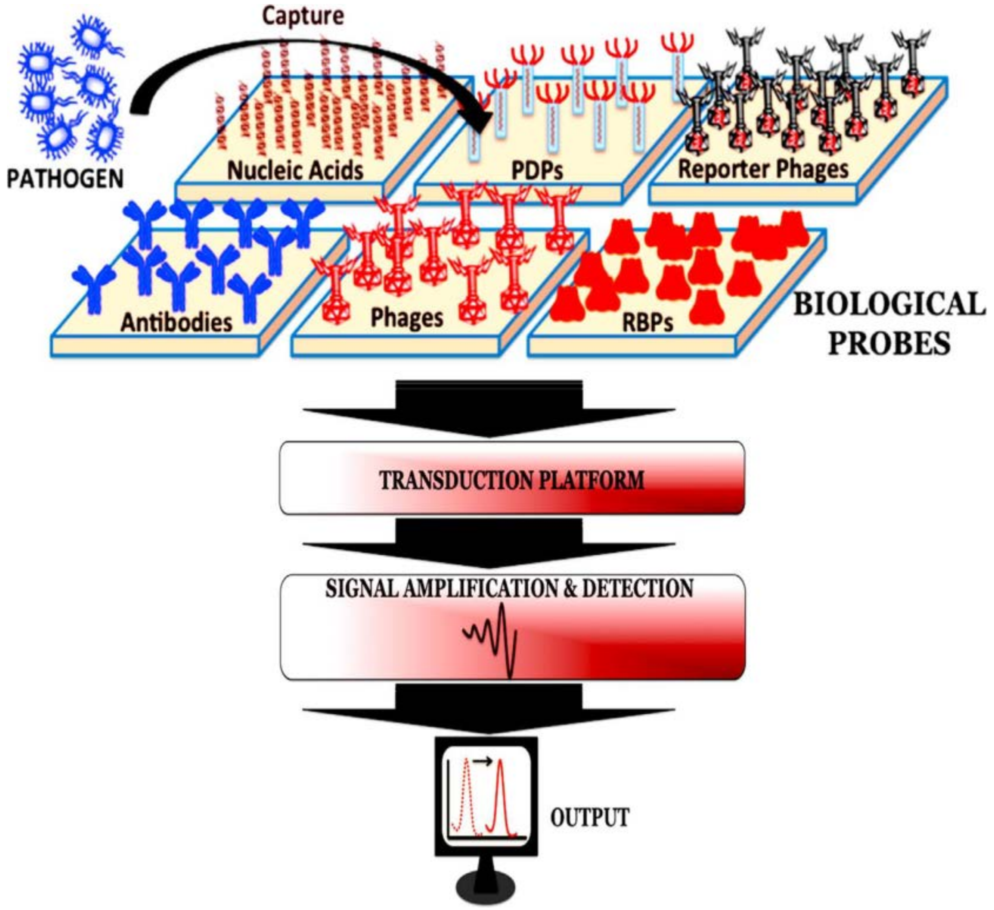
Biosensors based diagnosis

- A wide variety of sensors have been developed and commercialized for various applications.
- Depending on the operating principle of the sensor, the analytes could be detected using a sensor based on electrical, chemical, electrochemical, optical, magnetic or vibrational signals.
- The limit of detection could be enhanced by the use of nanomaterial matrices as transducers and the specificity could be enhanced by the use of bio-recognition elements such as DNA, antibody, enzymes, etc.



Schematic of pathogen identification strategies using different biological recognition probes including antibodies, DNA probe, phage, PDPs (phage display peptides) and RBPs (phage receptor binding proteins).

Biosensor Platforms Based on Nanomaterials

- Nanoparticles display electronic and optical properties and can be synthesized using different types of materials for electronics and sensing applications
- The popularity of nanomaterials for sensor development could be attributed to the high surface area, high electronic conductivity and plasmonic properties of nanomaterials that enhance the limit of detection.
- The immobilization of the biorecognition element, such as DNA, antibody and enzyme, can be achieved using various approaches including biomolecule adsorption, covalent attachment, encapsulation or a sophisticated combination of these methods.
- The nanomaterials used for biosensor construction include metal and metal oxide nanoparticles, quantum dots, carbon nanomaterials such as carbon nanotubes and graphene as well as polymeric nanomaterials.

- Nanoparticles have been utilized with other biological materials such as antibody for detecting *Xanthomonas axonopodis* that causes bacterial spot disease
- Gold nanoparticle-based optical immunosensors have been developed for detection of karnal bunt disease in wheat using surface plasmon resonance (SPR)
- In addition to single probe sensors, nano-chips made of microarrays which contain fluorescent oligo probes were also developed for detecting single nucleotide change in the bacteria and viruses with high sensitivity and specificity based on DNA hybridization

