FORENSICS PROCTOR INSTRUCTIONS

The forensics test should be administered in a lab classroom. Each person or partnership should work at a workstation. They'll have some materials at their tables and some on the center table. See below.

CENTER SUPPLIES TABLE:
Set up the following things at the center table.
- Ziploc labeled "Fiber 1" with cotton fibers in it (obtain fibers from the internet or a cut-up t-shirt that's 100% cotton)
- Ziploc labeled "Fiber 2" with polyester fibers in it
- Ziploc labeled "Fiber 3" with wool fibers in it
- Ziploc labeled "Fiber 4" with nylon fibers in it
- Beaker of iodine with a pipette
- Beaker of Benedict's with a pipette
- Hot water bath (large beaker of almost boiling water on a hot plate)
- Strips of chromatography paper (enough for 3 per person or team)
- 3 pens labeled with "Jake," "Gina," or "Amy." SEE CHROMATOGRAPHY SECTION OF ANSWER KEY FOR MORE INFO ON THIS.
- Tape

EACH STATION:
Set up the following things at each station.
- LABELED weigh boats with small amounts of each of the 6 powders. Label them "powder 1," "powder 2," etc. **If you can't find the powders listed on the test**, substitute them with powders you can find and ask someone familiar with the event to help you change the answer key (making sure the powders match the correct suspects).
- Small LABELED beaker with 1M or 2M HCl and pipette
- Small LABELED beaker with 1M or 2M NaOH and pipette
- Large beaker labeled "waste"
- Small beaker with nothing in it (they'll do chromatography using this)
- Wash bottle with distilled water
- Bunsen burner (do not light them. have people light them themselves)

Before the test starts, tell everyone what materials are at the center table and what's on each station. All test takers should have long sleeved shirts, pants, close-toed shoes, labcoats or aprons, and goggles. Let people split the test.

FORENSICS TEST

Produced by duPont Manual High School

Name(s): _____

Score: _____/120

Yesterday, in New York City's 99th Precinct, an heirloom watch was stolen from Captain Raymond Holt. 3 primary suspects from the precinct have appeared during preliminary investigation, descriptions of which are listed below. Use these descriptions and the evidence from the scene to answer the questions and determine which suspect committed the crime. Since you've read all these instructions, draw a star in the top right corner of this test for a bonus point.

Jake Peralta: Jake, one of the NYPD's best detectives who also has a Die Hard obsession, has a running competition with Captain Raymond Holt to determine who is the ultimate "detective/genius." In his spare time, he enjoys baking homemade cheese crackers for his friends. He wears his polyester and silk lined detective jacket everywhere. Jake is pretty irresponsible and his desk is covered in a suspicious white powder. **This powder has been collected and is labeled Powder 1.**

Gina Linetti: Gina is Captain Holt's assistant. She loves dancing with her dance troupe, Dance-y Reagan, while wearing a cotton and wool costume. Gina loves squirrels and often plays with them in the park. She loves floral print blouses and usually wears them with a polyester or linen cardigan. Gina also secretly attends college to try to finish her bachelor's degree. Her school has many stray cats who love to interact with students. In her free time, she enjoys a good bath and making plaster sculptures. She recently hurt her back and is using heating packs. A white powder has been collected from Gina's space heater and is **labeled Powder 2.**

Amy Santiago: Amy is also one of the NYPD's best detectives. She wears a silk shirt and a silk blazer to work every day, and Gina frequently describes her style as boring. Amy recently visited her parents, who own several horses. She sprained her ankle trying to ride one of these horses and is using a heating pack to treat it. She likes to cook for her friends but is terrible at it. Her "cookies" are made with salt, flour, and baking soda. Amy is also a very clean person and has tried many times to clean off the suspicious white powder off of Jake's desk **(this is Powder 1).** Another powder has also been collected off of Amy's blazer. **This powder is labeled Powder 3.**

At the crime scene, a note, three powders **(Powders 4, 5, and 6)**, four fiber samples, and two hair samples were found. More information about each of these pieces of evidence is located in their corresponding test section.

Section 1: Chromatography

There are three pens on the supplies table, one from each of the suspects. Each pen is labeled with the suspect's name. Create chromatograms from each of these pens and **tape them below**. Each chromatogram is worth **3 points**. Then, fill out the table and compare the chromatograms to the (already calculated) data from the pen from the note at the crime scene. Finally, answer the questions below.

