

Forensic Genetics and Legal Medicine 2019-2020

13th May 2020

**Beyond identification
(activity level)**



DNA testing is one-dimensional

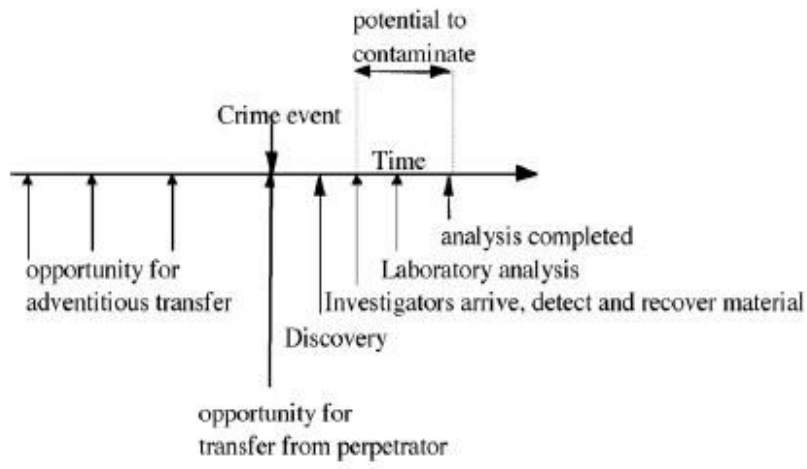
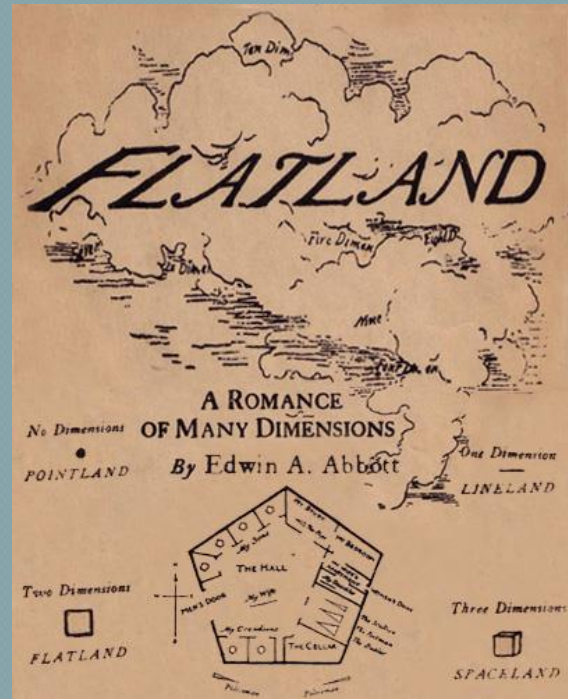
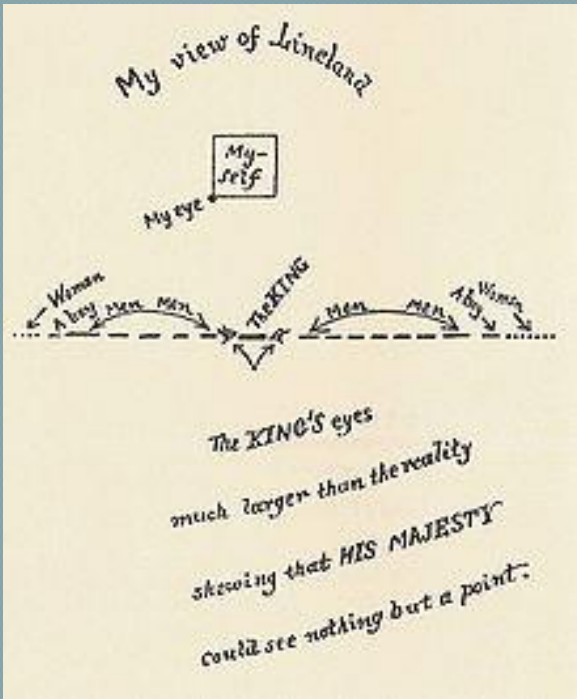


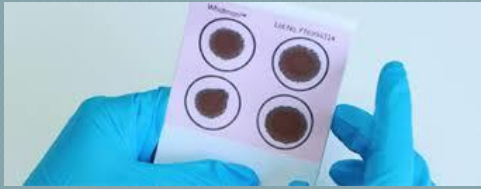
Fig. 1. A generalised timeline that illustrates the potential means by which a DNA profile may be propagated.

