Phenomena in nature are often complex and are influenced by many different factors. Systematic investigations in form of scientific studies are conducted to understand and describe their interrelationships which lead to their expression. For this purpose, scientists use specific strategies and study designs so that they exclude perturbating factors and arrive at an evidence-based result.

1. Descriptive Study Designs

Descriptive study designs are scientific observations, that means they include **observing**, **measuring**, and **describing** of phenomena without any kind of intervention. These are often used when a natural behaviour without artificial influences is to be scientifically investigated. In general, you can distinguish between four different descriptive study designs:

Longitudinal
Cross-sectional
Mixed longitudinal
Time-lag

2. Experimental Study Designs

The goal of an experiment is to determine **the influence of one of the independent variables** by changing it while keeping the other independent variables as **controlled** and **constant** as possible. The change in the dependent variable is then measured and a statement about the influence of the independent variable on the overall system can be obtained.

With scientific experiments, a few basic principles must be followed:

Quality requirements

There are many different types of experimental setups and study designs in science. These differ in their applicability and quality. Here, we want to give you a quick overview over them. We will explain the different designs to you by means of an example study, so that the differences become clear. Starting with the simplest design, we will then move over to more complex, but higher quality ones.

Example hypothesis:
"The maximum power output during cycling is higher with a 60° hip angle than with a 50° hip angle"
With this hypothesis, we get one independent variable with two levels (L1: 60° hip angle and L2: 50° hip angle) as well as one dependent variable (DV: maximum power output).

In science, however, there is often not only one independent variable, but several, which do not simply affect the dependent variable in isolation, but also have interaction effects. If we come back to our bicycle example, another independent variable would be the saddle height for example, which of course also influences the hip angle as well as the maximum power output. If you would now perform two isolated experiments on both variables, you would simply ignore the interaction both of them. To avoid this, so-called factorial experiments are carried out.

In our example we have two independent variables, which are also called factors (hip angle and saddle height) with two levels each (hip angle: 60° and 50° hip angle; saddle height: 85% leg length and 95% leg length):

	L1	L2
F1: Hip angle	60°	50°
F2: Saddle height	85% leg length	95% leg length

In factorial experiments, all factors are measured at all levels. The number of individual measurements thus results from the number of factors (n) and the number of levels (k): k^n. In our case it is as $2^2 = 4$. Here, usually a Randomized Trial Design is selected, so that the sample is split up randomly into k^n groups.

3. Randomization

As mentioned several times in this article, subjects are often randomly assigned to individual experimental groups. This minimizes the differences between those groups by distributing persons with certain characteristics equally by use of the probability theory. Thereby, unbiased measurements are possible, and blinding will be facilitated. Also, the statistical power increases by randomization. A general distinction is made between three different types of randomization:

1. **Simple**
   The simple randomization is an intuitive procedure such as coin tossing and is therefore also called **coin randomization**. Hereby, selection and allocation biases can already be excluded. Especially in small studies, however, it may happen that group sizes differ a lot due to random allocation. The larger the sample, the higher the probability that the groups are of equal size.

2. **Restricted**
   The restricted randomization method serves the purpose of keeping the group sizes equal. It is also called **permuted-block randomization**. Here, the block size and

allocation ratio are given, and the randomization happens within these boundaries.

3. **Adaptive**
   The adaptive randomization serves the purpose of keeping group sizes equal as well. In contrast to the restricted randomization, there are no fixed boundaries. Rather here, the probability of being assigned to a group is constantly adapted. That means, it decreases if the group is overrepresented and increases if the group is under-represented. Therefore, it is called **adaptive biased-coin randomization**.