# Touch DNA. What is it? Where is it? How much can be found? And, how can it impact my case?

*A question and answer guide to all things touch DNA*

*by Suzanna R. Ryan, MS*
*Ryan Forensic DNA Consulting*
*January, 2012*

With the technology of today, the simple act of picking up an object or touching a surface can lead to the identification and apprehension of a criminal. In the world of the forensic DNA analyst, the analysis of "touch" DNA samples is no longer the exception to the rule, it is the norm. In the past few years, not only have the number of touch DNA evidence items being submitted to the lab for analysis skyrocketed, but the number of journal articles regarding touch DNA and DNA transfer (both primary and secondary) have also increased greatly. This article is intended to update the reader on the latest touch and transfer DNA research and attempts to answer some of the most common questions that are asked regarding the topic.

### *What is "touch" DNA?*

First, a review of what touch DNA is and how it arrives on an object. Touch DNA is simply DNA that is transferred via skin cells when an object is handled or touched. The average human sheds roughly 400,000 skin cells per day (Wickenheiser, 2002); however, since it is known that the top-most layers of skin are basically "dead", being keratinized and having lost their nuclei (Kita, et al 2007), where does the touch DNA come from? Kita, et al, performed experiments which showed that small amounts of fragmented DNA is present on the surface of the skin and they theorized that these fragments of DNA may be constantly sloughed off the keratinized cornified layer of skin and that sweat may also contain fragmented DNA. Later research by Quinones and Daniel (2011) verified that the presence of sweat helps to contribute to the DNA profile obtained from touch DNA samples. These researchers showed that cell free nucleic acids, or CNAs, (basically free-floating DNA fragments not encapsulated in the cell nucleus) contribute greatly to the total amount of DNA present in a sample with CNAs being detected in the sweat of 80% of healthy individuals tested. They also found that, along with CNAs, nucleated cells were present in sweat samples taken from volunteers. Interestingly, most DNA extraction methods do not utilize the portion of the sample where CNAs are found - the aqueous portion of the extract - and after centrifugation to collect the cellular material, the supernatant (containing the CNAs) is generally discarded. Changing the extraction methodology to utilize the DNA from the cell-free nucleic acids has the potential to significantly increase the amount of DNA available for profiling, as illustrated in the Kita, et al, article.

### *How much DNA is left behind when an object is touched?*

One of the most common questions asked regarding touch DNA is, "how much DNA is expected to be transferred" given a certain set of circumstances. Unfortunately, this is a very difficult question to answer as there are so many variables involved with touch DNA. However, we can use the information

from various studies to provide a baseline idea of how much DNA might possibly be recovered from touched objects. Keep in mind that the amount of DNA needed to yield a full DNA profile with most commercially available amplification kits is approximately 1 nanogram (ng) of DNA and partial profiles can be obtained with even less starting material. The following table presents a summary of the various amounts of DNA that have been detected in published studies:

Table1: Summary of amount of DNA detected via contact:

| Amount of DNA | Mean | Contact type/substrate | Source |
|---|---|---|---|
| 0 - 5.2ng | 0.52ng | glass held for 60s | Daly, et al 2011 |
| 0 - 14.8ng | 1.23ng | fabric held for 60s | Daly, et al 2011 |
| 0 - 169ng | 5.85ng | wood held for 60s | Daly, et al 2011 |
| 0.16 - 6.4ng | | swab of hands | Bright & Petricevic, 2003 |
| 0-0.4ng | | fingers pressed on various substrates for 30s | Alessandrini, et al 2003 |
| 0 - 50.8ng | 1.7ng | various volume crime evidence items | Raymond, et al (2009) |
| | 4.3ng | wallets held for 60s | Raymond, et al (2009) |
| 3.1 - 33ng | 11.7ng | wallets held for various times | Raymond, et al (2009) |
| | 17.8ng | plastic knife held for 15 min. | van Oorschot and Jones (1997) |
| 6.8ng | | mug held for 15 min. | van Oorschot and Jones (1997) |
| 34ng | | glass held for 15 min. | van Oorschot and Jones (1997) |
| | 51ng | vinyl gloves worn for 20-90 min | van Oorschot and Jones (1997) |
| | 11.68ng | cotton rubbed with palm, finger, and side of hand for 15s | Goray, et al (2010) |
| | 0.396ng | plastic rubbed with palm, finger, and side of hand for 15s | Goray, et al (2010) |

