tains germs of cholera, we can have its chemical analysis done by Experiment and verify whether our hypothesis is true or not.

Indirect verification is *verification by deduction.* We deduce, as accurately as possible, all the consequences which logically follow from our hypothesis, and then compare the deduced consequences with actual facts. In other words, we expect that such and such consequences should follow if our hypotheses were true. If those consequences are actually there, the truth of the hypothesis is verified ; and if they are not there, the truth of the hypothesis is overthrown. Thus, indirect verification does not depend on direct observation or experiment, but on a *roundabout way* of deducing consequences from the supposed hypothesis and then seeing their agreement or disagreement with facts.

We depend on indirect verification where direct observation and experiment are out of the question.

Proof of Hypothesis.

We must distinguish between the *verification* of a hypothesis and its *proof*. Verification is not complete proof but a stage on the road to proof. If the consequences deduced from a hypothesis tally with facts, the hypothesis is confirmed or verified, but not yet proved. To prove a hypothesis is a step farther than verification. In order to be *proved* or *established*, a hypothesis must stand as the *only* hypothesis, excluding all rival hypotheses which are in the field. So long as this condition is not fulfilled, a hypothesis cannot be regarded as *proved*. Clifford writes : "In order to make sure that your supposition is true, it is necessary to show not merely that that particular supposition will explain the facts, but also that no other one will." The proof of a certain hypothesis requires the disproof of all other hypotheses, and verification alone cannot guarantee this requirement. A verified hypothesis can be symbolically represented as:—

If A, then X

X

No conclusion.

Thus, verification which is logically like the affirmation of the consequent in a hypothetical reasoning is no proof unless it can be shown that no other hypothesis can explain the fact in question. Not only do we require that X should follow from A but also that it should follow *only* from A and from *none else*. It is only then that the hypothesis A will be *proved* as an explanation for the fact X. Thus, a hypothesis is proved or established only after the exclusion of all other proposed hypotheses. When Kepler rejected nineteen hypotheses before accepting a valid one, namely, that Mars moves in an ellipse, he was reasonably justified in regarding this hypothesis as not only *verified* but *proved*. To take a simple example : if my watch is stolen, my suspicion may lie on A, B and C. If on investigation, the watch is found in the possession of A, then one of my hypotheses is confirmed but not finally proved. Further investigation may show that B was the real thief and that he had sold the stolen watch to A. Now, the hypothesist hat B is the culprit is *proved* and the remaining two hypo-

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theses are then given up. Of course, no hypothesis can be proved unless it is confirmed ; but from this it does not follow that if a hypothesis is confirmed, it is also proved.

A hypothesis which is proved to be true may explain more facts than those for which it was originally invented. This is called the ***extension of hypothesis***, and is a great test in its favour. For example, if in a certain theft the stolen property is recovered from a person, the supposition is that he is a thief. Now this supposition will be proved to be true if some other thefts are also recovered from the same person. To take examples from the realm of science : gravitation which was devised first to explain the movements of heavenly bodies was extended later on to other facts, until it came to be universally applied to matter. Similarly, Drawin's Theory of Evolution was in the beginning intended to explain the origin of species, but now its application has been extended to the origin of social institutions, forms of government, and even the formations of the solar and stellar systems. Of such extension of hypotheses the history of science is rich in instances. Nature is a harmonious system, and the more a hypothesis tends to be in harmony with not only the facts which it undertakes to explain but also with facts in other departments of nature, the stronger will be the evidence in favour of its truth.

To sum up: a hypothesis, in order to be proved, must be *verified*, must be *the only hypothesis* to explain the facts in question, and must also be *in harmony with facts or laws in other spheres of Nature.*

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Crucial Experiments :-

Crucial Instance.

Generally, many hypotheses seem to explain the phenomenon under investigation. In such a case, we have to decide as to which of the rival hypotheses is the true one. This is done by means of a crucial instance (*Instancia Crusia*). A crucial instance is an instance or a fact which can be explained only on *one* of the several hypotheses, and which, therefore, decides the conflict between them. Its function is to prove *one* hypothesis as valid and to negative all others as invalid. The term "crucial" comes from the Latin *crucis* or *crux* which means *a cross*, a finger-post which is generally put up at the crossings of roads to indicate the right way to be taken. A crucial instance thus is a fact which enables us to choose the right hypothesis and to leave the wrong ones. Hence it serves a very important function. "One single circumstance, which admits of one explanation *only*, is more decisive than a hundred others which agree in all points with one's own hypothesis, but are equally well explained on an opposite hypothesis." (Ueberweg.)