Gill P et al, Forensic Sci Int Genet 2010



✓ DNA persistence

• DNA from air dried body fluids retains sufficient quantity and quality to generate full STR profiles for several years, even decades (storage at room temperature of air dried samples is standard for databasing purposes)



• shorter but prolonged persistence can be observed for DNA deposited by simply touching objects



Table 1
Results from trace DNA casework samples, sorted by the time difference between the offence and sample collection.

Time between offence and collection	Time between collection and lab receipt (days)	Sample	Offence	DNA quantity (ng/μL)	Estimated total DNA in extract (ng)	DNA profile result ^a
1 h 40 min	225	FPS ^b at point of entry	Burglary	0	0	Neg
1 h 40 min	33	Earprint on door	Burglary	0.003	0.12	Partial <12
1 h 40 min	15	FPS on counter	Armed robbery	0.045	1.8	Mixture
1 h 45 min	39	Register note clips	Armed robbery	0.002	0.08	Partial <12
2 h 15 min	11	Handmark on counter	Armed robbery	0.017	0.68	Amel only
2 h 19 min	37	Service counter	Armed robbery	0.025	1.0	Amel only
2 h 23 min	383	FPS at point of entry	Armed robbery	0.025	1.0	Partial <12
2 h 23 min	383	Security wire above counter	Armed robbery	0	0	Neg
2 h 40 min	9	Cash register, FPS	Armed robbery	0	0	Neg
2 h 40 min	22	Arm mark on counter	Armed robbery	0.002	0.08	Mixture
2 h 40 min	22	Arm mark on counter	Armed robbery	0.008	0.32	Full profile
2 h 52 min	7	Display mat on counter	Armed robbery	0.056	2.24	Mixture
3 h 10 min	13	Perspex partition	Armed robbery	0.046	1.84	Mixture
3 h 30 min	230	Shopping basket	Armed robbery	0.178	7.12	Mixture
3 h 30 min	230	Freezer door	Armed robbery	0.007	0.28	Partial <12
3 h 30 min	230	Rear loading dock door	Armed robbery	0.066	2.64	Mixture
3 h 50 min	169	FPS on window sill	Burglary	0.033	1.32	Mixture
4 h 5 min	4	Register keyring	Theft	0.004	0.16	Amel only
5 h 15 min	29	Area around reg. plates	Theft	0	0	Neg
5 h 15 min	29	Area around reg. plates	Theft	0.001	0.04	Neg
5 h 40 min	29	Computer harddrive	Burglary	0.002	0.08	Partial <12
5 h 50 min	19	Plant pots	Burglary	0	0	Neg
8 h 45 min	7	Screwdriver handle	Burglary	0.18	7.2	Partial ≥12
9 h 25 min	31	Earprint on door	Burglary	0	0	Neg
10 h 5 min	173	FPS at point of entry	Burglary	0	0	Neg
10 h 42 min	24	Safe handle	Burglary	0.002	0.08	Neg
11 h 35 min	121	Glovebox handle	Robbery	0.014	0.56	Mixture
11 h 35 min	144	FPS on security camera	Arson	0.003	0.12	Neg
14 h 25 min	24	FPS at point of entry	Burglary	0.02	0.8	Partial ≥12
14 h 58 min	5	FPS at point of entry	Burglary	0.009	0.36	Neg
16 h	36	FPS on bumper	Theft	0.001	0.04	Neg
17 h 31 min	66	FPS at point of entry	Burglary	0	0	Neg
19 h 26 min	14	Earprint on door	Burglary	0	0	Neg
19 h 31 min	35	FPS at point of entry	Burglary	0.028	1.12	Partial <12
19 h 55 min	12	Earprint on door	Burglary	0.002	0.08	Neg
20 h 55 min	131	Auto gearshift	Vehicle offence	0.001	0.04	Neg
21 h 10 min	226	Earprint on door	Burglary	0	0	Neg
1 d	16	Wallet	Burglary/SMV	0.074	2.96	Amel only
1 d	219	FPS at point of entry	Burglary	0	0	Neg
2 d	13	FPS at point of entry	Burglary	0	0	Neg
3 d	14	Partial FP on camera	Burglary	0	0	Neg
3 d	6	Gas bottle handle	Drugs	0.032	1.28	Mixture
3 d	241	FPS at point of entry	Theft	0.001	0.04	Neg
5 d	17	Passenger doorhandle	Assault	0.022	0.88	Full profile
9 d	304	Handbag	Robbery	0.002	0.08	Neg
11 d	142	Cheque book	Theft	0.004	0.16	Partial <12
22 d	180	Glucodin powder box	Drugs/firearms	0.004	0.16	Neg
55 d	32	Bag	Drugs	0.105	4.2	Full profile
62 d	39	Ziplock bag	Drugs	0.001	0.04	Neg
62 d	8	FPS on laptop	Burglary	0.032	1.28	Mixture