### *Is DNA always left on an object via touch?*

It is important to note that not every contact leaves enough DNA behind to yield a DNA profile. Often I am asked, "If a person touched this [insert object], would they *necessarily* have left DNA behind?" The

short answer is no, not always. Journal articles regarding the transfer of DNA have shown that DNA is not always transferred through contact alone. Lowe, et al (1999) found that 12 of 30 subjects transferred little to no DNA to a sterile tube after handling for 10 seconds. Djuric, et al (2007) discovered that one female test subject transferred a DNA profile that was not her own to a sterile tube. A research article by Rutty (2001) showed that of 29 simulated strangulation samples, only 19 yielded DNA results. Of these, only 7 showed signs of both the "victim's" and the "suspect's" DNA. Phipps and Petricevic (2006) discovered that 51%-70% of individuals (depending on which hand was tested) failed to leave behind their DNA on a sterile tube that was held for 10 seconds. In addition, a study by Raymond, et al (2009) on trace DNA success rates noted that of 252 trace casework samples (all from surfaces touched by hands), 111 (44%) did not produce a profile. A study by Castella and Mangin (2008) analyzing the results from 1739 contact traces from real casework showed that just 26% of the contact traces had a DNA profile suitable for entry into the Swiss DNA database.

It is important to take into account, however, the date the study was published and what methodologies were used at that time as improvements in the technology and methodology of DNA analysis have arisen. For example, many of the earlier touch and transfer DNA articles report results from samples amplified with Profiler Plus and/or CoFiler which are older amplification kits that often used a larger amplification volume (50 microliters (ul), as compared to the standard 25ul reaction volume of today's kits) and required a split of the sample extract into two amplification reactions (20 ul maximum into the Profiler Plus tube, 20ul maximum into the COfiler tube). In addition, the majority of the earlier papers list extraction volumes of anywhere from 50 ul to 200 ul. It was not necessarily routine for the DNA extract to be concentrated to a small volume (as little as 10 to 12ul) as it is today, so it may be that additional DNA profiles would have been developed in these earlier studies if this concentration step had been performed. In addition, many labs today have the option of using specialized techniques designed to maximize their DNA results. For example, in addition to concentrating one's DNA extract, the analyst may also have the option to increase the injection time on the Capillary Electrophoresis instrument thus increasing the amount of DNA entering the capillary for detection. Additional Taq enzyme and the protein BSA (which helps overcome PCR inhibition) can be added to the amplification reaction. Some labs have the option to reduce the amplification volume even further (from 25ul to 12.5ul, for example), which has been shown to increase the sensitivity of the reaction. In addition, the amplified DNA can be subjected to post-amplification clean-up steps, and additional amplified product can be added to the sample tube for injection. Each of these steps have the possibility of increasing the amount of DNA observed on the resultant electropherogram, but it is important to be aware of possible interpretational difficulties that may arise from using these techniques.

### *What factors tend to increase the amount of DNA available for transfer?*

Initial research by van Oorschot and Jones in 1997 indicated that regardless of the amount of time an object was held (5s, 30s, 3min or 10min), the amount of DNA detected did not vary significantly. Wickenheiser (2001) concurred with this assessment as an earlier study he and Kisilevsky conducted found that the amount of DNA transferred to a substrate during handling is independent of handling time. That being said, if an item is handled numerous times or with pressure or friction involved, then an increase in the amount of DNA present may be expected.

