

**October/November 2016 Teacher's Guide for**

***Guilty or Innocent? Fingerprints Tell the Story***

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# About the Guide

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Articles from past issues of *ChemMatters* and related Teacher’s Guides can be accessed from a DVD that is available from the American Chemical Society for $42. The DVD contains the entire 30-year publication of *ChemMatters* issues, from February 1983 to April 2013, along with all the related Teacher’s Guides since they were first created with the February 1990 issue of *ChemMatters*.

The DVD also includes Article, Title, and Keyword Indexes that cover all issues from February 1983 to April 2013. A search function (similar to a Google search of keywords) is also available on the DVD.

The *ChemMatters* DVD can be purchased by calling 1-800-227-5558. Purchase information can also be found online at <http://tinyurl.com/o37s9x2>.

# Student Questions

**Guilty or Innocent? Fingerprints Tell the Story**

* 1. How was the first fingerprint evidence obtained that was used to secure a United States conviction?
  2. Explain why no two individuals (even identical twins) have the same set of fingerprints.
  3. Is it possible to remove your fingerprints from your fingers? Give an example of someone who unsuccessfully tried.
  4. How are the three types of fingerprints (patent, plastic, and latent) different from each other?
  5. How are eccrine and sebaceous sweat glands different?
  6. Describe the composition of a fingerprint.
  7. Describe two factors that influence the quality of a fingerprint.
  8. Why does fingerprint powder stick to latent fingerprints?
  9. How are fluorescent dyes used with visualizing fingerprints?
  10. How are fingerprints preserved once they have been dusted?
  11. Once a fingerprint has been obtained, how is it matched to a person?
  12. What other types of information can be obtained from a fingerprint besides identities?

# Answers to Student Questions

**(taken from the article)**

**Guilty or Innocent: Fingerprints Tell the Story**

* + 1. **How was the first fingerprint evidence obtained that was used to secure a United States conviction?**

*"The intruder, upon fleeing, touched the wet paint on a porch rail outside the house, leaving four fingerprints."*

* + 1. **Explain why no two individuals (even identical twins) have the same set of fingerprints.**

*Fingerprints form when babies are in the womb developing. All environmental details in the womb influence how fingerprints will look; therefore, no two fingerprints can be identical.*

* + 1. **Is it possible to remove your fingerprints from your fingers? Give an example of someone who unsuccessfully tried.**

*No, fingerprints cannot be removed from your fingers. "Like it or not, your fingerprints are with you for life." John Dillinger tried to remove his fingerprints with acid and a police suspect tried to bite off his fingerprints.*

* + 1. **How are the three types of fingerprints (patent, plastic, and latent) different from each other?**

*Patent fingerprints are visible to the naked eye and are left by wet fingers which have blood, ink, oil, or other liquid on them. Plastic fingerprints are 3-D and are formed in soft material such as wet paint, and they are also visible to the naked eye. Latent fingerprints are those that are not visible to the naked eye and require processing to become visible.*

* + 1. **How are eccrine and sebaceous sweat glands different?**

*Eccrine sweat glands are the most common; they produce sweat containing not only water but also amino acids, salts, and lipids. Sebaceous sweat glands produce the oily substance, sebum.*

* + 1. **Describe the composition of a fingerprint.**

*Fingerprints are a combination of sweat (water, amino acids, and salts) and lipids, including sebum.*

* + 1. **Describe two factors that influence the quality of a fingerprint.**

*Two factors influencing the quality of a fingerprint are:*

1. *Dry skin has fewer oils on it, and the fingerprint will be less distinct.*
2. *Porous surfaces absorb the fingerprint making it last longer but harder to visualize. Nonporous surfaces leave more distinct fingerprints.*
   * 1. **Why does fingerprint powder stick to latent fingerprints?**

*Fingerprints are largely nonpolar, and the nonpolar fingerprint powder binds to it because “like dissolves like”.*

* + 1. **How are fluorescent dyes used with visualizing fingerprints?**

*Some fingerprint powders also contain fluorescent dyes which cause the fingerprint to glow brightly under a black (UV) light.*

* + 1. **How are fingerprints preserved once they have been dusted?**

*Once revealed, fingerprints are preserved by photography and by lifting the fingerprint with adhesive tape and transferring it to a card.*

* + 1. **Once a fingerprint has been obtained, how is it matched to a person?**

*To match the person’s fingerprint, it is compared to a computer databank of fingerprints. Of the several possible closest matches, a trained fingerprint analyst will then look at the details that make each fingerprint unique before making the final determination.*

