

Forensic Uses of Blood

Blood Properties & Characteristics
Presumptive Tests
Blood Stain Pattern Analysis

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Overview

- What is Blood?
- Blood Types
- Presumptive Blood Tests
- Blood Pattern Analysis



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What is Blood?

- Fluid circulating throughout the body
- Transports oxygen, electrolytes, nourishment, hormones, vitamins and antibodies to tissues and transports cellular waste to excretory organs
- Components of blood:
 - Plasma (straw-colored liquid in which the blood cells are suspended)
 - Red blood cells (anucleated – carry O_2 and CO_2)
 - White blood cells (nucleated – defense against infection and disease)
 - Platelets (45% of total blood volume – cell fragments responsible for clotting)

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Blood and Body Weight

- On average, blood accounts for 8% of total body weight
 - 5 to 6 liters of blood for males
 - 4 to 5 liters of blood for females
- A 40% blood volume loss, internally and/or externally, is required to produce irreversible shock (death).

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Forensic Uses

- Although DNA analysis has replaced most conventional serology tests, there is still some useful class information in blood
 - Species
 - Type
 - Rh Factor
 - Disease
 - Secretor status

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Class Characteristics

- There are 4 major blood types based on the presence and type of surface cell proteins:
 - AB: have both A and B blood proteins
 - A: have only A proteins
 - B: Have only B proteins
 - O: have no blood proteins
- There are also surface cell proteins called Rh factors
 - Individuals either have these (Rh+) or lack them (Rh-)

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Class Characteristics

- The absence or presence of certain blood diseases are also class characteristics
 - HIV
 - Hepatitis
 - Sickle cell anemia
 - Etc.
- About 80% of the population are secretors
 - Secretors secrete their blood antigens into their tears, sweat, semen and saliva
 - The presence of any of these substances permits identification of the blood type of the suspect

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Presumptive Tests for Blood: Kastle-Meyer

- Presumptive tests are conducted on stains that might be blood
- *They are not conducted on stains that are **obviously blood***
- The K-M test detects the presence of peroxidase enzymes in the stain
- Other substances besides blood, such as potatoes and horseradish, contain peroxidase enzymes (which will give a false + result)
- Thus, a + K-M test is not definitive, and only indicates the *possible* presence of blood
- Other tests are needed to verify the presumptive results

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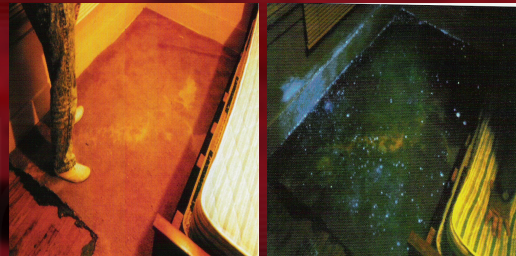
Luminol

- Works in a similar fashion to phenolphthalein (K-M), except Luminol *chemiluminesces* in the presence of blood
- Can test large areas at once
- Must be viewed & photographed in total darkness



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Luminol



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Blood Pattern Analysis

- Most evidence recovered from a crime scene (such as hairs, footwear, fingerprints and DNA) is analyzed for the purpose of determining the *identity* of the individuals involved
- In contrast, bloodstain pattern analysis is used to determine *what happened* at a crime scene, and the sequence of events

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Blood Pattern Analysis

The use of physics, measurement, math and reasoning to interpret bloodstain patterns within a forensic setting may show:

- The direction blood was travelling in
- The angle with which it impacted
- The possible distance between origin and impact
- The nature of the force used
- The direction from where the force came
- The relative position of people at the scene
- The type of object or weapon used
- The minimum number of blows
- The sequence of events
- The possible identification of the hand used

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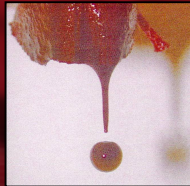
Basic Principles

- A free falling drop of blood forms a sphere, not a teardrop shape
- A sphere is the lowest possible energy state for a liquid (in flight)
- A spherical drop will break into smaller drops
 - When it strikes another object
 - When acted upon by some force

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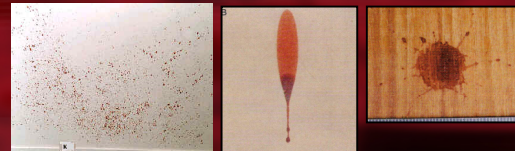
The Shape of Blood in Air

- Surface tension holds the drop together as a sphere
 - What is surface tension?
- Under normal conditions, blood will form drops of uniform size – roughly 0.05 mL



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Blood Spatter



Blood drops form different shapes and sizes

- Blood spatter analysts examine these patterns to reconstruct the activity at the crime scene.