Researchers aren't exactly sure why sometimes DNA is transferred to an object via touch and sometimes it is not. However, some known factors that can affect the amount of DNA available for transfer include:

- **Shedder status**. Several studies have indicated that some individuals may be considered "good shedders", someone who tends to slough or shed skin cells at a greater rate than others (Lowe, et al 2002). However it should be noted that the use of the terms "good" and "bad" shedders has recently been debated as other studies have found that it is nearly impossible to determine if someone is a good or bad shedder as repeated tests on the same person on different days can give very different results (Phipps & Petricevic, 2006).
- **Hand washing**. If a person has not washed their hands recently, there tends to be more DNA present on the surface of the hands as washing will remove many of the shed cells on the surface of the hands.
- **Personal Habits**. Some individuals tend to touch their face, eyes, nose, hair, etc. more often than others thus picking up DNA from those areas to be transferred onto the next thing that is touched. Wickenheiser (2002) described this process as "loading" the fingers with DNA.
- **Type of Contact**. Goray, et al, (2010) demonstrated that factors such as pressure and friction can also relate to how much DNA is transferred onto a touched object. An increase in the amount of pressure applied tends to lead to an increase in the amount of DNA transferred and the application of friction to the contact increases the amount of DNA transferred even further.
- **Substrate**. Rough surfaces (wood, concrete, grooved surfaces) tend to collect and retain skin cell DNA better than smooth surfaces. This is why the grip and trigger area of a gun, which are generally rougher, are swabbed for DNA while the smooth areas can be processed for latent prints.
- **Perspiration**. As discussed earlier, sweat is known to increase the amount of DNA available for transfer. It is thought that this may occur for two reasons. First, as the sweat passes through a person's pores and makes its way to the skin surface, it may collect cells along the way and wash them to the surface (Wickenheiser, 2002). Second, the previously mentioned study by Quinones and Daniel (2011) showed that sweat also contains epithelial cells and cell-free nucleic acids which represent additional DNA available for transfer to an object.

### *Once the DNA gets there, how long will it stay?*

Another common question when dealing with touch DNA is, "how long does it last?". As with most questions relating to touch DNA, there is no easy answer. Very little study has been done to assess the persistence of touch DNA, but this is becoming an increasingly important area of research, particularly as defense attorneys begin presenting arguments to suggest that touch DNA found at a crime scene can be explained by the suspect's presence at the scene at an earlier time that is completely unrelated to the crime at hand.

Consider the following scenario: A DNA profile matching a male DNA suspect is located on a brick wall outside of the home of a murder victim. The DNA appears to be from skin cells as it is negative for

blood, semen, and saliva. How did the DNA get there? The prosecution's theory is that the suspect fled the crime scene by climbing over the brick wall. Considering that blood evidence matching the victim is found nearby on the wall, this is a viable possibility. However, upon investigation, it is revealed that the suspect previously lived at the home in question and is, in fact, a relative of the murder victim. Could it then be possible that the suspect left his skin cell DNA at an earlier date when he either lived at the home or visited his relative? What about a swab taken from the counter top of a burglarized jewelry store? Surveillance video shows the masked robber placing his ungloved hands on the counter in order to jump over the counter. DNA results yield a mixture of DNA that includes the suspect. Defense attorneys argue that their client's DNA is present due to an earlier visit to the store when he was browsing for a new ring for his wife. How can we determine which of the scenarios are accurate?

Only one study this author is aware of directly addresses the persistence of touch DNA. Raymond, et al, (2009) conducted an investigation into the persistence of DNA at crime scenes. They applied known quantities of "buffy coat" DNA (the white blood cell and platelet layer of whole blood) to gloss-painted wooden window frames, pieces of vinyl (to simulate handbags), and control samples consisting of glass microscope slides. Not surprisingly, they found that the chance of recovering DNA from an outdoor crime scene decreases significantly over time with two weeks being the major drop-off point for most of the samples. The control samples fared much better, with full profiles able to be developed even after six weeks (the longest time period tested). This study also provided a table of results obtained from actual touch DNA casework samples and included the time between the offense and the collection of the evidence. Great variability existed, however, it is interesting to note that two of the three evidence items with greater than 50 days between offense and collection yielded DNA profiles. A bag in a drug case collected at 55 days post offense yielded a full DNA profile with 4.2ng of DNA present and fingerprints on a laptop collected 62 days after the offense yielded 1.28ng and a mixture of DNA. One additional study dealing with direct amplification of touch DNA samples (Linacre, et al (2010)) briefly discusses the stability of touch DNA on fabrics. Volunteers rubbed their thumb and forefinger between a sample of fabric for 5 seconds. The fabric samples were left exposed to light on a window ledge and then subjected to direct amplification. Linacre, et al, were able to generate nearly complete Powerplex 16 profiles from touch DNA on acrylic, nylon, and polyester for up to 36 days after transfer (the longest time period tested).