* + 1. **What other types of information can be obtained from a fingerprint besides identity?**

*The age of the fingerprint, the gender of the person, and the presence of cocaine or cocaine metabolites can be sometimes be identified from a person's fingerprint.*

# Anticipation Guide

Anticipation guides help engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Directions:**  *Before reading*, in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Your fingerprints don’t become permanent until you are around two years old. |
|  |  | 1. You leave something behind every time you interact with the environment. |
|  |  | 1. Latent fingerprints are easy to see. |
|  |  | 1. Your fingerprints leave an oily nonpolar residue behind. |
|  |  | 1. Fingerprints last longer on nonporous surfaces such as glass. |
|  |  | 1. Fingerprint powder is polar. |
|  |  | 1. The most common type of fingerprint powder is made of carbon. |
|  |  | 1. After dusting and photographing, fingerprints are attached to a card with adhesive tape. |
|  |  | 1. The amino acids excreted in sweat are the same in women and men. |
|  |  | 1. The age of fingerprints can be determined by examining the oily residue. |

# Reading Strategies

These graphic organizers are provided to help students locate and analyze information from the articles. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the articles. The use of bullets helps them do this. If you use these reading strategies to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

***Teaching Strategies (for entire October/November 2016 issue):***

* Links to **Common Core Standards for Reading**:
  + ELA-Literacy.RST.9-10.1:Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
  + ELA-Literacy.RST.9-10.5: Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
  + ELA-Literacy.RST.11-12.1:Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
  + ELA-Literacy.RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
* Links to **Common Core Standards for Writing**:
  + ELA-Literacy.WHST.9-10.2F: Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).
  + ELA-Literacy.WHST.11-12.1E: Provide a concluding statement or section that follows from or supports the argument presented.
* **Vocabulary** and **concepts** that are reinforced in this issue:
  + Forensic science
  + Molecular structures
  + Polar and nonpolar molecules
  + Wavelengths of light
  + Chemical reactions
  + Personal and community health
  + Heavy metals
  + Conservation of matter
  + Consumer choices
* Some of the articles in this issue provide opportunities for students to consider how understanding chemistry can help them make informed choices as consumers.
* To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The Background Information in the *ChemMatters* Teachers Guide has suggestions for further research and activities.
* In addition to the writing standards above, consider asking students to debate issues addressed in some of the articles. Standards addressed:
  + **WHST.9-10.1B** Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and **counterclaims** in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns.
  + **WHST.11-12.1.A** Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

**Directions**: As you read, complete the graphic organizer below to describe the chemistry of using fingerprints as evidence in forensic science.

|  |  |
| --- | --- |
|  | **Chemicals used with examples and properties** |
| **Fingerprint components** |  |
| **Revealing fingerprints** |  |
| **Future of using fingerprints for identification** |  |

**Summary:** On the bottom or back of this paper, write a short email (about 5 sentences) to a friend who is interested in forensic science explaining the value of fingerprint identification.

# Connections to Chemistry Concepts

**(for correlation to course curriculum)**

1. **Polarity**—Fingerprints contain both polar (primarily water and salts) and nonpolar (primarily lipid) compounds. The article ties the binding of fingerprinting powders to the polar and nonpolar components in the fingerprints. Also, the charge distribution in polar and nonpolar molecules is mentioned in the article.
2. **Biochemistry**—Connections are made between the watery secretions of the eccrine sweat glands and the oily, lipid secretions of the sebaceous glands found in fingerprints. Lipids are identified as a type of hydrocarbon compound.
3. **Intermolecular attractions**—The binding between nonpolar substances is identified as a type of dispersion-force attraction. The temporal nature and the weak strength of dispersion forces are discussed in the article. Also, the common expression “like dissolves like” is used in the context of nonpolar fingerprint powder binding to the nonpolar components in a latent fingerprint.

