Summary of: Reviewing the state of biosensors and lab-on-a- chip technologies: opportunities for extreme environments and space exploration

Key findings and quantitative results:

1. **Space Exploration and Extreme Environments**: - Space exploration is entering a new golden age with rapid increases in both manned and unmanned missions. - Current practices for chemical and biological compound detection are based on classical analytical methods. - Space missions require in situ real-time analytical measurements under harsh conditions. - Biosensors are emerging technologies suitable for space exploration and extreme environments.

2. **Lab-on-a-Chip (LoC) Nanobiosensors**: - LoC nanobiosensors are miniaturized, portable, and efficient for real-time analysis. - They offer high accuracy, low payload, and real-time capabilities. - LoC nanobiosensors are ideal for applications in space and remote environments.

3. **Key Features**: - Robustness: Sensors and electronics for harsh conditions. - Low cost: Low production and consumption costs. - Real-time capabilities: In situ real-time analysis. - Small form factor: Compact, lightweight, and easy to use.

4. **Examples of Applications**: - **Extreme Temperature**: Monitoring temperature changes in proteins. - **Volcanic Conditions**: Monitoring volcanic acoustic signals. - **Environmental Microbes**: Monitoring pollutants, contaminants, and pathogens. - **Underwater Conditions**: Monitoring marine variables like nutrient content. - **H+ Ion Monitoring**: Monitoring pH changes in extreme environments.

5. **Current Applications**: - **Space Microbiology**: Monitoring microbial persistence on spacecraft. - **Radiation Monitoring**: Real-time monitoring of radiation exposure. - **Health Monitoring**: In situ analysis of astronauts' health.

6. **Future Research Directions**: - **Advanced Materials**: Nanomaterials for improved sensor properties. - **Digitalization**: Digitalization of routine monitoring procedures. - **Automation**: Increased use of point-of-care diagnostics.

7. **Quantitative Results**: - **Cost**: Low production and consumption costs. - **Accuracy**: High selectivity and sensitivity. - **Response Time**: Fast response times. - **Precision**: High precision in real-time analysis. - **Energy**: Autonomous operations in remote environments.

8. **Examples of Quantitative Data**: - **In Situ Analysis**: Real-time analysis of analytes in extreme environments. - **Field Studies**: Data collected in arid environments like the Puna plateau. - **Sensor Performance**: Sensor measurement confirmed by proving to be steady, repeatable, and consistent with theoretical predictions.

9. **Examples of Quantitative Data**: - **In Situ Analysis**: In situ ammonia detection using a gas diffusion cell. - **Field Studies**: Data collected in the field to monitor copper ions directly onto printed strips. - **Sensor Measurement**: Sensor measurement confirmed by proving to be steady, repeatable, and consistent with theoretical predictions.

10. **Quantitative Data**: - **In Situ Analysis**: In situ analysis of analytes in extreme environments. - **Field Studies**: Data collected in arid environments like the Puna plateau. - **Sensor Measurement**: Sensor measurement confirmed by proving to be steady, repeatable, and consistent with theoretical predictions.

This review highlights the key findings and quantitative results of current research on biosensors and lab-on-a-chip technologies, focusing on their application in space exploration and extreme environments.