To assess whether it is possible that a touch DNA profile could have been left behind at a time prior to the alleged incident, it is important to gather as much information as possible. What is the item of evidence? Rough objects would be expected to collect more skin cell DNA as compared to smooth items. Does the evidence have cracks, crevices, or grooves where skin cell DNA might collect and be somewhat protected? An example might be a gun grip, buttons on a cell phone, or a computer keyboard. Was the item indoors (DNA expected to last longer), or was it outside exposed to the elements (heat, humidity, water, UV light, and bacterial growth all degrade DNA)? Was the item an object that may have been touched by many people (bank door handles, etc.) or only by very few (a weapon or a car steering wheel, for example)? It is impossible, however, to put an exact time-line on how long touch DNA evidence, or any biological evidence for that matter, might last. It is clear that additional studies are needed in order to help answer the questions regarding the persistence of touch DNA evidence that are often asked by investigators and attorneys alike.

***Is secondary DNA transfer a possibility in this case?***

Another common question in regards to touch DNA analysis is, "Is it possible that my client's DNA arrived on the item of evidence via secondary transfer?". In other words, could someone's DNA be found on an item even though they never actually touched that item? Based upon several recent studies, the answer is, yes, this is indeed possible.

Secondary transfer can be from:

1. person to person to object - I shake your hand and my DNA is transferred via primary transfer to your hands. You then pick up a knife and transfer my DNA to the knife (secondary transfer)

2. person to object to person - I pick up and swing a wooden bat and transfer my DNA to the handle (primary transfer), you pick up the same bat and a swab of your hands reveals my DNA (secondary transfer)

3. person to object to object - I use a bath towel (primary transfer of my DNA to the towel) that is then wrapped around a gun and my DNA is found on the gun (secondary transfer from towel to gun).

One of the initial studies on secondary DNA transfer- after the original short correspondence describing examples of secondary transfer published by van Oorschot and Jones in Nature in 1997 - was a study by Ladd, et al, (1999) who appear to have sought to dispel the possible interference of secondary DNA on an item of evidence. They conclude their paper by stating that "Secondary transfer was not observed under our experimental conditions". However, a closer look reveals that low-level secondary transfer was indeed observed. The authors note that, "on occasion, minor peaks (below 75RFU) from the second individual were observed". This is secondary transfer. In addition, as mentioned above, the increased sensitivity common with today's methods and techniques would likely have yielded an even greater appearance of secondary DNA transfer in the Ladd study. More recent studies indicate that secondary transfer of DNA can and does occur under varying circumstances.

Daly, et al (2010) studied DNA transfer of touch DNA onto three substrates: wood, glass, and fabric (100 samples each). Of the 300 samples, they found that mixed DNA profiles (indicating a person to person to object secondary transfer) were obtained in ~10% of the samples. Interestingly, they note two instances in which a male profile or a major male/minor female profile was obtained from samples held by *female* individuals. These results echo the results of a study by Lowe, et al (2002) wherein an individual held hands with a second individual and then handled a pre-sterilized plastic tube and transferred *only* the second individual's DNA to the tube, none of their own.

