did Patrick Blackett look like according to the author ?

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5) What kind of research did he do at the Cavendish laboratory in Cambridge University?

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6) What is the official version given by the author about the legend of the poisoned apple ? Does it relate in any way with what you thought about it ?

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7) What subject did Blackett create and what kind of geopolitical position did he adopt ?

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8) What did Blackett say about experimental physicists ? Give a few examples of experimental physicists and what they did.

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9) Why is it important for chemists to remember what Blackett had said before ?

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10) What is Blackett's most important message ? Quote an example from the text. Do you agree with Blackett's assertion ?

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II. ROLE PLAY :

Imagine Oppenheimer and Blackett are working together on the positron.

ROLE A : You're Robert Oppenheimer, a famous American physicist also called 'the father of the atomic bomb'. You are extremely jealous of Blackett because Blackett's accomplishments are outstanding and never-ending. You feel less important than Patrick Blackett. You're mad at him and you would like to find a way to stop him from doing more research.

ROLE B : You're Patrick Blackett, the 'father of Operations Research'. Your work proved very successful during military operations and Winston Churchill is your close friend. Churchill never makes a decision without calling you and asking for your opinion first. You have become a Baron and the President of Royal Society and you're working on many new projects that could help your country. You once meet Robert Oppenheimer, the American physicist known for the creation of the atomic bomb. You don't know him very well but you know he was reported to be mad and insane.

Imagine their conversation and imagine the way Blackett reacts.

USE AS MANY OPERATIONS RESEARCH TERMS AND CONCEPTS AS YOU CAN.

WORD BANK :

purportedly : prétendument
yarn : 1) fil de laine 2) histoire, conte, récit
to be enshrined : être inscrit / être enchâssé
accomplished : être accompli/ être réussi/ être abouti
recipient : destinataire
to be famed : être célèbre
to be multifaceted : multiforme/ aux capacités variées et multiples
convoy : cortège/ convoi/escorte
lure : appât/ leurre/tentation
linchpin : pivot / cheville/goupille/élément central/pilier
to try one's hand : s'essayer à/ expérimenter
to vindicate : justifier / revendiquer/venger/disculper
a take : une prise de vue
to straddle the boundary : chevaucher la démarcation
an assay : un dosage
musing : rêverie/songe

a jack-of-all-trades : un touche-à-tout / un homme à tout faire
versatile : polyvalent