BioElectronics: An Industry Perspective

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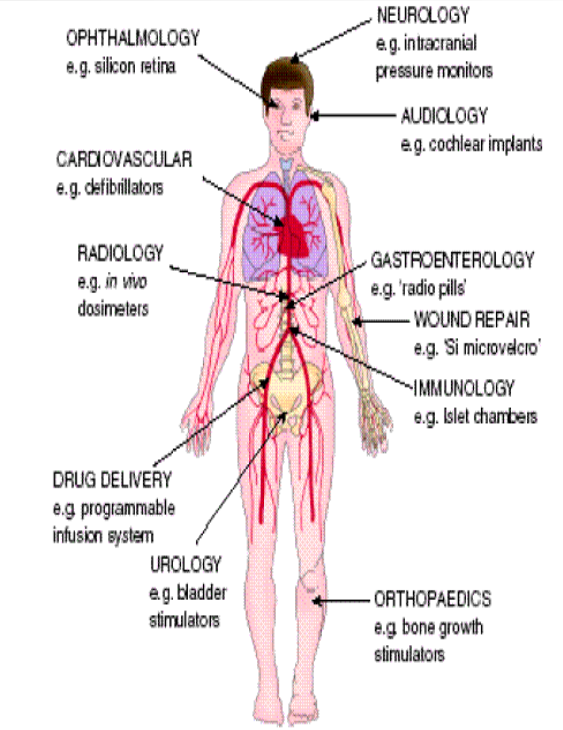
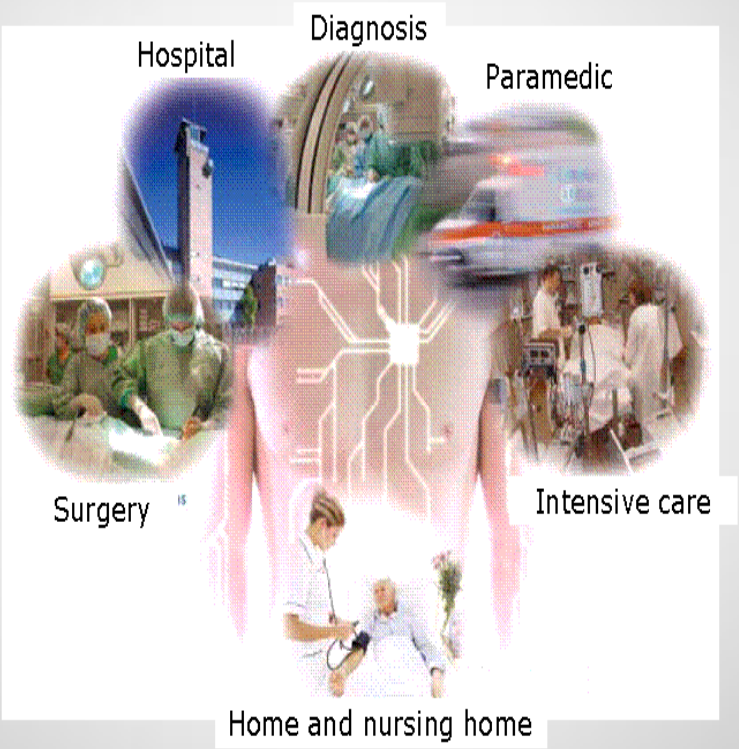
Biosensors Are All Around Us

Within You

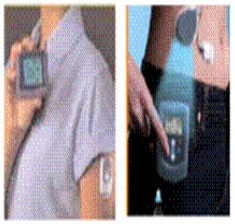
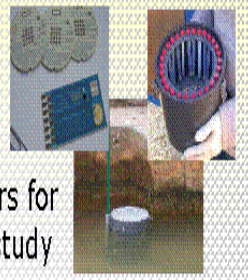


With You



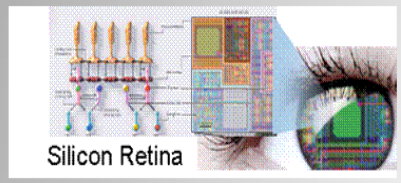
Around You

The Evolution of Biosensor Applications

	Within You	With You	Around You
Present	**Medical Implant**	**Glucose Monitoring**	**Environmental Monitoring**
	 Pacemaker	 Continuous Monitoring	 Sensors for field study
	• First wearable pacemaker developed in 1957 • Today's implantable pacemaker has complex algorithms, inputs, and outputs	• FDA or CE approved, while requiring calibration with reference method (finger sticks glucose monitor) • Monitoring 3-5 days duration • Wireless transmission to carry-on readers	• With miniaturization and network capability • Tracking devices • Bio-Sensing with live microbial for sampling