A detailed study of secondary DNA transfer of skin cells was performed by Goray, et al, (2010). These researchers found that freshly transferred skin cells transferred to a secondary surface more easily than dried transfers and that non-porous primary substrates (such as plastic and glass) generate increased transfer rates whereas porous secondary substrates (cotton was used in the experiment), "facilitate significantly greater transfer compared to non-porous ones". In addition, it was found that transfer rates approximately double when pressure is involved in the transfer, as opposed to a passive contact, and that transfer rates increase even further when friction is used. The authors used their findings to estimate

the amount of primary DNA deposit that would be necessary to allow for the secondary transfer of 1 nanogram of DNA. The authors state:

> The amount of original deposit will vary significantly depending on substrate, manner of contact and, in some instances, the freshness of deposit. If, for example, a fresh sample was deposited on cotton (soft and porous) and then subjected to pressure contact (with no friction) with a secondary substrate that is hard and non-porous, like plastic, a minimum deposit of 385ng of DNA is needed for 1ng to have been transferred, collected, and extracted....Whereas, if the type of primary and secondary substrate was reversed (primary was hard, non-porous and secondary soft, porous), and in addition the sample was dried prior to contact that involved friction, then only 2ng of DNA needs to be deposited for 1ng to be retrieved.

An example of how secondary transfer could conceivably affect the interpretation of a case was illustrated by Sarah Jones and Kirsty Scott of the SPSA Forensic Services (Aberdeen) during the Body Fluids Conference jointly hosted by the Forensic Science Society & the Centre for Forensic Investigation, University of Teesside and reported in Science and Justice 50 (2010). Jones and Scott performed experiments to determine if non-intimate contact could result in the transfer of DNA to a male volunteer's underwear and penis. Of three scenarios reported, one resulted in the transfer of the female volunteers' DNA to both the underwear (33% of the samples) and penis (67% of the samples) of the male volunteers even though no direct contact from the female to the male had occurred. The scenario involved 1 minute of face-touching, 3 minutes of handholding and immediate urination by the male. However, when a 15 minute period was introduced between the non-intimate contact and urination, no female DNA was detected on either the underwear or penis of the male volunteers.

It is also possible for DNA to transfer from person to object to object. In fact, a recent study by Goray, et al, (2011) discusses the DNA transfer that can occur within forensic exhibit packaging. Their study illustrated some startling results. The authors prepared numerous "mock" evidence samples and packaged and handled them in a manner to mimic the movement of evidence packaged at the crime scene and transported to the laboratory. The results showed the transfer of skin cells from a swab to the interior of the packaging (a plastic tube). In addition, saliva from cigarette butts was found to transfer to other cigarette butts packaged in a manilla envelope, and blood stains were shown to transfer to other areas on the same item and to other items packaged in the same container as well as onto the interior of the packaging itself. In addition, bloodied knives showed the transfer of DNA containing material from the tip of the knife to to other areas of the knife including the handle.

***Is it possible to tell who handled an item last or most?***

Due to the variable nature of DNA transfer, it is generally not possible to determine who might have handled an item last. The same is true regarding who might have handled an item the most. For example, just because one person's DNA profile is more prevalent on an item like a cell phone, for instance, this does not necessarily mean that they must have handled the phone last. In addition, it does not mean that the phone must be theirs because more of their DNA is present. It could simply mean that one of the factors that tend to increase the amount of DNA transferred (as discussed above) is in play. For example, perhaps they are a "good shedder", or they may have some personal habits which lead

to a greater amount of DNA on their hands, or they simply may not have washed their hands for an extended time period.

***What sort of items might possibly contain touch DNA?***

The sky is the limit with this sort of question. Almost any item might conceivably contain touch DNA evidence. The key is to focus on those items that were most likely to be touched given a particular crime event. In addition, it is important to select items that have not been handled by multiple individuals as the DNA results may be uninterpretable due to the complex mixtures of DNA likely to be obtained. So, in the case of a copper theft from a church, for example, it would be better to swab the tools left behind at the scene than the front door handle of the church. Investigators and analysts must use their experience and their common sense in order to choose the most useful and probative items to test.