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Factors Affecting Shape and Size

- The size of blood spatter is affected by
 - Velocity of blood
 - Degree and type of force
 - Amount of blood
 - Distance traveled
- The shape of blood spatter is affected by
 - Impact surface
 - Angle of impact

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Velocity: Low/Passive

Passive blood is that which falls from a bleeding person or bloody object without any force

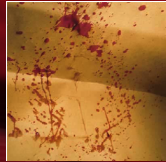
Many blood trails contain passive blood stains, and are formed when blood is falling from a moving person or object

Low velocity spatter travels at about 5 ft / second and forms a 4-10 mm diameter stain; it indicates that blood is dripping passively.

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Medium Velocity Spatter

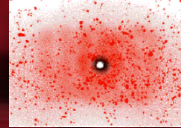
- Medium velocity spatter is produced by beating with an object or fist
- Stabbings can also produce medium velocity stains
- Medium velocity spatter travels at 5 – 25 ft / second and makes a <3 mm diameter stain; it usually indicates blunt trauma or sharp trauma, or it could be cast-off.



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High Velocity Spatter

- High velocity blood spatter occurs when a strong, explosive force projects blood in an aerosolized spray (gunshot)
- High velocity spatter travels at 100+ ft / second and forms stains with diameters of < 1 mm; it indicates gunshot trauma, injury with power tools, or an object striking with extreme velocity (high speed car crash, explosion).



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Terminal Velocity

Blood falling through the air will accelerate until terminal velocity is reached (25 feet/s).

This occurs at 15 feet for a 50 µl drop.

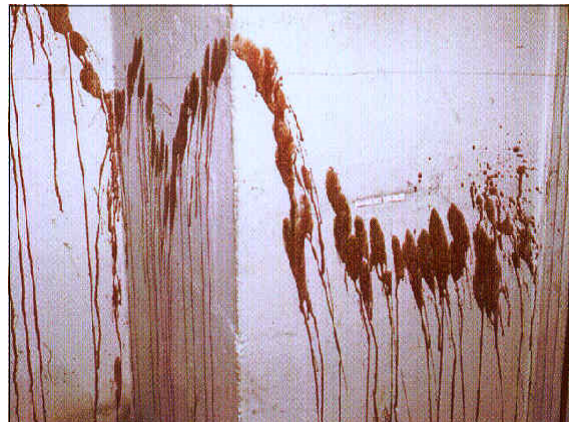
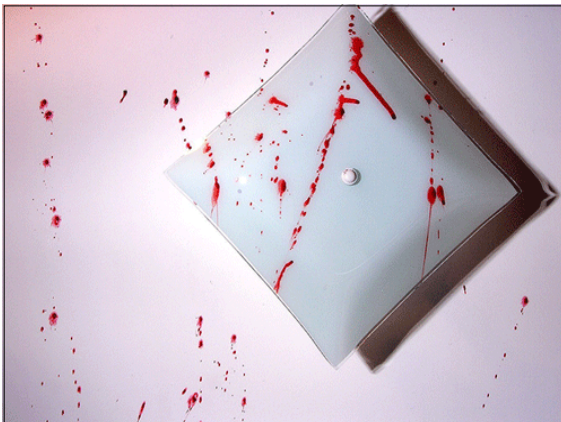
The farther a blood drop falls (up to 15 feet), the larger the resulting spatter will be.