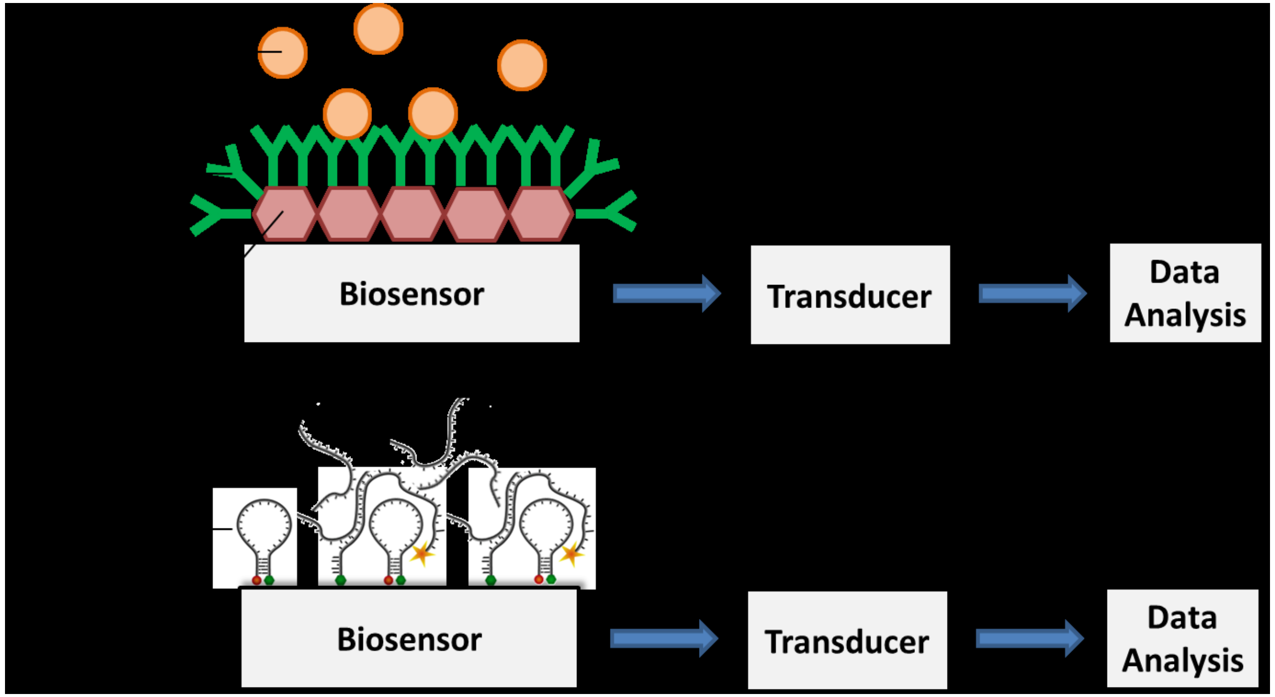
Affinity Biosensors

- Compared to the non-specific nanoparticle-based biosensors, inclusion of a bio-recognition element can greatly increase the specificity of the sensor. Consequently, other types of biosensors have been developed and among them affinity biosensors are popular.
- In affinity biosensors, the sensing is achieved based on the reaction of the bio-recognition element and the target analyte. Affinity biosensors can be developed using antibody and DNA as recognition elements.

Antibody-Based Biosensors

- The antibody-based biosensors provide several advantages such as fast detection, improved sensitivity, real-time analysis and potential for quantification.
- The biosensors enable the pathogen detection in air, water and seeds with different platforms for greenhouses, on-field and postharvest storages of processors and distributors of crops and fruits

- The principle of establishing antibody-based immunosensors lies in the coupling of specific antibody with a transducer, which converts the binding event to a signal that can be analyzed such as polyacetylene, polypyrrole or polyaniline



Schematic illustration of **(A) antibody-based and (B) DNA/RNA-based biosensor for analyte detection. The specific combination of analyte and immobilized antibody (A) or DNA/RNA probe (B) produces a physicochemical change, such as mass, temperature, optical property or electrical potential. The change can be translated into a measurable signal for detection.**

- Antibody-based biosensors could detect plant pathogens such as *Cowpea mosaic virus, Tobacco mosaic virus, Lettuce mosaic virus, Fusarium culmorum, Puccinia striiformis, Phytophthora infestans, orchid viruses* and *Aspergillus niger .*
- Antibody-based biosensor technology has made tremendous progress upon implementation of nanotechnology. Gold nanorods (AuNRs) functionalized by antibodies have been used to detect *Cymbidium mosaic virus* (CymMV) or *Odontoglossum ringspot virus* (ORSV) for rapid diagnosis of viral infections. The limits of detection (LODs) for CymMV and ORSV were reported to be 48 and 42 pg/mL, respectively, in leaf saps

DNA/RNA-Based Affinity Biosensor

- Due to the possibility of detection at a molecular level, the DNA-based biosensor enables early detection of diseases before any visual symptoms appear. The application of specific DNA sequences has been widely used for detection of bacteria, fungi and genetically modified organisms.
- Based on the specific nucleic acid hybridization of the immobilized DNA probe on the sensor and the analyte DNA sequence, DNA-based biosensor allows rapid, simple and economical testing of genetic and infectious diseases.
- The most commonly adopted DNA probe is single stranded DNA (ssDNA) on electrodes with electroactive indicators to measure hybridization between probe DNA and the complementary DNA analyte

- Bacterial pathogens are detectable by DNA-based biosensors due to their unique nucleic acid sequence, which can be specifically hybridized with the complementary DNA probe. The recognition of analyte DNA is dependent upon the formation of stable hydrogen bonds between the DNA probe and analyte DNA sequence. This is different from the antibody-based biosensors where hydrophobic, ionic and hydrogen bonds play a role in the stabilization of antigen-antibody complex.
- In addition to DNA-DNA hybridization for bacterial detection, the specific hybridization of DNA and complementary RNA was also exploited for the detection of plant viruses such as *Cymbidium mosaic virus (CymMV) and Odontoglossum ringspot virus (ORSV)*