We may obtain a crucial instance by Simple Observation or by Experiment. Let us make this clear by means of examples. Suppose A, B and C are suspected to be the murderers of X. Now, if observation shows that A and B were both lying in hospital as patients and were not in a condition to move at the time when X was murdered, then this crucial fact will rule out the hypothesis that they are the murderers. And that C was caught red-handed is a crucial fact which conclusively proves that *he* is the murderer.

When a crucial instance is obtained by Experiment, we have an *Experimentum Crucis* or a *Crucial Experiment*. Suppose there is a case of fever and that it is differently diagnosed as typhoid and malaria. Now, if experimental examination shows the presence of malaria germs in the blood of the patient, it will be a crucial experiment favouring the acceptance of the diagnosis that it is malaria and the rejection of the diagnosis that it is typhoid. Let us take an example of an *experimentum crusis* from the science of Physics. In Physics there was a conflict between the Corpuscular or Newtonian theory of light and the Undulatory or Wave-theory of light. According to the Undulatory theory, light moves with a greater velocity in a rarer medium than in a denser one. The Corpuscular theory, on the contrary, maintained the reverse of it, *i.e.*, that light moves with a greater velocity in a denser medium than in a rarer one. Fizeau and Foucault made an experiment on the velocity of light in air and water, and found that light travelled faster in air than in water. Now, this was a crucial experiment which favoured the acceptance of the Undulatory theory and the rejection of the Corpuscular theory of light.

To sum up : a crucial instance serves as a decisive factor between the rival hypotheses.

Development of Hypothesis.

It is clear from what has been said above that a hypothesis has to pass through several stages of development before it can be accepted as valid. We may note the following stages in the development of a hypothesis :—

First Stage.—To begin with, a hypothesis is a *provisional supposition* suggested by a preliminary survey of facts. It is just the starting point of inquiry. To quote Mill once more, it is *any supposition which we make either without actual evidence, or on evidence avowedly insufficient*. Obviously, at this stage the hypothesis possesses very little probability.

Second Stage.—If this provisional supposition *works* and gathers some evidence in its favour, it passes on to a higher stage of probability and becomes what is called a *working hypothesis*. Though *partially verified*, a working hypothesis is indispensable for further advance in our investigation. It is assumed as a convenient guide to inquiry and is held subject to revision, modification and even rejection in the light of subsequent investigation. "To work well, a hypothesis must be both resourceful and fruitful... To be resourceful, it must be rooted in a reasoned system or science. To be fruitful, it must be capable of continually extending its sphere or verification, and of bringing more and more facts under scientific control." (Gibson.)

Third Stage.—Many working hypotheses usually suggest themselves at the same time to be equally good. Selection has then to be made by an appeal to facts. If on trial, a working hypothesis is verified and confirmed, it becomes a *legitimate hypothesis*. At this stage, a hypothesis gets pretty strong because it is supported by facts.

Fourth Stage.—When a legitimate hypothesis *proves* itself as the *only* tenable hypothesis, it

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reaches the stage of validity and is called a *valid* or *scientific hypothesis*. At this stage, a hypothesis becomes a *Law* or *Theory*. We must, however, add that this stage of absolute validity and proof, no longer open to question, is only an *ideal* which may be *realized more and more*, but about which we can never be certain that it has been *fully realized* by a hypothesis. Our knowledge is always growing in its scope and contents, and every advance in it necessitates a revision of our previously accepted hypothesis.

Kinds of Hypothesis.

As the aim of a hypothesis is to explain certain phenomena, it is essentially explanatory in character. But a *distinction* is sometimes made between *explanatory* and *descriptive* hypothesis. A hypothesis is said to be explanatory when it accounts for the facts which it seeks to explain *by finding out their cause*. If, for example, a hypothesis attempts to explain the failure of a strike by pointing out its cause, it will be an explanatory hypothesis. A descriptive hypothesis accounts for facts *by simply describing the manner in which they happen*. If, for example, our hypothesis tells the way in which the strike started, developed and failed, it will be a descriptive hypothesis. Thus, a descriptive hypothesis simply tells us *how* a phenomenon happens, while an explanatory hypothesis also tells us *why* it happens as it does. The former simply describes what is, and the latter, what must be and why it must be. But we should not think that there is any opposition between the two. When a descriptive hypothesis describes the way in which