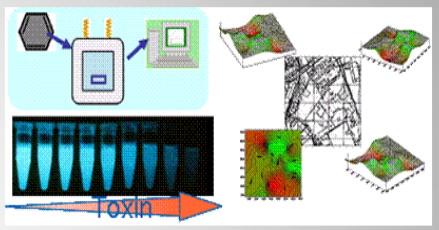
Evolution of Biosensor Applications

Near Future



- Video processor converts image into stimulation pattern with 60 electrode array pulses optic nerve
- Heavily dependent upon microprocessor performance
- Efforts to improve on electrode density, processing, connectivity, and power scheme

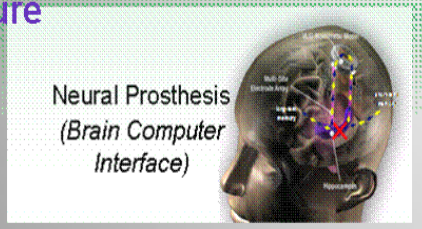
- Non-invasive wrist band device measuring glucose by electro-magnetic resonance with continuous monitoring
- Performance meets FDA standards for accuracy
- Self-calibration



Toxic Site Mapping with Bio-sensing

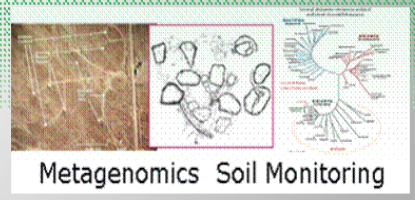
- Synthetic biology designed multi-functional organisms with self-generating energy and sensing capabilities for toxin detection
- With potential to combine with physical sensors, networking and informatics for large scale study

Future



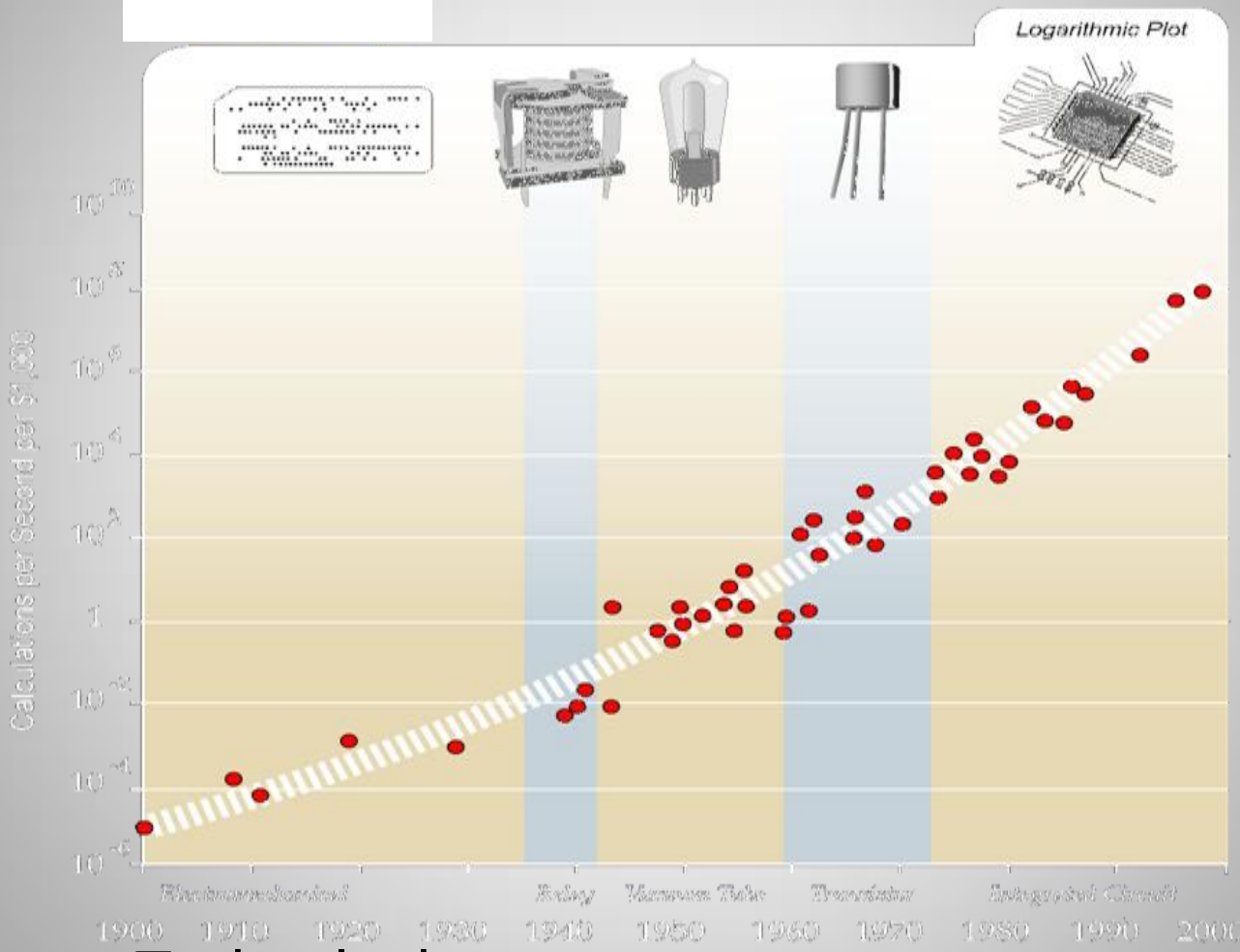
- Speech prosthesis nearing commercial availability
- Powerful computer processor required
- Complex real-time interface

