Monitoring of Animal Research Facilities with Internet of Things (IoT) Sensors

Background

Several industries (eg. pharmaceutical, chemical, cosmetics, and food), universities and government agencies spend tens of billions of dollars each year on animal research and testing. Animal test subjects must be properly housed, fed, cleaned and cared for. Animal housing rooms or vivariums are used for this purpose.

The cost of a single research mouse can be thousands of dollars. With such expenses involved in animal research, it makes sense to ensure your facility is properly equipped to monitor and care for your animals and to ensure that nothing goes awry, jeopardizing expensive research studies.

Maintaining the proper environmental conditions is vital for producing reliable research results. If the environment in the animal housing room is not properly controlled it can adversely impact animal health, compromising months of costly research, ie. is poor animal health a result of the test material or poor environmental upkeep? Thus, it's important for researchers to rule out the effects of environment when monitoring animal health. For this reason, the environmental parameters in animal housing rooms are strictly controlled and monitored.

Problem

- Animal research is expensive.
- Animal studies can take a long time.
- Building Management Systems (BMS) can fail.
- Alarms are often sent to facilities people, not researchers.
- Microenvironments are tough to monitor with a BMS.

Cloud-connected IoT Sensors are the ideal solution

Desired solution

- Monitor Temperature, Humidity, Light.
- Monitor conditions 24/7.
- Alerting during scheduled periods (lights should be out, but are not).
- Send messages to scientists running the studies.
- Small sensors to monitor microenvironments.
- Inexpensive, scalable.
- Unlimited Cloud storage.

What Parameters Should Be Monitored?

Relevant environmental parameters for animal monitoring are summarized in table 1 below.

Sample Parameter	Sample Target	Sample Concerns
Ambient Temperature	Animal housing rooms, cages, food storage	Rooms or cages too hot or too cold? Refrigerated animal food or medicine at risk if temperature is too high?

Sample Parameter	Sample Target	Sample Concerns
Relative Humidity	Animal housing rooms, cages, food storage	Rooms or cages too dry or too humid? Dry animal food at risk of mold or spoilage?
Lighting	Animal housing rooms	Intended light cycles maintained? Or has it been altered or disturbed?

An in-depth view of each parameter is presented below.

Light Levels

Maintaining circadian cycles for laboratory animals is extremely important, especially during behavioral studies. A disruption of circadian rhythms can cause numerous problems that can affect animal safety and jeopardize research integrity.

It's not enough to simply set light cycles and hope for the best. Stories abound about cleaning crews coming in and turning on the lights at night when they are supposed to be off or construction and other changes interfering with light cycles. It's a very inexpensive investment to install light metering that will alert you to an out of spec event. With cyclical data like lighting it's important to be able to set up repeating periods of time when lights should be either on or off and to alarm about different conditions during different periods.

For instance you would typically want to know if lights are on at night when they are supposed to be off. Therefore you would set an alarm between the hours of 6 PM and 6 AM only.
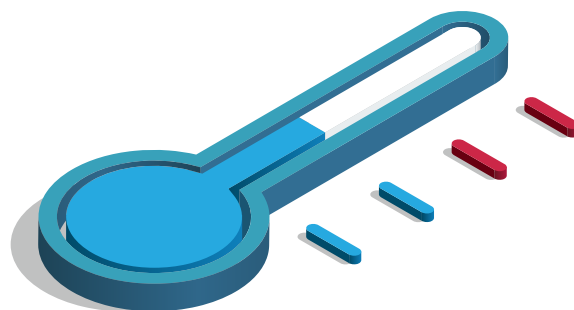
Temperature

Controlling temperature in an animal research environment is of paramount importance. Guidelines for temperature control are found in the Guide for the Care and Use of Laboratory Animals, 8th edition,

Institute for Laboratory Animal Research, National Research Council of the National Academies.

"Maintenance of body temperature within normal circadian variation is necessary for animal well-being. Animals should be housed within temperature and humidity ranges appropriate for the species, to which they can adapt with minimal stress and physiologic alteration. To maintain body temperature under a given environmental temperature animals adjust physiologically (including their metabolism) and behaviorally (including their activity level and resource use)."

If the temperature gets too low, changes to the animal's metabolism and behavior may alter test results in ways that can't be properly accounted for. Furthermore, simply monitoring one point in a large room may not be sufficient. Temperatures can vary considerably within a room due to microenvironments that often exist in animal housing rooms.

Humidity

Humidity is important for all animals, but can be particularly important for amphibians and tropical animals who are accustomed to a high humidity environment.

