# Principles of Biological Assay

Student Report

Based on D. J. Finney (1947)

**Abstract**

This report summarizes the key ideas from Finney's 1947 paper *The Principles of Biological Assay*. It explains what biological assays are, why statistical methods are crucial, and how dose–response relationships can be analyzed. The focus is on concepts a student can understand and apply, rather than the full technical details of the original article.

## 1 Introduction

A **biological assay** is a method of estimating the potency of a substance (drug, vitamin, poison, etc.) by observing the response of living organisms. For example, comparing how two insulin samples affect the blood sugar of rabbits is a biological assay.

Biological assays are needed when chemical analysis is not sufficient or when the actual biological effect is more important than the pure chemical amount. The key problem is *how to measure potency reliably and precisely.* Here statistics play an essential role.

## 2 Dose–Response Relationship

A biological assay depends on the relationship between **dose** and **response**. Suppose a subject receives dose $z$ of a substance, and the average response is $U$. Mathematically we can write:

$$E(u) = U = F(z)$$

where $F(z)$ is a function describing how the response depends on the dose.

For a valid assay:

- $F(z)$ must increase as $z$ increases (Condition I).
- The test preparation should behave like a diluted version of the standard (Condition II).

If both standard ($S$) and test ($T$) preparations are given, then:

$$U_S = F(z), \qquad U_T = F(pz)$$

where $p$ is the **relative potency** of the test compared to the standard.

# 3 Estimation of Potency

The main statistical problem is to estimate $p$. By transforming the dose scale, the dose–response curve can often be made linear. For example:

$$y = \alpha + \beta x$$

where $x$ is a transformed dose (like $\log z$) and $y$ is a transformed response.

## 3.1 Quantitative Responses

If the response is measured on a continuous scale (e.g. weight, acidity, blood sugar), linear regression is used. For two preparations:

$$Y_S = a_S + bx, \qquad Y_T = a_T + bx$$

Relative potency is:

$$\log R = \frac{a_T - a_S}{b}$$

## 3.2 Quantal Responses

In some cases the response is "all-or-nothing" (alive/dead, cured/not cured). We then measure the proportion responding at each dose. Transformations such as **probits** or **logits** are used to make the dose–response curve linear.

For example, with logits:

$$\operatorname{logit}(P) = \log \frac{P}{1-P} = \alpha + \beta \log z$$

# 4 Example: Synthetic Data

Table 1 shows an example dataset comparing the responses to different doses for a standard and a test preparation.

| Dose (mg) | Standard Response (%) | Test Response (%) |
|---|---|---|
| 0.1 | 8 | 12 |
| 0.2 | 15 | 22 |
| 0.5 | 35 | 45 |
| 1.0 | 60 | 70 |
| 2.0 | 80 | 88 |
| 5.0 | 95 | 98 |

Table 1: Synthetic dose–response data for a biological assay.

The corresponding dose–response curves are shown in Figure 1.

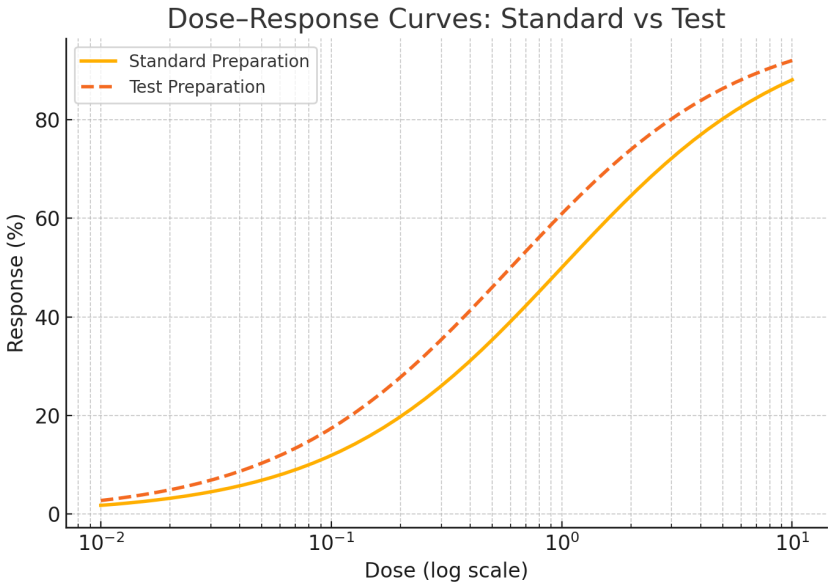


Figure 1: Example dose–response curves for a standard preparation and a test preparation. The relative potency is estimated by comparing the horizontal shift between the two curves.

# 5 Design of Assays

Good assay design is essential:

- Use multiple dose levels (at least 3 per preparation) to test linearity.
- Spread doses over the expected range of responses (not only extreme values).
- Balance the number of test subjects between standard and test samples.

The simplest design is a "four-point assay" (two doses of standard, two doses of test). This is efficient, but may not check linearity. Adding more points reduces efficiency slightly but provides stronger validity checks.

# 6 Conclusion

Biological assays combine biology with statistics. The central idea is comparing dose–response curves of a test substance against a standard. With correct design and analysis, assays can provide precise and reliable estimates of potency, whether the response is measured quantitatively or as an all-or-nothing outcome.