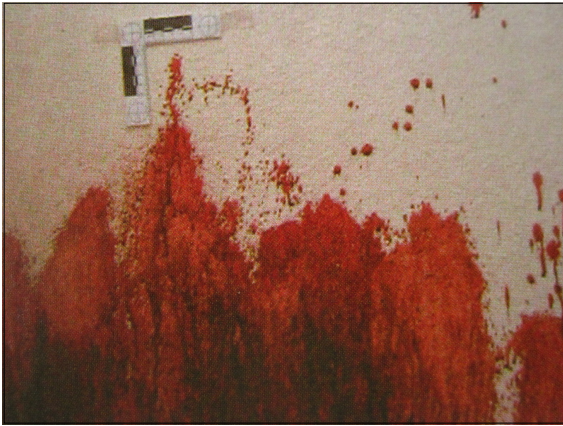
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Other Types of Projected Blood

- Arterial spray: pattern resulting from blood exiting the body under pressure from a breached artery
- Aspirated blood (blood that is coughed or sneezed out) is very small and can mimic high velocity spatter
 - Use context to determine which type it is
- Cast-off blood: pattern resulting when blood flies off of a moving object

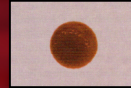
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Blood Spatter: Distance

- Size of drop stain depends (in part) on the volume of the drop.



- Volume depends on the object the blood originated from (small gauge needle = small; baseball bat = large)

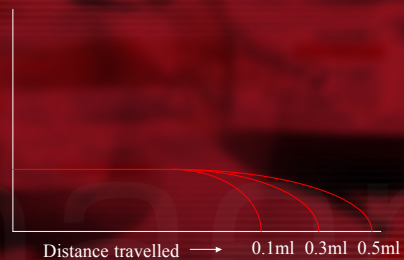
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Size and Flight

- The effect of air resistance is inversely proportional to the size of blood drop
- Larger drops are less effected by air resistance
- Small drops are more effected (more slowed) by air resistance
- Larger drops will travel further through the air if given the same initial energy as smaller drops

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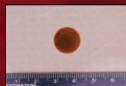
Effect of Air Resistance



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Surface and Blood Spatter

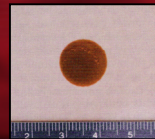
- The **type of surface** the blood strikes affects the size and appearance of the blood drops.
- Blood droplets that strike a hard smooth surface, like a piece of glass, will have little or no distortion around the edge.
- Blood droplets that strike linoleum flooring (or other uneven surface) may be distorted or show scalloping around the edges.
- Surfaces such as wood or concrete distort blood drops to a larger extent. Notice the spines and secondary spatter present in the photo.



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Angle of Impact

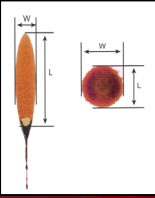
- Angle of impact
 - Vertical drops are circular
 - Blood drop shape elongates as angle of impact decreases from 90°
- To calculate angle:
 - Measure length and width in millimeters
 - Divide width by length
 - Take the inverse sin (\sin^{-1})
 - Resulting number is the angle of impact
 - Example: $10\text{mm}/40\text{mm} = .25 \sin^{-1} = 14.47$ degrees



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Angle of Impact


- 90 degrees – 
- 60 degrees – 
- 30 degrees – 
- 10 degrees – 





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Angle of impact



90°



80°



70°


60°


50°


30°


20°

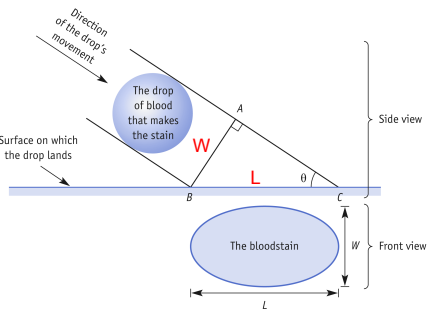

10°

Decreasing angles of impact of single falling blood droplets.

Image used with permission from Stuart James, February 2007.

OHT 5.4

(a)

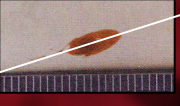


Information from bloodstains obtainable by trigonometry

Jackson & Jackson: Forensic Science © Andrew R. W. Jackson and Julie M. Jackson 2004

Directionality

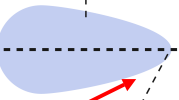
Determining Direction of Blood




- When a drop hits at an angle other than 90°, it will form an ovoid or tear drop shape on the surface it hits
- The more narrow end of the blood stain will point in the direction of travel.
- The steeper the angle, the longer and more narrow the blood stain

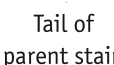
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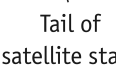
OHT 5.3


Parent bloodstain


Satellite bloodstain

one exception!