- Nano-robot in blood stream with biochemical sensors of multiple functions
- Nano-power generator allows long-term real-time monitoring



- Comprehensive ecological study (for soil cleanup) with next-generation DNA sequencing tool
- Need for rapid assay processing as well as data processing capabilities

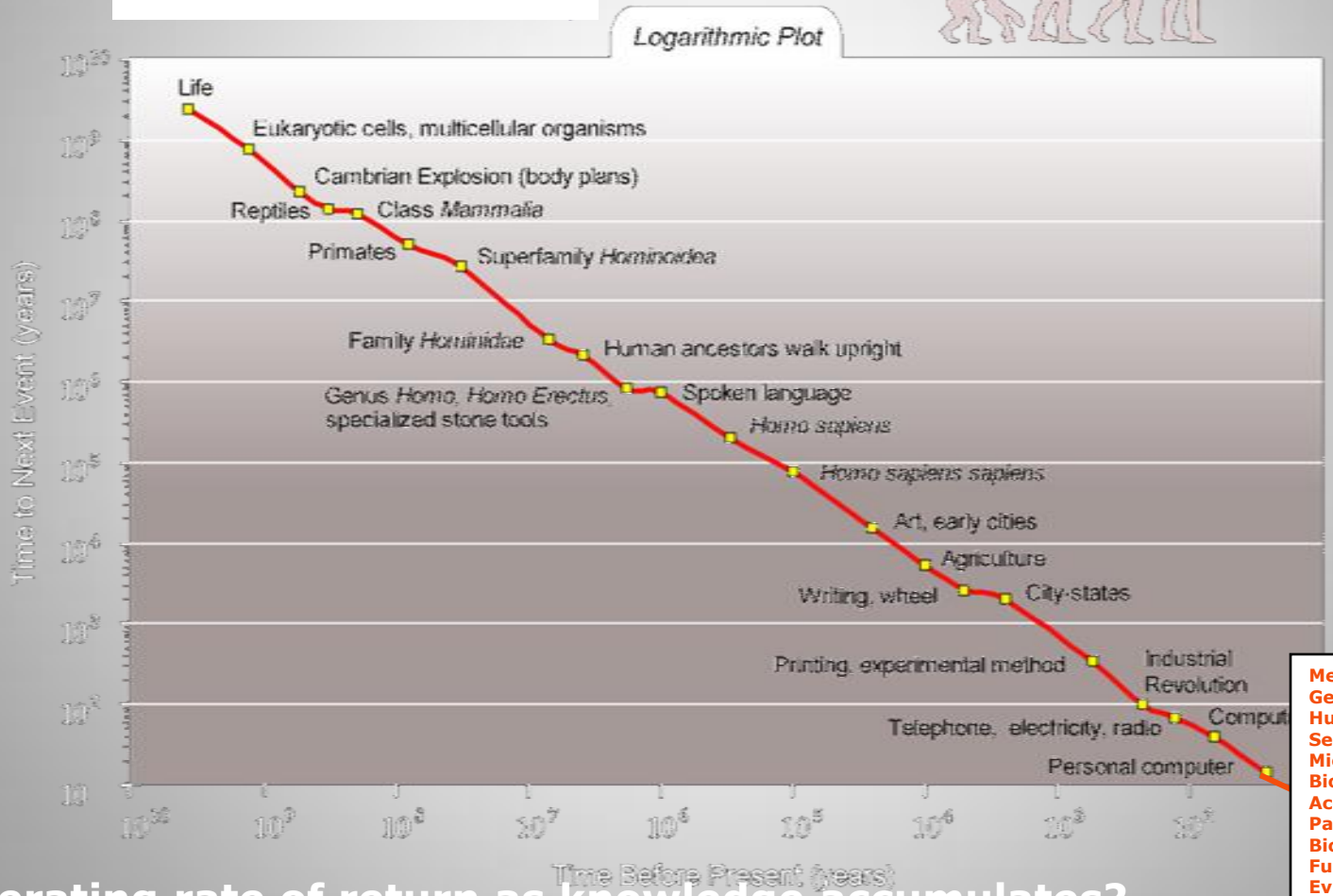
Law of Accelerating Returns
Moore's Law One Example