"Relative humidity should also be controlled, but not nearly as narrowly as temperature for many mammals; the acceptable range of relative humidity is considered to be 30% to 70% for most mammalian species. In mice, both abnormally high and low humidity may increase preweaning mortality (Clough 1982). In rats, low relative humidity, especially in combination with temperature extremes, may lead to ringtail."

Microenvironments

Another reason to monitor animal facilities is because microenvironments can exist within an animal housing room. Light levels can be diffused by cages as you go from the top of the room to the bottom. Temperature and humidity can vary widely depending on the type and number of animals being housed.

It's often not enough to just know the temperature, humidity and light level in one area of a very large room, as provided by Building Management Systems. It's often necessary to know more about the microenvironments throughout the room. This helps pinpoint animal subjects that were exposed to less than ideal environments that could adversely impact their health. So what is the best way to get this information? Installing small IoT sensors, like the Element A, in the microenvironment, such as the cage, allows you to monitor it for any environmental gradients throughout the animal housing room.

Building Management Systems

Building Management Systems (BMS) are often used to control the environment for animal research facilities. These are complex, sophisticated control systems often managed by facilities managers. While robust, they can run into unforeseen problems, like equipment failures, power issues, or unintended human intervention such as, the cleaning crew turning lights on and off. To mitigate against such unforeseen circumstances, doesn't it make sense to have redundant sensors to ensure that optimal conditions are maintained in animal housing rooms? A simple mistake or blown circuit can put months of research at risk. It would be nice to have a second check on environmental conditions to make sure that your animal housing rooms are under control.

Another challenge related to a BMS is access to environmental data. Usually, Building Management Systems are controlled and monitored by the facilities manager. This means that scientists conducting high-stakes research with animal subjects may not be granted access to environmental data or be alerted when environmental conditions deviate from optimal conditions for animal health. Under these circumstances, an independent, wireless monitoring system could be the best choice for scientists to gain access to the environmental data relevant to their studies.

Alternatively, if a facility does not have a Building Management System, scientists are likely responsible for monitoring animal housing rooms with the tools of their choice. Under these circumstances, a wireless IoT monitoring system could be the best choice for monitoring the environment.

Regardless of whether a facility has a Building Management System, an independent monitoring system, whether primary or secondary, is a valuable addition to an animal housing facility. Benefits include automated data collection through IoT technologies, secure yet facilitated access to environmental data, and a backup system in case of issues with the Building Management System.

Whether or not a facility has a Building Management Systems, scientists can still take the data into their own hands and ensure their studies are properly controlled.

The Ideal Solution: Enviromental Monitoring with IoT Sensors

We've already established there are many good reasons for monitoring environmental conditions of animal research facilities with independent systems, but what is the best approach to implementing this? You want a system that is reliable, runs continuously with minimal intervention, stores large amounts of information, alerts you to out of spec conditions and costs far less than a full blown Building Management System. The solution is to use cloud-connected Internet of Things sensors, like the Element A and Element T. Element A measures four environmental parameters - temperature, light levels, relative humidity and pressure, while Element T measures temperature of an environment or a laboratory asset, such as a refrigerator, freezer, oven, or incubator.

These sensors continuously measure and transmit the data to the Elemental Machines Cloud via a gateway. Data stored in the Cloud can be accessed on the Elemental Machines dashboard anytime or any place you have an Internet connection. Users can set up alarms to alert them of any out of spec conditions. For instance, if a refrigerator storing test medicine should get too warm or if someone leaves the door open, the system can send a text message alarm to the laboratory operations team alerting them to this out of spec condition so they can take action before any test medicine is compromised.

Likewise, if the environment is supposed to be dark at night for animal subjects you can set an alarm between the hours of 7 PM to 7 AM to be notified of any changes in the lighting conditions. For instance, if the lights are turned on by the cleaning crew or someone else during this time frame, you can get an alert about this condition.

Conclusion

An IoT-based environmental monitoring system can be a useful asset to many animal housing facilities, regardless of whether they have Building Management Systems, an independent system can serve as a backup in the event of equipment failures, human errors, or power failures. Additionally, an independent IoT-based system can offer secure access to animal housing room environmental data. Lastly, independent IoT monitoring systems can provide greater insight into environmental gradients within a room as compared to a BMS. With so many advantages, it only makes sense to have an independent or backup monitoring system for your animal testing facilities. Small, scalable, wireless IoT sensors are the perfect system for continuously monitoring and alerting in animal research facilities.

References

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