Phenotype v. Genotype: Why Identical Twins Have Different Fingerprints

By Edward P. Richards, J.D., M.P.H., Professor of Law, UMKC School of Law

The last decade of forensic science has been dominated by genetic analysis. Lawyers now focus on DNA testing to prove the guilt or innocence of those accused of crimes, pushing traditional techniques such as fingerprint analysis into the background. Ironically, however, fingerprint analysis could be used to solve a key conundrum of genetic analysis — how do we tell about identical twins?

Identical twins develop when a single fertilized egg splits in two, leading to two embryos. Because they both came from the combination of the same egg and sperm, they have identical DNA, barring the generally undetectable micromutations that begin as soon as cells start dividing. To a standard DNA analysis, they would be indistinguishable. Yet the parents of twins can usually tell them apart by subtle visual cues, and, while their fingerprints are generally similar, they are not identical.

Fingerprints and physical appearance in general are part of an individual's phenotype, which arises from the interaction of the individual's genes and the developmental environment in the uterus. In the case of fingerprints, the genes determine the general characteristics of the patterns that are used for fingerprint classification. As the skin on the fingertip differentiates, it expresses these general characteristics. However, as a surface tissue, it is also in contact with the amniotic fluid in the uterus. The fingertips are also in contact with other parts of the fetus and the uterus, and their position in relation to uterus and the fetal body changes as the fetus moves on its own and in response to positional changes of the mother. Thus the microenvironment of the growing cells on the fingertip is in flux, and is always slightly different from hand to hand and finger to finger. It is this microenvironment that determines the fine detail of the fingerprint structure. While the differences in the microenvironment between fingers are small and subtle, their effect is amplified by the differentiating cells and produces the macroscopic differences that enable the fingerprints of twins to be differentiated.

More generally, the environment in the uterus affects the phenotypic development of all parts of the twin fetuses. Thus, despite an identical DNA structure of the two fetuses, a very careful examination of other physical characteristics will show that twins are systematically different, although those differences may be too subtle to detect without careful measurement. This process of differential development continues throughout life. As twins age, they diverge more and more, and in middle and old age will look more like non-identical twins.