# Possible Student Misconceptions

**(to aid teacher in addressing misconceptions)**

1. **“A person's fingerprints can be changed, because I've seen it done in movies.”** *While fingerprints can be changed with treatments like acids, bleach, abrasion, or surgery, the changes are only temporary unless the treatment goes deeply enough to damage the dermis of the skin. Fingerprints are genetic and are set by the end of the sixth month of fetal development. Changes that are drastic enough to permanently alter the fingerprints would also damage the dermis, thereby becoming a new part of the fingerprint. Surgery and severe injury can alter the fingerprints, but the genetics of the fingerprints and any lasting injury or change to the dermis would be reflected in the new fingerprints.*
2. **“So, in the movies how can they use the finger from another person or cast an impression from another person's finger to fool the security?”** *It's all part of the magic of movies! In most cases it is not possible to use a severed finger or a dead person's hand to thwart biometric security devices. The trauma of severing a finger and the immediate changes in physiology that occur would quickly alter the fingerprints and render the severed finger useless. Changes in circulation, body temperature, and nerve reactions would make the severed finger unusable. In addition, the best biometric security systems use "liveness" tests to prevent plastic copies, photographs, etc. from being used.*
3. **“Fingerprints are foolproof identification and can be positively linked to just one individual.”** *There have not been any peer-reviewed, scientific studies to collaborate the widely-held belief that fingerprints are unique, and no two people have the same fingerprints. While the probability is low, the actual probability is not known. When a high-quality fingerprint is checked against a computer databank of fingerprints, the computer typically returns several possible matches. An expert fingerprint analyst then examines the possible matches and compares them to the print in question. The final match hinges on the skill, biases, and experience of the fingerprint analyst. Being human, mistakes are possible and have been documented.*

# Anticipating Student Questions

**(answers to questions students might ask in class)**

1. **“What are the laws that determine whether my fingerprints can be taken and whether they can be kept?”** *Almost all states (48) in the United States allow legal authorities to obtain the fingerprints of juveniles for felonies and severe crimes. The ages at which these fingerprints can be taken from the juvenile vary, but some start as early as age 11. In some cases, photographs of obtaining the juvenile fingerprints must accompany the fingerprints. In many cases, the fingerprints must be deleted from the records when the juvenile becomes an adult. Students would need to research laws for specific states.*
2. **“Are there court cases where fingerprint evidence was used that resulted in a wrong conclusion?”** *Yes. See "Misidentified fingerprint cases" in the “Background Information” section, above.*
3. **“Does wiping off a gun or glass remove the fingerprints?”** *The simple answer is yes, if done correctly. Most people are not careful enough to completely remove all of the fingerprints, and they may leave partial prints behind. In addition, bullet casings and magazines that are not wiped down properly will have fingerprints remaining on them. Wiping an object may smudge the fingerprints rendering them less useful or incomplete. Developing a latent fingerprint from a gun is only about 5% successful even when the gun is not wiped off. However, traces of DNA may be left on the gun or glass even after wiping it off, and DNA evidence is more powerful than fingerprint evidence in most cases.*

# Activities

**Labs and Demos**

1. **Latent fingerprint developing and analysis:** This lab activity, “Latent Prints”, is written for grades 4–8, but could be used with older students, as well. Complete student handouts and teacher support are provided, as students crush graphite and then dust it onto latent fingerprints. A student question asks them to discuss the size of the forces of attraction between the graphite powder and the fingerprint. This is where high school teachers could more fully develop the electrical explanation to discuss solubility (like dissolves like) and intermolecular forces. (<http://www.omsi.edu/sites/all/FTP/files/chemistry/NH-PDF/NH-G23-LatentPrints.pdf>)
2. **Lifting fingerprints with body powder and colored chalk dust:** This activity, "Detective Lab Section 4: Dust and Lift", from Westminster College provides an alternate method of developing and lifting latent fingerprints using body powder and dust from colored chalk. The lab is straight-forward; however, there are no teacher guides, answers, or other support provided. (<http://www.westminster.edu/about/community/sim/pdf/detectivelab4dustandlift.pdf>)
3. **Recover latent fingerprints using several methods:** Students briefly learn the history of fingerprinting and then recover their own fingerprints with iodine fuming, cyanoacrylate (Superglue) fuming, fingerprint powder, and graphite in "Fingerprinting Lab". Students use the recovered fingerprints to match to an unknown fingerprint. The lab activity materials include basic safety precautions, student worksheets, and teacher answers and directions. (<http://www.terrificscience.org/lessonpdfs/FingerprintingLab.pdf>)
4. **A crime scene is solved with fingerprint analysis:** A bakery was robbed and fingerprint evidence was left behind in "Sticky Fingers". Students learn about fingerprints by capturing and analyzing their own fingerprints on a white latex balloon using pencil lead powder. After learning characteristics of fingerprint patterns, the students use supplied fingerprints to solve the crime. The lab activity includes student worksheets and teacher answers. (<http://forensics.rice.edu/en/materials/activity_ten.pdf>)
5. **Develop latent fingerprints with black tempera paint powder:** A classroom activity, "Hunt for the Serial Arsonist", that accompanied the 1995 NOVA video, *Hunt for the Serial Arsonist*, directs students to recover their latent fingerprints from a sheet of paper (similar to the actual case) using black powdered tempera paint. Students graph their fingerprint type data, make predictions regarding distribution patterns, and compare their class data to the general population. The lab activity can be completed without viewing the associated video. (<http://www.pbs.org/wgbh/nova/education/activities/2214_arsonist.html>)
6. **Intermolecular forces, a demonstration and student activity:** This activity based on the 5E model starts with a teacher demonstration of bending water and advances to student exploration and identification of intermolecular forces acting in water, ethanol, acetone, and pentane. "Intermolecular Forces" includes student materials and a brief set of teacher materials. (<http://sites.jmu.edu/chemdemo/files/2011/06/Intermolecular-Forces-Lesson-Plan.docx>)
7. **A jigsaw activity comparing intermolecular forces:** Students are randomly assigned to one of four groups (London dispersion forces, Debye (induced) dipole, dipole-dipole, or hydrogen bonds) where they access Web sites to become proficient on their intermolecular force. The activity, “Intermolecular Forces (IMFs)”, includes questions that students must be able to answer. Some of the YouTube video links in the lesson are no longer active. (<http://edtech2.boisestate.edu/lindabennett1/502/Bonds%20and%20IMFs/bonding%20jigsaw.html>)