^a Neg: no profile; Amel only: only the Amelogenin locus present in the profile; partial <12: less than 12 alleles in the profile; partial ≥12: 12 or more alleles in the profile but less than a full profile; and mixture: a mixture of more than 1 person's DNA in the profile.
^b FPS: fingerprints.

Guidelines for long-term storage of biological samples

Type of Evidence ²	Frozen 	Refrigerated	Temperature Controlled 
Urine	Best		
Dry Biological Stained Items			Best
Bones			Best
Hair			Best
Swabs with Biological Material			Best (dried)
Vaginal Smears			Best
Feces	Best		
Buccal Swabs			Best

15-25°C
<60% humidity

During the drying period samples should be stored in paper (transpiring) envelopes or bags to prevent the formation of moisture (such as in plastic bags) that favors the proliferation of microorganisms and consequent DNA degradation

Adapted from National Institute of Justice: The Biological Evidence Preservation Handbook: Best Practices for Evidence Handlers 2013

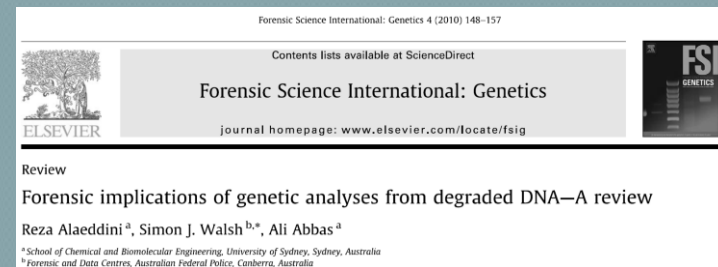
- soft tissues: frozen; in exceptional conditions when freezing facilities are not available or freezer space is limited (mass disasters) room temperature in preservative solutions (alcoholic solutions, EDTA, DMSO) or in solid salt! (Whatherson et al. Forensic Sci Int Genet 2018)

✓ DNA persistence

- If DNA loss through degradation in forensic samples were strictly time dependent it could be possible (provided we have a reliable idea of the starting DNA content of a stain, depending on body fluid, volume, etc...) it could be possible to infer deposition time

- In addition to time, the persistence of any biological material depends on a range of DNA-degrading environmental factors, including: temperature, exposure to UV, rain, wind, humidity and presence of micro-organisms.

- ✓ As a consequence it is almost impossible to infer DNA deposition time from DNA yield or quality of STR profiles



DNA degradation derives from:

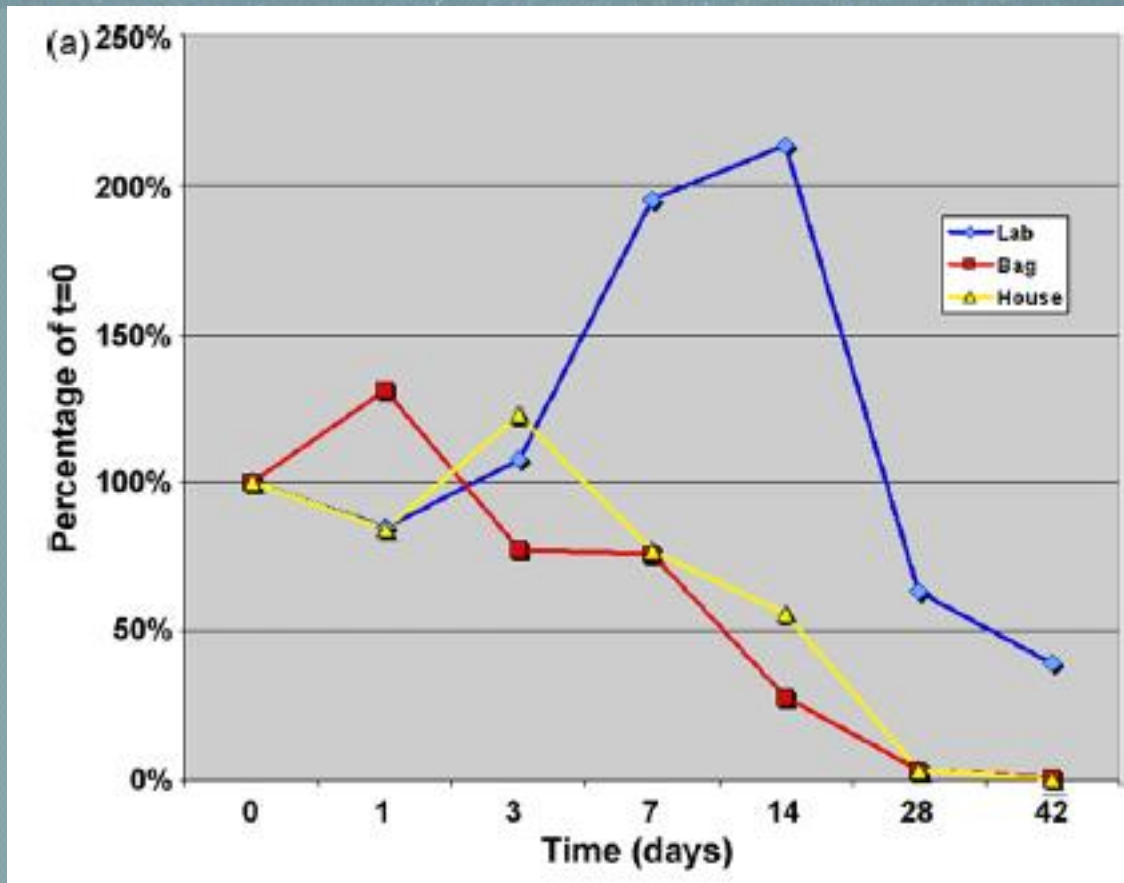
- endogenous nucleases freed after cell death
- microbial nucleases (growth favoured by humidity and nutrients, like cadaver tissues)
- nonenzymatic hydrolysis (low pH, high temperature)
- nonenzymatic oxidation (radiations)

3 μ l spots of buffy coat stored:

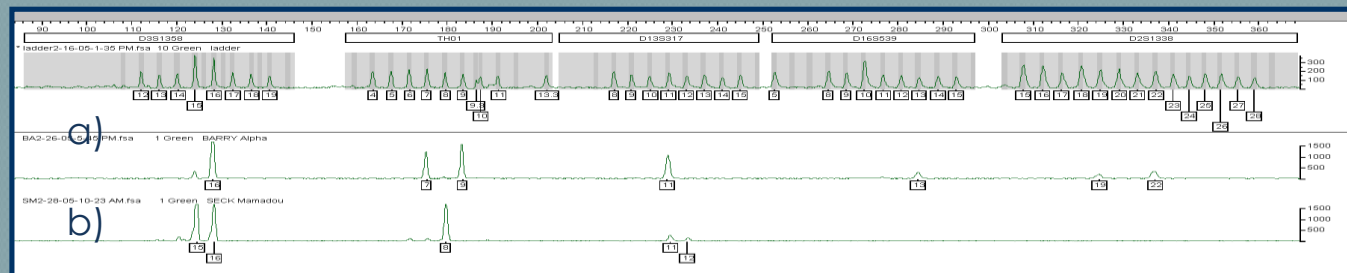
■ inside, protected from sun/rain; controlled temperature

■ outside, protected from sun/rain; environmental temperature

■ outside, exposed to sun/rain; environmental temperature



Raymond et al. Forensic Sci Int Genet 2009



a) Cigarette butt smoked 5 years before testing, stored as ■
 b) Cigarette butt smoked 1 day before testing, stored as ■

Unless...



