



What are *In vivo*, *In vitro*, and *In silico* Studies?

In vivo means in a complete living animal. Studies in both humans and animals are called in vivo studies. In vivo studies are usually done after *in vitro* safety studies in order to make sure that living people or animals will not be harmed. If a chemical does great harm in vitro to cells, tissues and organs, caution must be applied in follow-on studies with living humans and animals. One result of in vivo animal studies is to find safe, and effective, doses of medicines that can be used to treat people and animals. These safe doses are called “no adverse effect” doses. In vivo studies are also performed to look for harmful effects of low-doses of chemical substances, both natural and non-natural.

In vitro is a term that has two meanings; 1) In glass, and 2) Outside of a living body. The second meaning is generally used by scientists, because experiments outside of the body need not be conducted using glass (such as glass slides, jars and other equipment). When “in vitro” is used to describe a study, it means that the study is not performed on complete living organisms. Studies using chemicals, cells, tissues and even functioning isolated organs are classified as in vitro. In vitro studies are important because they provide important information, and they cannot harm living humans or laboratory animals. They are important for studying how living organisms work and how medications, heat, light, radiation and other factors might affect people and animals. In vitro research has limitations because it does not include all of the complexity and inner coordination of organs in a living body.

In silico translates as “in silicon”. Silicon is a chemical element used in making computers, so “in silico” describes research that uses computers instead of living subjects (*in vivo*) or isolated cells, tissues and organs (*in vitro*). Much new scientific knowledge is obtained using computer models, but such knowledge is limited because computer models can’t fully capture the vast complexity and variety of living things. An example of in silico research is climate modeling. Climate models include mathematical equations that describe events that control the Earth’s temperature. These events include the heat provided by the sun and how it warms the air, the oceans, and the land areas. In silico studies can also model some of the functions of cells, organs animals and people. However, the results of in silico studies must be verified in the real world. In silico studies are also called “simulations” of the real world.