**Simulations**

1. **Atomic interactions including van der Waals forces:** This PhET simulation, “Atomic Attractions”, permits students to manipulate a variety of combinations between two atoms and see the resulting attractive and repulsive forces. Students can vary the distances between the atoms, the size of the atoms, the strength of the interactions, and show the forces as total force or as a combination of attractive (van der Waals) force and repulsive (electron overlap) force. Learning goals, teacher tips, and additional teacher-submitted materials are available to assist teachers and students to use this simulation most effectively. (<https://phet.colorado.edu/en/simulation/atomic-interactions>)

**Media**

1. **A video explanation of fingerprint analysis:** This YouTube video, “How to Compare Fingerprints—The Basics”(5:43), provides a clear explanation of the common fingerprint patterns, defines pattern terminology, and walks the viewer through the steps used to compare fingerprints. It is a clear and concise guide to the three-step ACE (Analysis, Comparison, Evaluation) comparison process. (<https://www.youtube.com/watch?v=IrpTqKkgygA>)
2. **A video of developing latent fingerprints with Superglue:** “DIY Hacks & How To's: Developing Finger Prints with Super Glue” is a YouTube video (2:12) using materials typically found in many homes to develop latent fingerprints on hard surfaces. The video is easy to follow and understand. (<https://www.youtube.com/watch?v=l9Ovq4lq-9M>)
3. **van der Waals (London dispersion) forces video:** The Kahn Academy video “van der Walls Forces” (11:38) explains how London dispersion forces form and their importance. The video is typical Kahn Academy style with an easy-to-understand explanation and graphics. Fluorine is incorrectly symbolized in the video as “Fl”, and the explanation on stability describes noble gas atoms as "happy". (<https://www.khanacademy.org/science/chemistry/states-of-matter-and-intermolecular-forces/introduction-to-intermolecular-forces/v/van-der-waals-forces>)
4. **An intermolecular forces trick:** This five-minute video, "Intermolecular Forces Magic Trick", from Flinn Scientific's teacher resources videos by Mike Roadruck shows the intermolecular forces in contact cement and in water with two separate demonstrations involving a bit of magic flair. (<http://www.flinnsci.com/teacher-resources/teacher-resource-videos/best-practices-for-teaching-chemistry/teaching-strategies/intermolecular-forces-magic-trick/>)
5. **High school fingerprinting PowerPoint:** This high school presentation, “Fingerprints”, provides an overview of fingerprinting history, types, and analysis. (<http://www.georgetownisd.org/cms/lib/TX01001838/Centricity/Domain/854/fingerprints2013.ppt>)
6. **Dermatoglyphics PowerPoint:** This college introduction to fingerprint identification, “Dermatoglyphics: An Introduction to Fingerprints”, also includes history, types, identification, and methods of detecting fingerprints. (<http://webpages.ursinus.edu/scienceinmotion/Experiments/ExperimentWordDocs/Fingerprinting/Dermatoglyphics.ppt>)
7. **Physical Evidence PowerPoint:** "Physical Evidence: Let the evidence Speak for Itself" looks at how physical evidence is collected and handled. It includes Locard's Principle, upon which fingerprinting and other forensic science methods are based. (<http://sciencespot.net/Media/FrnsScience/physicalevidence09.ppt>)
8. **Intramolecular vs. intermolecular forces:** The video, "Intramolecular vs. Intermolecular Forces", (8:58) from the ACS Middle School Chemistry website is designed to help teachers understand the differences between these two forces. While it is marketed to middle school, the content may be useful to many high school teachers. (<http://www.middleschoolchemistry.com/teacherbackground/chapter4/intramolecular_intermolecular.php>)
9. **PowerPoint on apocrine and eccrine sweat glands:** This presentation, "Sweat", provides an overview of apocrine and eccrine glands in sweat. Information along with diagrams is included in the slideshow. ([http://faculty.ksu.edu.sa/noa/Documents/**Sweat**.ppt](http://faculty.ksu.edu.sa/noa/Documents/Sweat.ppt)) Note: the site is slow to load. When it has loaded, it will ask for a password; simply click “cancel” and the slide show loads.
10. **Infographic on fingerprinting:** The *Compound Interest* Web site has an infographic, “Crime Scene Chemistry: Fingerprint Detection”, which has information on types of fingerprints, fingerprint powders, and a few types of fingerprint development processes. Accompanying the infographic is an article providing more information for the material summarized on the infographic. Teachers may want to check on the possibility of having the infographic enlarged and printed by their library media center or a local print shop in a poster size for a colorful classroom visual. (<http://www.compoundchem.com/2016/07/26/fingerprints/>)