A prostitute was strangled in her apartment

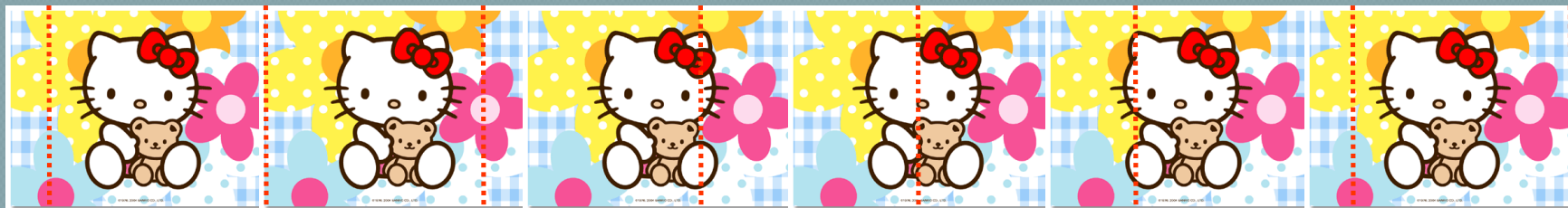


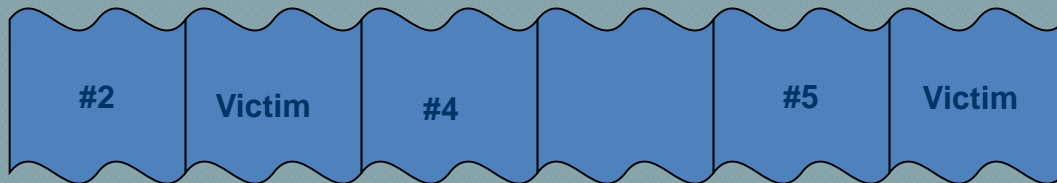
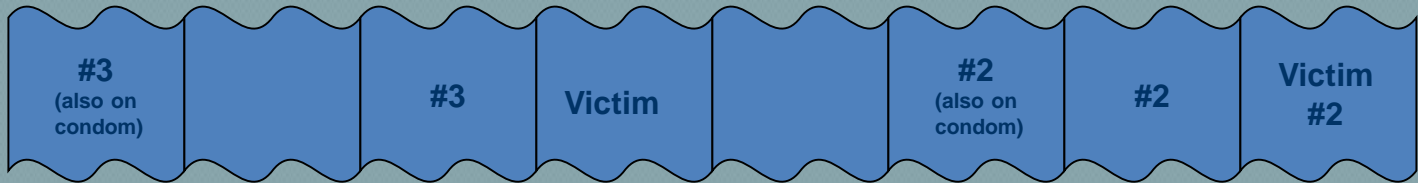
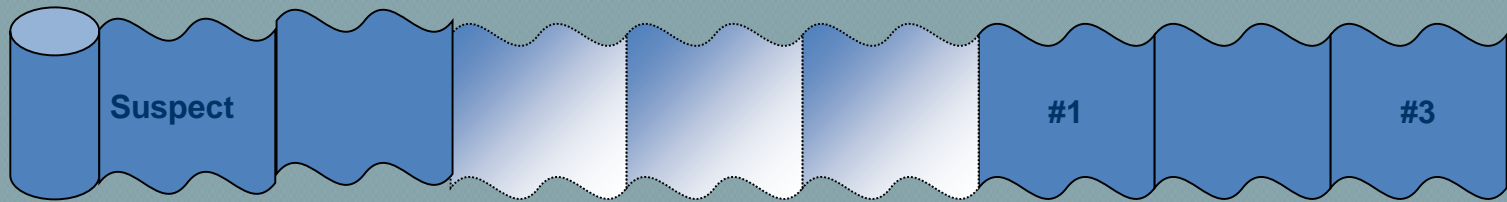
In a bucket in the apartment two condoms and several pieces of kitchen paper the clients used to clean themselves are found. DNA profiles of 6 different men are identified



The DNA profile on one of the pieces of paper matches that of a man who had killed 5 women 20 years before and who had been recently released from jail. But how to prove he was the actual killer among the 6 clients?

Tear lines in the roll of paper not alligned with decoration





✓ Background DNA

- The DNA present on the surface prior to the deposit of interest being placed on the surface during the action of interest
- most surfaces and items, unless new or cleaned, will have some DNA on them that has been acquired from previous use, especially so for personal items and shared items used regularly
- If items possessing background DNA are then used by others mixtures can be expected
- in some situations it may be useful to collect a sample from an area immediately adjacent to the area targeted on an evidentiary sample, thus revealing a profile that is possibly very similar to the background component of the target evidentiary sample (substrate controls)
- ✓ Implications in fingernail DNA analysis
 - The presence of offender's DNA under the victim's fingernails (and viceversa) could be assumed as proof of physical altercation
 - Studies show that (happily) co-habiting persons carry under their fingernails the DNA of cohabitating individuals in 14-37% of samples

Prevention of contamination



Self DNA
(DNA rich saliva
droplets, hair, dandruff)

Self DNA and non-self DNA
transferred through hands,
clothes, shoes

Disposable equipment



- DNA-free certified swabs should be used
- swabs not used for stain collections should be processed along with stain samples as control blanks
- Several crimes in France, Germany and Austria between 1993 and 2009 were connected through the same female DNA profile («Phantom of Heilbronn»): it actually was from a worker at the factory producing the swabs...