Tail of parent stain

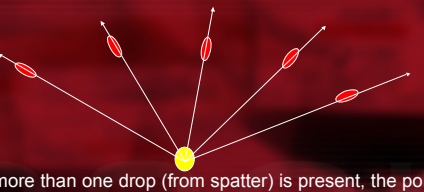

Tail of satellite stain

tail points in direction of travel

Figure 5.7 Parent and satellite bloodstains (arrow shows direction of travel)

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Determining Point or Area of Origin

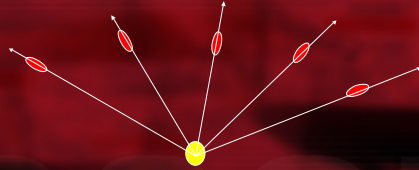


- If more than one drop (from spatter) is present, the point of origin can be determined
- You will need: a scientific calculator, metric ruler, protractor, string, and sturdy vertical post

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Point of Origin

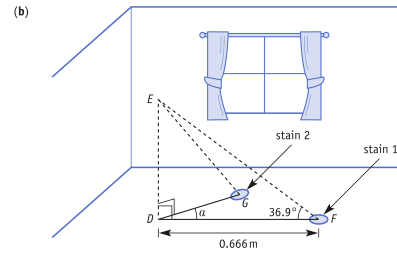
Determining Point of Origin



- This is a 2-dimensional point of origin.
- It is also possible to determine the 3-D point of origin

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OHT 5.5



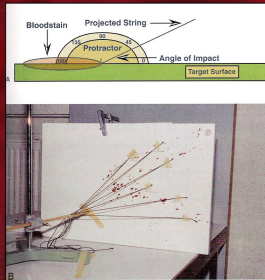
Information from bloodstains obtainable by trigonometry (continued)

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Point of Origin

For each blood drop, a string can be guided backwards along the angle of impact. The point at which multiple strings converge is the point of origin.



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Point of Origin



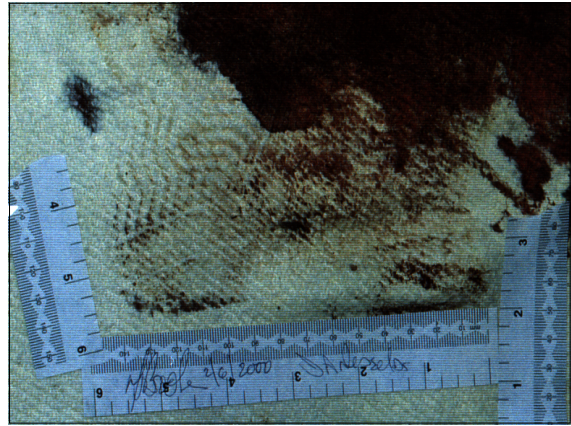
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Other Patterns in Blood

- Transfer patterns
- Void patterns
- Flow patterns

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Drying Time Factors

- Temperature - the higher the temperature the quicker the blood will dry.
- Humidity- the higher the humidity the slower the blood will dry.
- Air flow - the greater the air flow of the surface of the blood the faster the blood will dry
- Exposed Surface - shallow pools with greater surface/volume ratio will dry quicker than deep pools.

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Clotting Time

- Clotting time outside the body ranges from 3 – 15 minutes
- Spattered clots indicate that time passed between the initial bleeding and later blows
- Coughing of clotted blood may indicate post-injury survival of victim

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Wounding

The amount of blood lost depends upon the size and location of the injury.

- Greatest loss is from blood under the greatest pressure: the arteries
- Size of damage - the more damage the more blood lost (normally)

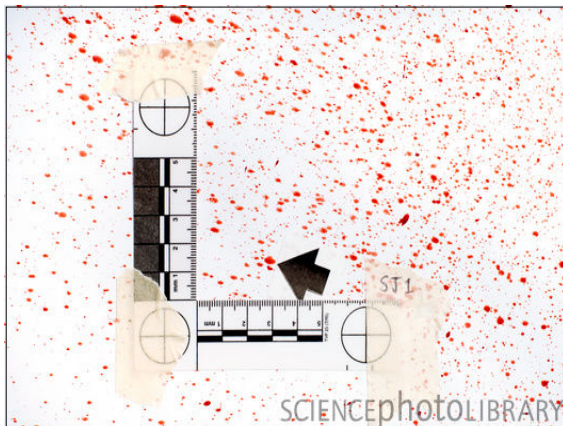
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Recording Bloodstains at the Scene

- Photography
 - Most likely, a blood spatter expert will *not* visit the scene
 - Therefore it is crucial that photos are taken properly, otherwise the evidence is useless
 - **Bloodstains must be photographed with a ruler**
 - **Use a normal lens**
 - **Keep film plane parallel to surface to avoid distortion**
- Sketches & Video
 - Augment the photography by providing context

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What's wrong with this photo?