**Lessons and Lesson Plans**

1. **Forensics fingerprinting lesson, grades 9–12:** This eight-day lesson provides all the resources, references, links to standards, activities, reading materials, and assessments to complete a unit of study on fingerprinting. The unit, "Forensics Fingerprinting Lesson Grades 9-12", starts with the basics of fingerprinting but moves forward to analyze the flaws in fingerprinting by investigating the case of Brandon Mayfield. (See "Misidentified fingerprint cases" in “Background Information” above.) (<https://www.oercommons.org/authoring/9440-forensics-fingerprinting-lesson-grades-9-12/view>)
2. **Forensics curriculum for high school:** The ACS ChemClub Web site (<https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/forensics.html>) points readers to “Forensics Illustrated–Step under the Tape”, which contains a complete curriculum for high school forensic sciences. Reading materials, PowerPoint presentations, worksheets, photographs, projects, labs, assessments, and teacher materials. A link to other forensic science Web sites might be of interest to teachers. While not devoted specifically to fingerprinting, many of the resources involve fingerprinting. This is a rich resource. (<http://bsapp.com/forensics_illustrated/index.html>)
3. **Intermolecular forces lesson unit:** The American Association of Chemistry Teachers (AACT) provides its members access to a unit titled *Intermolecular Forces*. (You must be an AACT member to access the material.) A 30-minute lesson activity, “Intermolecular Forces”, provides students with an opportunity to acquire background information through a simulation tutorial and a student worksheet. The unit also includes two labs, “Physical Properties” and “Solubility and Compound Type”, which allow students to study the intermolecular forces of various substances and to investigate the concept of like dissolves like. A simulation, “Intermolecular Forces”, is provided that requires computers with Odyssey software installed and allows students to study dipole-dipole forces, hydrogen bonds, and London dispersion forces. The AACT unit provides teacher preparation materials, time required for each activity, teacher notes, and objectives.