*The following is a short list, by no means comprehensive, of some items that may be swabbed and submitted to the crime lab for touch DNA analysis:*

| Item of Evidence | Type of case |
|---|---|
| Firearms, knife handles, weapon handles | any |
| Fired casing | any |
| Steering wheel and other vehicle swabs | carjacking, etc |
| Fingerprints on victim | any |
| Ligatures, hand cuffs, shoestrings | strangulation, kidnapping, rape, etc |
| Hand swabs from suspects | strangulation, rape |
| Face swabs from child victims (slapping, hitting) | child abuse |
| Swabs from limbs removed from animal carcasses | poaching |
| cell phones swabs | robbery, etc |
| victim neck swabs | strangulation |
| swabs from torn or forcibly removed clothing | rape, assault |
| airbag | DUI cases and others |
| tools | burglary |
| baggies | drug possession |
| paper demand notes | bank robberies |
| clothing items, hats, masks, gloves, glasses | any |

## LITERATURE CITED:


Bright, J and Petricevic SF. Recovery of trace DNA and its application to DNA profiling of shoe insoles. Forensic Sci. Int. 145 (2004) 7-12.

Castella V and Mangin P. DNA profiling success and relevance of 1739 contact stains from casework. Forensic Sci. Int.: Gen. Suppl. Ser. (2008) 405-407.

Daly DJ, et al. The transfer of touch DNA from hands to glass, fabric, and wood. Forensic Sci. Int. Genet. 6 (2012), 41-46.

Djuric M, et al. DNA typing from handled items. Forensic Sci. Int.: Gen. Suppl. Ser. (2008) 411-412

Hulme, J. Body Fluids Conference jointly hosted by the Forensic Science Society & the Centre for Forensic Investigation, University of Teesside: 18-19 April 2008 Convenors: Julie Allard and Brian Rankin. Science & Justice 50 (2010) 100-109.

Goray, M et al. Investigation of secondary DNA transfer of skin cells under controlled test conditions. Legal Medicine 12 (2010) 117-120.

Goray, M et al. DNA transfer within forensic exhibit packaging: Potential for DNA loss and relocation, Forensic Si. Int. Genet. (2011), doi 10.1016j.fsigen.2011.03.013

Graham EAM and Rutty GN. Investigation into "normal" background DNA on adult necks: implications for DNA profiling of manual strangulation victims. J Forensic Sci. (2008) 1074-1082.

Kita, T et al. Morphological study of fragmented DNA on touched objects. Forensic Sci. Int. Genet. 3 (2008) 32-36.

Ladd C, et al. A systematic analysis of secondary DNA transfer. J. Forensic Sci. 44 (6) (1999) 1270-1272.

Linacre, A, et al. Generation of DNA profiles from fabrics without DNA extraction. Forensic Sci. Int. Genet. 4 (2010) 137-141.

Lowe A, et al. The propensity of individuals to deposit DNA and secondary transfer of low level DNA from individuals to inert surfaces. Forensic Sci. Int. 129 (2002) 25-34.

Phipps M and Petricevic S. The tendency of individuals to transfer DNA to handled items. Forensic Sci. Int. 168 (2007) 162-168.

Quinones I and Daniel B. Cell free DNA as a component of forensic evidence recovered from touched surfaces. Forensic Sci. Int. Genet. 6 (2012) 26-30.

Raymond, JJ et al. Trace evidence characteristics of DNA: A preliminary investigation of the persistence of DNA at crime scenes. Forensic Sci. Int. Genet. 4 (2009) 26-33

Raymond JJ, et al. Trace DNA success rates relating to volume crime offences. Forensic Sci. Int.: Gen. Suppl. Ser. (2009) 136-137.

Raymond JJ, et al. Trace DNA and street robbery: A criminalistic approach to DNA evidence. Forensic Sci. Int.: Gen. Suppl. Ser. 2 (2009) 544-546.

Rutty GN. An investigation into the transference and survivability of human DNA following simulated manual strangulation with consideration of the problem of third party contamination. Int. J. Legal Med. (2002) 116: 170-173.

van Oorschot RAH and Jones MK. DNA fingerprints from fingerprints. Nature. Vol 387 (1997) 767.

Wickenheiser, RA. Trace DNA: A review, Discussion of Theory, and Application of the Transfer of Trace Quantitites of DNA Through Skin Contact. J. Forensic Sci. 47 (3) (2002) 442-450.