What type of blood spatter is this? What happened here?

- Bloodstains found in the front yard
- On side of car
- On hood of car
- Continued along side of house



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What story do these bloodstains tell you?



What story do these bloodstains tell you?



Glossary

- **Angle of Impact:** The acute or internal angle formed between the direction of a blood drop and the plane of the surface it strikes
- **Arterial Spurt Pattern:** Bloodstain patterns resulting from blood exiting the body under pressure from a breached artery
- **Back Spatter:** Blood directed back towards the source of energy or force that caused the spatter. Back spatter is often associated with entrance gunshot wounds
- **Cast Off Pattern:** A bloodstain pattern created when blood is released or thrown from a blood bearing object in motion (such as a weapon)
- **Expired or Exhaled Blood:** Blood that is blown out of the nose or mouth as a result of air pressure and/or air flow which is the propelling force
- **Flow Pattern:** A change in the shape and direction of a wet bloodstain due to the influence of gravity or movement of an object

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Glossary

- **Forward Spatter:** Blood which travels in the same direction as the source of energy or force causing the spatter. Associated with gunshot exit wounds
- **High Velocity Spatter:** Bloodstain pattern caused by a high-velocity force/impact of approx 100 ft/sec or greater. Pattern is characterized by mist-like dispersal (1 mm or smaller). Because the droplets are so small, they cannot travel far horizontally. A gunshot typically produces this type of spatter.
- **Impact Pattern:** Bloodstain pattern created when blood receives a blow or force resulting in the random dispersion of smaller drops.
- **Low Velocity Spatter:** Bloodstains produced on a surface when the blood source has been subjected to a low velocity force, approx 5 ft/sec or less.
- **Medium Velocity Spatter:** Bloodstains produced on a surface when the blood source has been subjected to a medium velocity force between approx 5-25 ft/sec. A beating typically produces this type of spatter.

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Glossary

- **Passive Spatter:** Passive bloodstains are drops created or formed by the force of gravity alone
- **Point or Area of Convergence:** A point or area to which a bloodstain pattern can be projected. This point is determined by tracing the long axis of well-defined bloodstains within the pattern back to a common point or area
- **Point or Area of Origin:** The three dimensional point or area from which the blood (that produced a bloodstain) originated. This is determined by projecting angles of impact of well-defined bloodstains back to an axis constructed through the point or area of convergence
- **Satellite Spatter:** Small droplets of blood that are produced, upon impact with a surface, around or beside a drop of blood
- **Serum Stain:** A clear, yellowish stain with a shiny surface often appearing around a bloodstain after the blood has retracted due to clotting. The separation is affected by temperature, humidity, substrate, and/or air movement

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Glossary

- **Swipe:** The transfer of blood onto a surface not already contaminated with blood. One edge is usually feathered, which indicates the direction of travel
- **Smear/Smudge:** A bloodstain that has been distorted to such a degree that further classification is not possible
- **Terminal Velocity:** The maximum speed to which a free-falling blood drop can accelerate in air (approx 25.1 ft/sec)
- **Transfer Pattern:** A contact bloodstain created when a wet, bloody object contacts a second surface as the result of compression or lateral movement, sometimes producing a recognizable image of the bloody object
- **Void or Shadow:** Absence of a bloodstain in an otherwise continuous bloodstain pattern. Often the geometry of the void will suggest an outline of the object which has intercepted the blood (such as a shoe, furniture, a person, etc.

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Review Questions

- Knowing the blood type allows you to rule out suspects rather than identify them. Why is this?
- What is surface tension?
- What are the class characteristics of blood?
- What are the individual characteristics of blood?

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Resources

- E. Waldrip, Southern Institute of Forensic Science
- A. Linacre, University of Strathclyde
- M. Juno, San Jose State University

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