**1. Standard Light Microscope with Staining**

* **Cost**:
  + Light microscope: **$50–$400**
  + Staining materials (e.g., Gram stain, methylene blue): **$10–$30**
* **What It Does**:
  + Allows you to observe **bacterial morphology** (shape, size, arrangement).
  + Stains like **Gram stain** differentiate between **Gram-positive** and **Gram-negative** bacteria.
  + **Methylene blue** helps make bacteria visible.
* **What You Get**:
  + General **morphology** of bacteria.
  + Doesn’t show live vs. dead cells unless using specific viability stains.
* **Limitations**:
  + No information on **stress responses** or **cell viability** without additional staining.

**2. Phase Contrast Microscope**

* **Cost**:
  + Phase contrast microscope: **$300–$2,000**
* **What It Does**:
  + Enhances the **visibility** of transparent specimens like bacteria.
  + Works without staining, making it great for observing **live cells** in real-time.
* **What You Get**:
  + Can observe **live bacteria**, their **movement**, and **growth**.
* **Limitations**:
  + Cannot differentiate between **live** and **dead** cells.
  + Expensive compared to a standard light microscope.

**3. Colony Counting**

* **Cost**:
  + **Agar plates**: **$10–$30**
  + **Incubator**: DIY for **$20–$50** or commercial one for **$100–$300**
* **What It Does**:
  + Grow bacteria on agar plates, then count the number of **colonies** formed.
  + Estimates **bacterial survival** and **growth**.
* **What You Get**:
  + **Quantitative data** on bacterial **viability** (how many bacteria survived).
* **Limitations**:
  + Requires time for bacteria to grow into colonies.
  + No **real-time** data and doesn’t show **live** vs. **dead** cells unless combined with viability stains.

**Summary:**

* **Light Microscope with Staining** is affordable but lacks live/dead differentiation.
* **Phase Contrast Microscope** offers enhanced viewing of **live bacteria** but is more expensive.
* **Colony Counting** is the cheapest way to measure **bacterial survival**, but it doesn’t provide real-time results or live/dead status without extra methods.

**Main Problem:**

You are studying **bacterial survival** in the context of a **weather balloon** experiment, and the main challenges are:

1. **Bacterial stress** (How bacteria survive harsh conditions).
2. **Survivability assessment** (How to track survival and stress markers).
3. **Budget limitations** (Trying to avoid costly equipment).

**Key Equipment Needed:**

1. **Microscope**:
   * **Standard Light Microscope**: Allows for **morphology observation** but **no live/dead differentiation**.
   * **Phase Contrast Microscope**: Enhances visibility of live cells without staining, but can be more expensive.
   * **Fluorescence Microscope**: Best for tracking **live/dead cells** and **stress markers**, but **expensive**.
2. **Incubator**:
   * Required to **sporulate bacteria** or maintain ideal growth conditions.
   * A **DIY incubator** can be made with simple materials (**$20–$50**).
   * A small commercial incubator costs around **$100–$300**.
3. **Bacterial Stains**:
   * **Gram stain**, **Methylene blue**, or **Viability stains** for differentiating between **live** and **dead** cells.

**Methods for Assessing Bacterial Survivability:**

**1. Standard Light Microscope with Staining**

* **Cost**:
  + **Microscope**: **$50–$400**
  + **Staining**: **$10–$30**
* **What It Does**:
  + Observes bacterial **morphology** (shape, size, arrangement).
  + Stains (e.g., **Gram stain**) help differentiate bacteria.
* **Limitations**:
  + Does **not** differentiate **live** vs. **dead** cells without additional stains.

**2. Phase Contrast Microscope**

* **Cost**:
  + **$300–$2,000**
* **What It Does**:
  + Enhances **visibility** of **live** cells without staining.
  + Great for observing **cell movement**, **growth**, and general morphology.
* **Limitations**:
  + Cannot differentiate **live** vs. **dead** cells.
  + More expensive than a standard microscope.

**3. Colony Counting**

* **Cost**:
  + **Agar plates**: **$10–$30**
  + **Incubator**: DIY (**$20–$50**) or commercial (**$100–$300**).
* **What It Does**:
  + Grow bacteria on **agar plates** and count colonies to estimate **bacterial survival**.
  + A **simple and inexpensive** method for assessing **viability**.
* **Limitations**:
  + No **real-time** data (you have to wait for colonies to grow).
  + **No live/dead differentiation** without additional viability tests.

**Fluorescence Microscopy (For live/dead analysis)**

* **Cost**:
  + Typically **expensive** (a few thousand dollars).
* **What It Does**:
  + Uses specific dyes or markers to differentiate **live** vs. **dead** cells based on **fluorescence**.
  + Tracks **stress responses** and **cell viability**.
* **Limitations**:
  + **Cost** may be prohibitive, and specialized training is required.

**Cost Summary:**

* **Standard Light Microscope**: $50–$400
* **Phase Contrast Microscope**: $300–$2,000
* **Fluorescence Microscope**: Several thousand dollars
* **Bacterial Stains**: $10–$30
* **DIY Incubator**: $20–$50
* **Commercial Incubator**: $100–$300
* **Agar Plates**: $10–$30