Suspect	Number of components in ink [1 POINT EACH]	R_f of the component that traveled the farthest (show work) [2 POINTS EACH]
Pen from the crime scene	3	0.778
Jake		
Gina		
Amy		

[2 POINTS] Whose pen was used to write the note found at the crime scene?

[2 POINTS] Identify the stationary and mobile phases that you used to create these chromatograms.

[1 POINT] What does a high R_f indicate about a component?

[3 POINTS] What does TLC stand for? What are its stationary and mobile phases?

Section 2: Powders

Directions: Determine the identity of each of the 6 powders (Powder 1 was collected from Jake and Amy. Powder 2 was collected from Gina. Powder 3 was collected from Amy. Powders 4-6 were collected from the crime scene).

| Powder number	Powder ID, CHEMICAL NAME AND CHEMICAL FORMULA [2 POINTS EACH]	List what test results helped you identify this powder [1 POINT EACH]	Who (may be multiple suspects, one suspect, or no one) does this powder incriminate? [1 POINT EACH]
1			—
2			—
3			—
4			
5			
6			

Section 3: Polymers

Retrieve samples of fibers 1, 2, 3, and 4 from the supplies table. Identify each fiber from the crime scene and complete the table below. Then, answer the questions.

Fiber number	What is the identity of the fiber? [2 POINTS EACH]	List what test results helped you identify this fiber [1 POINT EACH]	Who (may be multiple suspects, one suspect, or no one) does this fiber incriminate? [1 POINT EACH]
1			
2			
3			
4			

[1 POINT] What is the name of the pigment that colors hair and skin?

Two hair samples were also found at the crime scene. The physical samples are not available, but microscope photos of the two hair samples are below. Identify the type of these hairs from the photos. Then, answer the questions below.
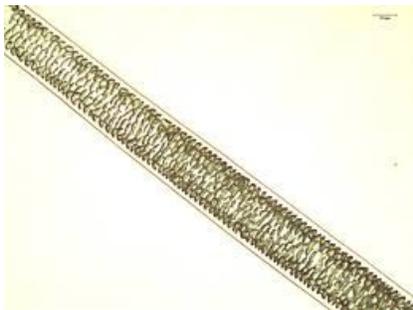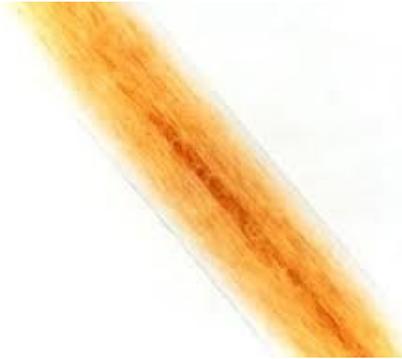
Hair 1:

[1 POINT] What type of hair is this?
[2 POINTS] List the features that helped you identify what type of hair this is.

[1 POINT] Who (may be multiple suspects, one suspect, or no one) does hair 1 incriminate?
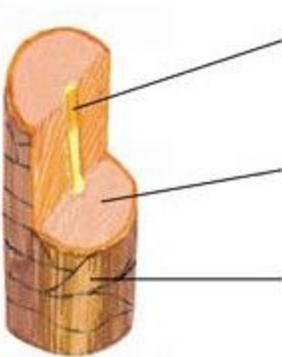
Hair 2:

[1 POINT] What type of hair is this?

[2 POINTS] List the features that helped you identify what type of hair this is.

[1 POINT] Who (may be multiple suspects, one suspect, or no one) does hair 1 incriminate?

[3 POINTS] Label this diagram of a hair.

Plastics:

[4 POINTS] What are the burn test results of the following plastics?
PETE: _____
PMMA: _____
PVC: _____
HDPE: _____

[2 POINTS] Draw the structure of HDPE versus LDPE.

Section 4: Fingerprints

Jake's, Amy's, and Gina's fingerprints are shown below.

| JAKE | AMY | GINA |

[3 POINTS] Identify each suspect's fingerprint type.
Jake: _____
Amy: _____
Gina: _____

[3 POINTS] How common is each fingerprint type? (What percent of Americans have each type?)
Jake's type: _____
Amy's type: _____
Gina's type: _____

[1 POINT] The following print was found at the crime scene. Whose print does it match?