Information Technologies *(of all kinds)* double their power *(price performance, capacity, bandwidth)* every year

Source: www.KurzweilAI.net

Has Bio Field reached the Critical Mass?



- Medical Implants
- Genomics
- Human Genome Sequenced
- Microarrays/ Biomarker Discovery Accelerates
- Pattern Recognition
- Bioinformatics Rules
- Function Elucidation
- Evidence Based Medicine
- Personalized Medicine
- Neuromorphic Systems

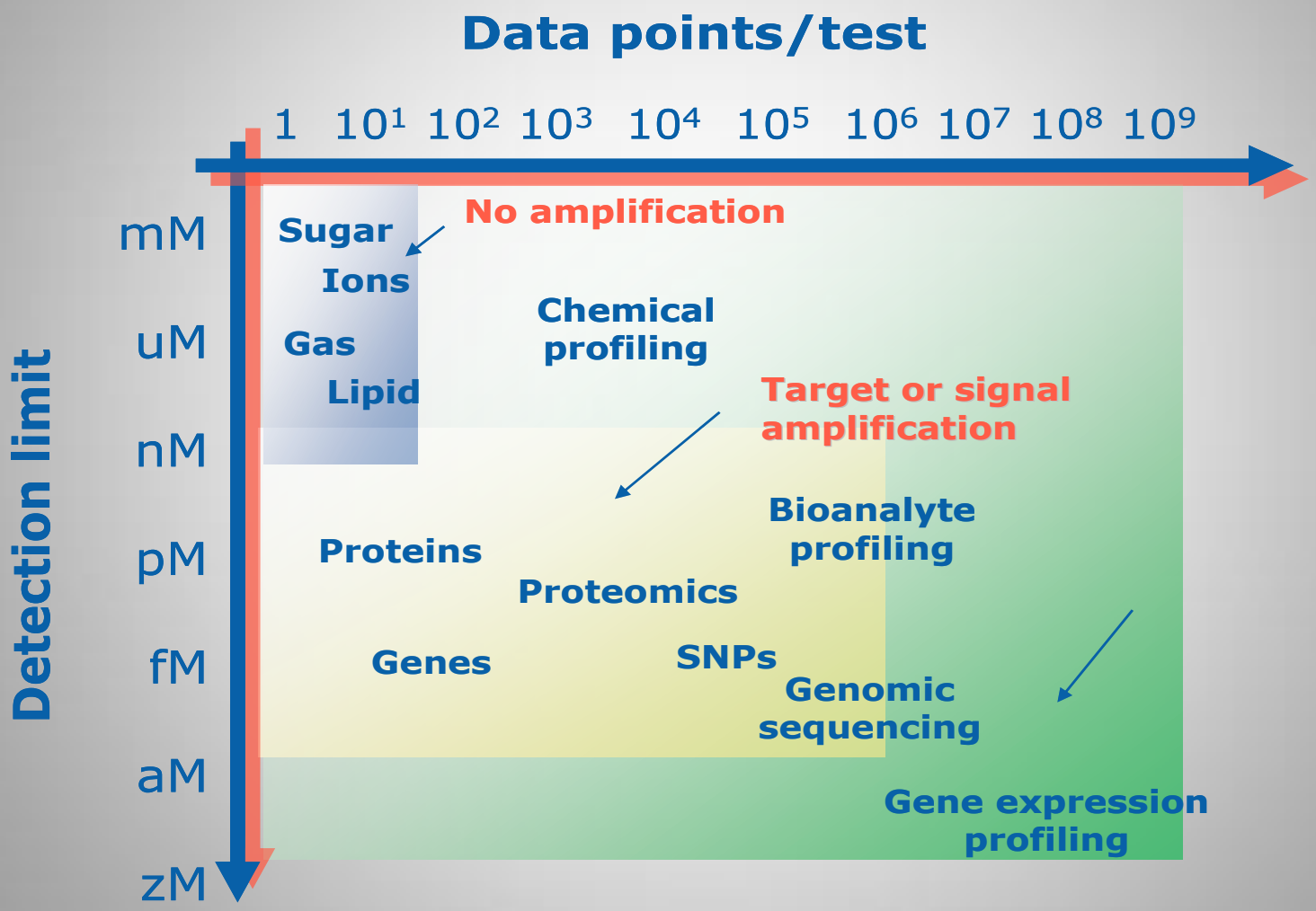
Accelerating rate of return as knowledge accumulates?

