Accurate diagnosis is important for the treatment and prevention of disease. However, diagnostic technologies that are highly applicable to the first world must be modified for low-resource developing countries. Primarily, the major concern is cost and the ability of the diagnostic technology to be adaptable given the lack of infrastructure such as reliable power, refrigeration, and trained personnel.

According to the World Health Organization, diagnostic tests must be ASSURED: Affordable, Sensitive, Specific, User-Friendly, Rapid, Robust, Equipment-free, and Delivered to those who need it.¹

Paper is an inexpensive material that can be utilized for the fabrication of microfluidic analytical devices. It is available everywhere. It is thin and lightweight which makes stacking, storing and transport easy. It is made of cellulose which makes it readily compatible with biological samples. It is flammable which means it is easily disposed of after use. Also, it is compatible with existing printing technologies.²

Microfluidic paper-based analytical devices are promising platforms for diagnostics in the developing world. The devices are made of patterned paper. They are inexpensive to fabricate, simple to use but with the added functionality of a microfluidic device. They require only small volumes of fluid and little or no external supporting equipment or power. They have been demonstrated to have the capabilities for quantitative detection. Their integration with camera-equipped cellular phones as a method for providing inexpensive diagnostics in a remote setting has also been proposed.²
Fabrication of microfluidic paper-based analytical devices involves patterning paper into defined hydrophilic channels bound by hydrophobic barriers. Martinez and others first patterned paper using photolithography. They patterned photoresist onto paper to form defined areas of hydrophilic paper separated by hydrophobic walls. However, the photoresist barrier is susceptible to damage from bending and folding. Bruzewicz and others sought to overcome this by patterning paper by plotting with PDMS. PDMS is an elastomer and is more flexible than photoresist. The method allowed the folding of paper without destroying the channel. Li and others used a plasma reactor to form hydrophilic patterns on hydrophobized paper. Fenton and others used a computer controlled knife plotter to pattern paper. Abe and others introduced a way to pattern paper and directly print chemical sensing inks on paper. They used a polystyrene-toluene solution to hydrophobize the paper and then toluene as “ink” to etch patterns. But the method that seems most suited for mass production of microfluidic paper-based devices is wax printing which was first developed by Lu and others. Wax printing, however, gives a poorer resolution compared to photolithography. This loss of resolution is due to the spreading of the wax on the surface of the paper as it melts. Carrilho and others came up studied the spreading of the molten wax and derived an expression that relates the width of the hydrophobic barrier to the width of the original printed line. Their model allowed calculation of dimensions of a printed pattern required to produce a certain resolution.

As an offshoot of research made on paper microfluidic devices, there is an emerging new technology for thread-based analytical devices. Like paper, thread is made of cellulose and thus shares a lot of its chemistry which can be utilized for the fabrication of microfluidic devices. A foreseen advantage on the use of thread as a platform in microfluidic fabrication is that it can be manipulated by sewing, knitting and weaving. Microfluidic thread-based analytical devices could also be viable platforms for diagnostic assays.
Li and others were the first to fabricate microfluidic devices using thread by plasma treatment of cotton thread. Reches and others opted to use mercerized thread which does not require plasma treatment. They were able to demonstrate several designs of thread microfluidic devices by using knots to define detection zones.

Several diagnostic assays have been made with paper and thread-based analytical devices. Glucose and protein assays of urine have been shown to allow for quantitative colorimetric detection by reflectance detection. Other examples are colorimetric tests for pH, alkaline phosphatase, cholesterol, nitrite, ketone, uric acid.

As a real world example, a liver function test has been developed by a non-profit enterprise called Diagnostics for All. Measuring liver function is critical for monitoring the adverse side effects of drugs used for HIV/AIDS and TB treatment.

The talk will discuss the interesting characteristics of paper that make it a good material for diagnostic technology. The methods of fabrication, quantitative detection, application, and relevance of paper-based microfluidic device to telemedicine will be discussed. A brief background on thread-based microfluidic devices will also be given.