(<https://www.teachchemistry.org/content/aact/en/classroom-resources/high-school/molecules-and-bonding/intermolecular-forces.html>)

**Projects and Extension Activities**

1. **Forensic activities to conduct at home:** The ACS ChemClub Web site (<https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/forensics.html>) contains a reference to this book, *Illustrated Guide to Home Forensic Science Activities*, containing many forensic science experiments that may be done at home. However, some activities may require supplies that are toxic or may require purchase from online sources. ***Safety should be carefully considered before performing any of the activities*.** The activities in the book specifically related to fingerprinting include: revealing fingerprints; lifting fingerprints; revealing fingerprints with iodine, ninhydrin, superglue, gentian violet, and acidified hydrogen peroxide. The online version of the book can be accessed at: (<http://www.thehomescientist.com/forensics/Illustrated_Guide_to_Home_Forensic_Science_Experiments.pdf>)
2. **Determining if fingerprint patterns are genetic:** This simple activity from *Scientific American* has family members look at their fingerprints (with a magnifying glass, if available) to see if there are similar patterns of loops, whorls, and arches in their fingerprints. The article “Succession Science: Are Fingerprint Patterns Inherited?” is available at: (<http://www.scientificamerican.com/article/succession-science-are-fingerprint-patterns-inherited/>).
3. **Capturing your own fingerprints with pencil graphite:** This basic activity can easily be conducted at home using simple materials. The activity, "Getting Familiar with Fingerprints", is targeted at elementary grades, but could be interesting and fun to do. (<https://www.nsta.org/sciencematters/docs/Shippensburg-FingerPrinting.pdf>)

# References

**(non-Web-based information sources)**

**The references below can be found on the   
*ChemMatters* 30-year DVD, which includes all articles   
published from the magazine’s inception in October 1983 through April 2013, all available Teacher’s Guides, beginning February 1990, and 12 *ChemMatters* videos. The DVD is available from the American Chemical Society for $42 (or $135 for a site/school license) at this site:** [**http://ww.acs.org/chemmatters**](http://www.acs.org/chemmatters)**. Click on the “Teacher’s Guide” tab directly under the *ChemMattersonline* logo and, on the new page, click on “Get the past 30 Years of *ChemMatters* on DVD!” (the icon on the right of the screen).**

**Selected articles and the complete set of   
Teacher’s Guides for all issues from the past three   
years are available free online at the same Web site, above. Click on the “Issues” tab just below the logo, *“ChemMattersonline”*.**



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This 1997 article is an interesting comparison to the current article. Advances in techniques and knowledge can be compared as well as similarities. The article describes a kidnapped child who was found using clothing fibers, not fingerprints, because children's fingerprints have a different composition than adults and disappear more quickly. (Noble, D. The Disappearing Fingerprints. *ChemMatters*, 1997, *15* (1), pp 9–12)

There is a variety of forensic science techniques, including fingerprints, in this article. Several examples of cases are used where forensic evidence was important. (Baxter, R. Forensics: Finding the Chemical Clues. *ChemMatters*, 2002, *20* (2), pp 12–13)

A discussion of the van der Waals forces that help geckos climb on slick surfaces like glass is included in this article about glues. Dispersion forces which cause fingerprinting powders to stick to latent fingerprints are a type of van der Waals force, and these dispersion forces are included in the discussion about glue. (Shiber, L. Sticky Situations: The Wonders of Glue. *ChemMatters*, 2006, *24* (4), pp 8–10)

The use of van der Waals forces related to nonpolar fats similar to the lipids and oils in fingerprints is found in this article dealing with dietary fats. Explanations regarding the nonpolar nature of fats, including diagrams, may benefit students requiring assistance with this concept. (Kimbrough, D. The Solid Facts about Trans Fats. *ChemMatters*, 2007, *25*, (4), pp 14–16)

While fingerprints are not the focus of this CSI-type article, the forensic techniques and the philosophy behind solving crimes is complementary to the feature article on fingerprinting. An activity using paper chromatography to identify inks is included in this article. (Brownlee, C. Forensic Chemistry: Solving Mysteries with Fascinating Science. *ChemMatters*, 2010, *28* (3), pp 17–19)

Solubility, polarity, and intermolecular forces are important in coloring foods. These same concepts are at work in fingerprinting and are explained in the article. (Rohrig, B. Eating with Your Eyes: The Chemistry of Food Coloring. *ChemMatters*, 2015, *33*, (4), pp 5–7)

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“Solving the Mystery of Fading Fingerprints with London Dispersion Forces” is a closely linked article to the featured Rohrig article. The fading fingerprints refer to children's fingerprints and the way they disappear more rapidly than those of an adult. A discussion of London dispersion forces is also prominent in the article. (DeLorenzo, R.; Kimbrough, D.Solving the Mystery of Fading Fingerprints with London Dispersion Forces. *J. Chem. Educ.*, 1998, *75* (10), pp 1300–1301; <http://pubs.acs.org/doi/pdf/10.1021/ed075p1300>; note that this link is a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