Adapted from www.KurzweilAI.net

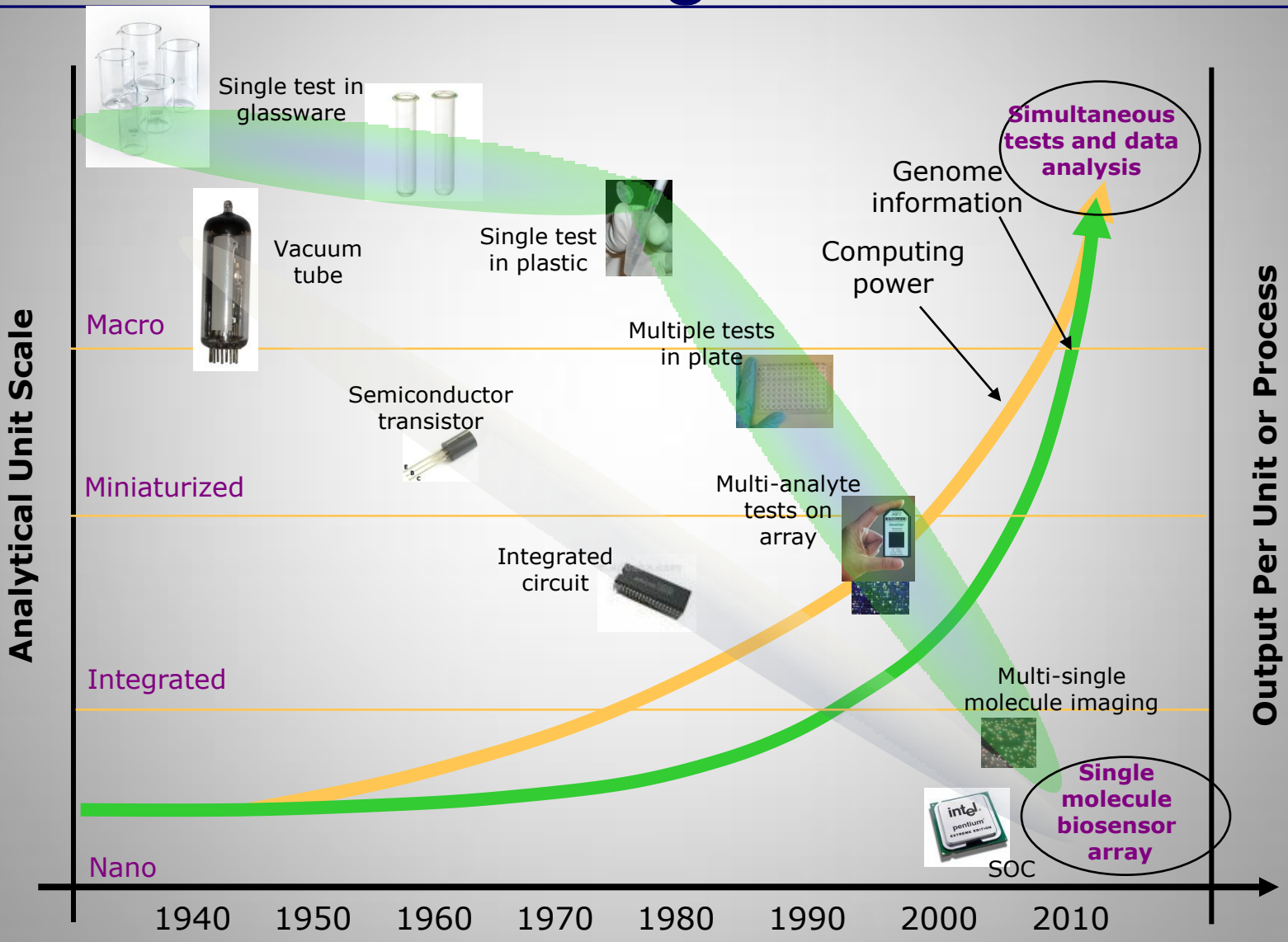
What Is Limiting this Acceleration?