(https://en.wikipedia.org/wiki/Phantom_of_Heilbronn)

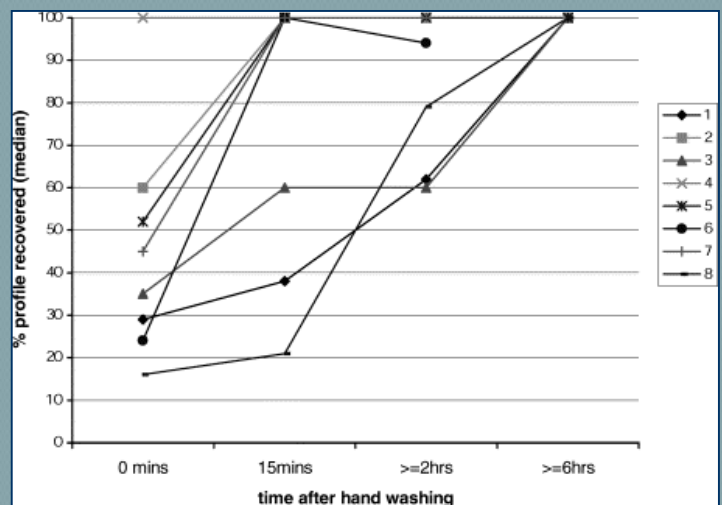
Non-disposable equipment



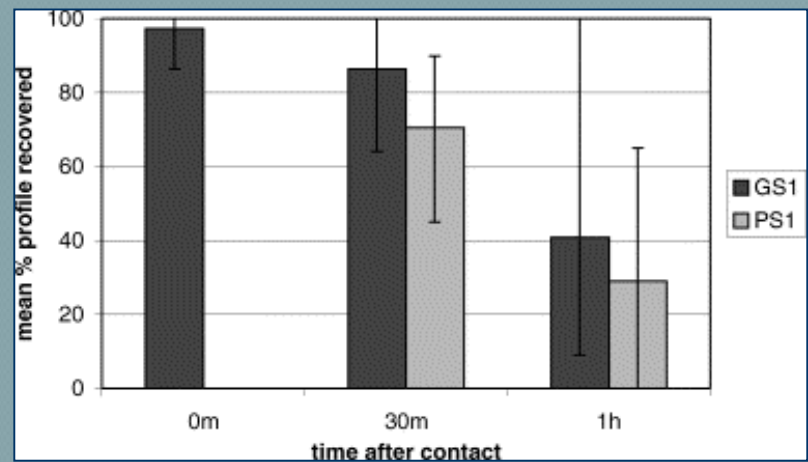
- 15-30 min treatment with 1:10 bleach (Schwark et al Forensic Sci Int 2012)

✓ DNA transfer

- direct/primary transfer: person's DNA is directly deposited onto an object/surface or hand/skin of another person just by contacting it (e.g. blood drop falling on the floor; cellular material transferred by handler to handled object)
- indirect transfer: the DNA deposited during direct transfer is transferred again to a new location, without direct contact of the original source of the DNA with the new location (e.g. transfer of a bloodstain by stepping on it; A picks a pen previously handled by B, then uses his own laptop transferring B's DNA on the keyboard)
- indirect transfer through handled object could be influenced by the different tendency of first handlers to deposit their DNA "shedder status"



Good (black) and poor (grey) shedders shake hands, then bad shedder touches object at different time intervals (good shedder DNA still prevalent after 1 h)



- ✓ Rigid categorizations of individuals as good and poor shedders was originally described, but later criticized
- ✓ Among the various factors that can influence the amount and type of DNA on the palmar surface of the hand:
 - Skin conditions (dermatitis, psoriasis)
 - Gender (males more likely to be heavy shedders)
 - Age (younger individuals more likely to be heavy shedders)
 - Presence of non-skin high DNA content body fluids on hand surfaces

Higher amounts of self DNA on the hands of young males (22% of male hands showed other than skin tissue by mRNA profiling versus 8% of female hands) (Lacerenza et al. Forensic Sci Int Genet 2016)

↓
More frequent identification of non-self DNA on female hands (leading to possibly higher indirect transfer rates)