The National Academies of Science published a powerful book in 2009 that critiqued the collection and use of forensic evidence in the United States and resulted in a major examination of forensic science practices and uses in the U.S. It is often referenced in forensic science papers and is important to read and know for people working in forensic sciences. This book has challenged forensic scientists to refine their collection and analysis methodology and to use more scientific processes in forensic sciences. (National Research Council, *Strengthening Forensic Science in the United States: A Path Forward*; National Academies Press: Washington, DC 2009). The book is available for purchase in printed form, or it can be downloaded for free at the National Academies Press Web site. (<http://www.nap.edu/catalog/12589/strengthening-forensic-science-in-the-united-states-a-path-forward>)

An article describing the chemistry behind some fingerprint visualization techniques is discussed in “Forensic Chemistry: The Revelation of Latent Fingerprints”. Two categories of visualization—those that react with the fingerprint residues and those that use intermolecular forces to adhere to the fingerprint residue—are explained in this article. (Friesen, J. Forensic Chemistry: The Revelation of Latent Fingerprints. *J. Chem. Educ.*, 2015, *92* (3), pp 497–504; <http://pubs.acs.org/doi/pdf/10.1021/ed400597u>; note that this link provides a brief abstract only, the full article is only available to American Chemical Society members or subscribers to this journal)

Two latent fingerprint activities designed for high school students using a structured-inquiry approach designed are described in “Activities Designed for Fingerprint Dusting and the Chemical Revelation of Latent Fingerprints”. One activity uses fingerprint dusting and the second uses chemical revelation techniques which are best conducted in a fume hood. (Friesen, J. Activities Designed for Fingerprint Dusting and the Chemical Revelation of Latent Fingerprints. *J. Chem. Educ.*, 2015, *92* (3), pp 505–508; <http://pubs.acs.org/doi/pdf/10.1021/ed500406v>; note that this link is a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal)

After the 2009 National Academies of Science report (above) condemning current forensic evidence techniques (including fingerprinting), the field of forensic science has steadily worked and improved to make forensics more science than craft. This article, written in layman's language, discusses some of the issues with forensic evidence and has great photographs, as well. (Greenwood, V. Beyond Reasonable Doubt. *National Geographic*, July 2016, pp 30–55)

# Web Sites for Additional Information

**(Web-based information sources)**

**Fingerprints**

The definitive resource for all things related to fingerprints comes from this publication from the National Criminal Justice Reference Center: *Fingerprint Sourcebook,* which is available online. The book includes these chapters:

1: History

2: Anatomy and Physiology   
of Adult Friction Ridge Skin

3: Embryology, Physiology,   
and Morphology

4: Recording Living and Postmortem  
Friction Ridge Skin Exemplars

5: Systems of Friction Ridge Classification

6: Automated Fingerprint Identification  
System (AFIS)

7: Latent Print Development

8: The Preservation of Friction Ridge  
Information

9: Examination Methodology

10: Documentation of Friction Ridge  
Impressions: From the Scene to the  
Conclusion

11: Equipment

12: Quality Assurance

13: Fingerprints and the Law

14: Scientific Research in the Forensic  
Discipline of Friction Ridge  
Individualization

15: Special Abilities and Vulnerabilities in  
Forensic Expertise

(<https://www.ncjrs.gov/App/Publications/abstract.aspx?ID=247300>)

The U.S. Marshalls Service provides a condensed, chronological history of fingerprinting at <https://www.usmarshals.gov/usmsforkids/fingerprint_history.htm>.

The Federal Bureau of Investigation (FBI) has information on multiple aspects of fingerprinting with links to additional information and resources on its Biometric Center of Excellence Web page. The FBI site includes fingerprint information on history, the concept, hardware, software, standards overview, and notable U.S. government fingerprint programs. (<https://www.fbi.gov/about-us/cjis/fingerprints_biometrics/biometric-center-of-excellence/modalities/fingerprint>)

The FBI has a Web site providing summary information on fingerprinting as well as additional biometric initiatives. The site also has links to further information on many of the topics. (<https://www.fbi.gov/about-us/cjis/fingerprints_biometrics>)

The fear of biometric invasion is discussed in this *Scientific American* article from 2014: <http://www.scientificamerican.com/article/biometric-security-poses-huge-privacy-risks/>.