Medical Research & Dx Need: To Type Rare Cells/Analytes In Complex Mixture Eg., HIV, Cancer, or Environmental Agents Etc

Biosensor Application Requirements-



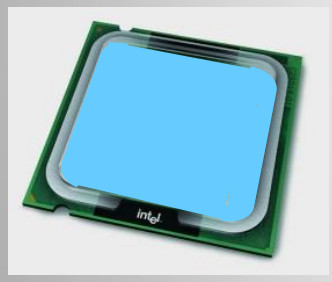
Opportunity for Convergence

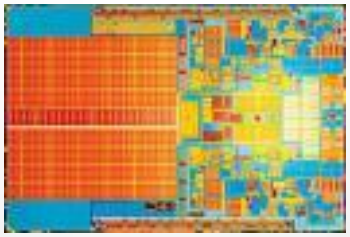


Opportunity at the Intersection of Two Fields

Biomolecules

Results



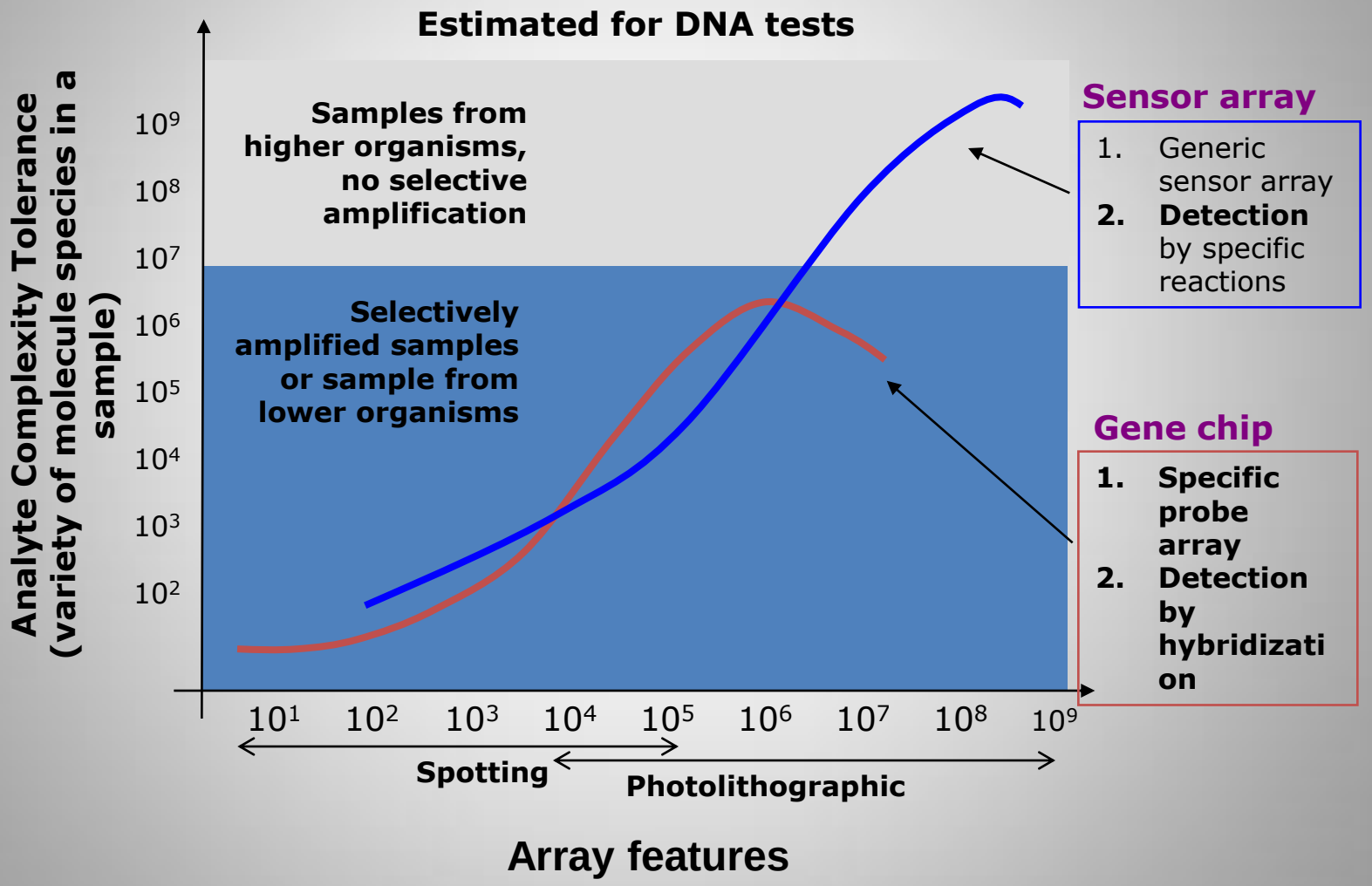


Parallel data collection using biosensor arrays

Rapid data processing and efficient data access

Fast results using parallel computing

Various Array Performance Characteristics

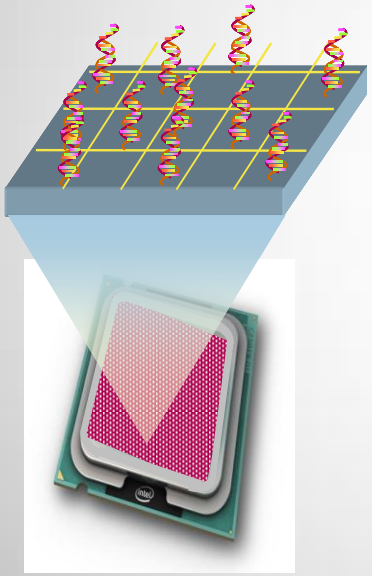


Massively Parallel Sensor Array Platform

Semiconductor-based biosensor platforms will enable personalized medicine and more…

Challenges

- Multiple marker profiling
- Low cost
- High precision/specificity
- High sensitivity
- Rapid test



Approach

Develop a high density silicon sensor array for highly parallel single molecule sensing

Vision