In addition, *USA Today* had an article in 2014 discussing future biometric measures (body odor) and the use of smartphones for pleasure and health (gait analysis, electrocardiograms, and fingerprints). The article wisely addresses the hot topic of who has the rights to collect, access, and use your biometric data. Find this provocative article at <http://www.usatoday.com/story/news/world/2014/04/19/ozy-biometric-identification/7904685/>.

An interesting article on using month-old fingerprints to catch poachers on ivory illegally harvested from elephants in Africa is found at <http://www.scientificamerican.com/article/new-powders-can-lift-poacher-prints-from-ivory-a-month-after-the-crime/>.

This site describes the process of recovering fingerprints from wiped metals, a particularly challenging task. The process uses the corrosion on the metals from the salts and other components found in the fingerprint. (<http://www.rsc.org/chemistryworld/News/2008/June/06060801.asp>)

In a bizarre case, an Idaho wakeboarder's severed finger is found inside a fish and identified, using his fingerprint. (<http://www.cbsnews.com/news/human-finger-found-inside-idaho-trout-belongs-to-wash-wakeboarder/>)

The ACS National Chemistry Week (NCW) theme for 2016 is “Solving Mysteries through Chemistry”. (<https://www.acs.org/content/acs/en/education/outreach/ncw.html>) The just-developed NCW 12-page brochure by the same name offers activities using chemistry to solve questions. The activity “Dusting for Fingerprints” on page 7 of the downloadable 2016 NCW pdf brochure describes a simple process to produce a latent fingerprint on glass and visualize it using black tempera powder or cocoa powder. (<https://www.acs.org/content/dam/acsorg/education/outreach/ncw/educationalresources/2016/ncw-2016-brochure-low-res.pdf>)

**Forensic science**

The ACS ChemClub Web site has a section devoted to forensics. This is an extensive resource containing activities, articles, and videos related to the popular field of forensic science. Some of these specifically relate to fingerprinting, but additional forensic science processes are also explored. The links and materials are appropriate for both students and teachers. (<https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/forensics.html>)

NOVA has an interesting article, “Forensic Tools: What's Reliable and What's Not-So-Reliable”, published in 2012. The problems with fingerprints, "lying" matching hairs, arson investigations, and drug testing are discussed in the article. (<http://www.pbs.org/wgbh/frontline/article/forensic-tools-whats-reliable-and-whats-not-so-scientific/>)

**Biometrics**

For a brief discussion from the Biometric Institute on the theft of your biometrics, see: <http://www.biometricsinstitute.org/pages/faq-6.html>.

What other types of biometric identification are available other than fingerprints? For that answer read the *USA Today* article, “Biometric Identification that Goes Beyond Fingerprints”, at <http://www.usatoday.com/story/news/world/2014/04/19/ozy-biometric-identification/7904685/>.

**Intermolecular forces**

A concise comparison of the strength of London dispersion forces and hydrogen bonds to French fries is made in the article, “Can London Dispersion Forces Be Stronger than Dipole-Dipole Forces, Including Hydrogen Bonds?” (Earles, T. Can London Dispersion Forces Be Stronger than Dipole-Dipole Forces, Including Hydrogen Bonds? *J. Chem. Educ.*, 1995. *72* (8), p 727; <http://pubs.acs.org/doi/pdf/10.1021/ed072p727>; note that this is a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

This is a technical discussion of the science behind the immiscibility of oil and water that goes further than the traditional "like dissolves like". The author suggests omitting most high school textbook explanations that may be misleading if the complete explanation cannot be included. (Silverstein, T. The Real Reason Why Water and Oil Don't Mix. *J. Chem. Educ.*, 1998. *75* (1), pp 116–118; <http://pubs.acs.org/doi/pdf/10.1021/ed075p116>; note that this is a brief abstract only, the full article is only available to American Chemical Society members or subscribers to the journal.)

“Intermolecular Bonding—Van der Waals Forces”, is a good explanation of van der Waals forces, with diagrams. Access it at <http://www.chemguide.co.uk/atoms/bonding/vdw.html>.

**Other sites**

This site provides an in-depth look at Locard's Exchange Principle, including the history behind the principle and other factors involved in crime scene reconstruction can be found at <http://www.profiling.org/journal/vol1_no1/jbp_ed_january2000_1-1.html>.

For a one-minute video, “Sweating”, describing eccrine and apocrine sweat glands in the body, see <http://www.nlm.nih.gov/medlineplus/ency/anatomyvideos/000127.htm>.