Generate and access analyte information anywhere and any time

Rationale

- Analytes are charged or can be made charged → detectable by semiconductor sensors
- Protein and DNA in nano dimensions → comparable to node dimension of semiconductor technology
- Many individual molecules in a sample→ array of billions of sensors manufactured by semiconductor technology

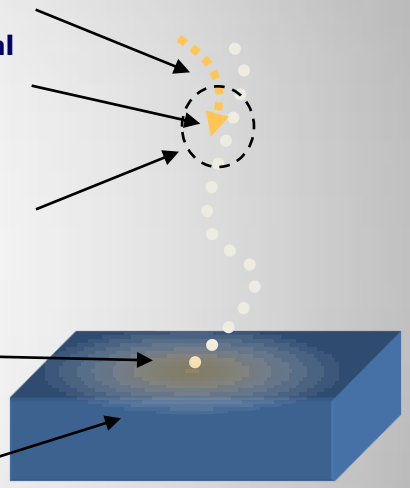
Key Risks

- Signal compatibility
- Reaction specificity
- Signal strength
- Signal diffusion
- Sensor sensitivity
- Sensor/Chem integration
- System/circuitry integration

Electrically detectable chemical species

Sequence-specific Signal

Signal amplification



Signal confinement

Signal detection

Opportunity and Challenges

- **Bio-compatibility: understanding surface interactions at the intersection of biology and silicon**
- **Designing for manufacturability: Compatibility with standard CMOS fabrication methods**
- **Cost/Volumes for intended applications - modularity**