[3 POINTS] Identify the circled minutiae on this fingerprint.

[2 POINTS] What features must match for two fingerprints to be considered matches?

[2 POINTS] What does IAFIS stand for? What is it?

Section 6: Other physical evidence

[3 POINTS] What does PCR stand for? Who invented it? What is PCR's purpose?

[1 POINT] Which DNA bases are purines? Which are pyrimidines?

[1 POINT] What's the formula to calculate the angle of impact of a blood spatter?

[3 POINTS] Define refractive index. What are the refractive indices of water and pyrex glass (borosilicate glass)?

[2 POINTS] What's the common name and the family of the insects that are usually first to arrive at a dead body?

Section 6: Analysis

[15 POINTS] Based on the evidence, identify the suspect who stole the watch.

END OF TEST
Remember to clean up your station once you're finished!

FORENSICS KEY

Yesterday, in New York City's 99th Precinct, an heirloom watch was stolen from Captain Raymond Holt. 3 primary suspects from the precinct have appeared during preliminary investigation, descriptions of which are listed below. Use these descriptions and the evidence from the scene to answer the questions and determine which suspect committed the crime. Since you've read all these instructions, draw a star in the top right corner of this test for a bonus point.

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Gina Linetti: Gina is Captain Holt's assistant. She loves dancing with her dance troupe, Dance-y Reagan, while wearing a cotton and wool costume. Gina loves squirrels and often plays with them in the park. She loves floral print blouses and usually wears them with a polyester or linen cardigan. Gina also secretly attends college to try to finish her bachelor's degree. Her school has many stray cats who love to interact with students. In her free time, she enjoys a good bath and making plaster sculptures. She recently hurt her back and is using heating packs. A white powder has been collected from Gina's space heater and is **labeled Powder 2.**

Amy Santiago: Amy is also one of the NYPD's best detectives. She wears a silk shirt and a silk blazer to work every day, and Gina frequently describes her style as boring. Amy recently visited her parents, who own several horses. She sprained her ankle trying to ride one of these horses and is using a heating pack to treat it. She likes to cook for her friends but is terrible at it. Her "cookies" are made with salt, flour, and baking soda. Amy is also a very clean person and has tried many times to clean off the suspicious white powder off of Jake's desk **(this is Powder 1).** Another powder has also been collected off of Amy's blazer. **This powder is labeled Powder 3.**

Section 1: Chromatography

There are three pens on the supplies table, one from each of the suspects. Each pen is labeled with the suspect's name. Create chromatograms from each of these pens and tape them below. Each chromatogram is worth 3 points. Then, fill out the table and compare the chromatograms to the (already calculated) data from the pen from the note at the crime scene. Finally, answer the questions below.

Chromatograms are worth 9 points total. As long as they are labeled with the name of each suspect and look something like this, they get full credit.

NOTE TO PROCTORS: This section may need to be altered depending on what pens you have available. Ask someone who's done forensics before to run the chromatograms for whatever pens you can find to help you fill out this table. The info for the pen from the crime scene should match the info for Gina's pen. Give the student credit if the Rf is within 0.1 of the one on the (adjusted) answer key.

Suspect	Number of components in ink [1 POINT EACH]	R_f of the component that traveled the farthest (show work) [2 POINTS EACH]
Pen from the crime scene	3	0.778
Jake	2	1.0
Gina	3	0.778
Amy	1	0.8

[2 POINTS] Whose pen was used to write the note found at the crime scene?
Gina's

[2 POINTS] Identify the stationary and mobile phases that you used to create these chromatograms.
Stationary = paper. Mobile = water

[1 POINT] What does a high R_f indicate about a component?
The component is very soluble in that particular solvent/mobile phase.
Also give credit if they say the component moves quickly in that solvent/is easily dissolved in that solvent.

[3 POINTS] What does TLC stand for? What are its stationary and mobile phases?
TLC stands for Thin Layer Chromatography. It uses a thin, uniform layer of silica gel coated onto a piece of glass, metal or rigid plastic. The silica is the stationary phase. The mobile phase can be any solvent.

Section 2: Powders

Directions: Determine the identity of each of the 6 powders (Powder 1 was collected from Jake and Amy. Powder 2 was collected from Gina. Powder 3 was collected from Amy. Powders 4-6 were collected from the crime scene).

Powder number	Powder ID, CHEMICAL NAME AND CHEMICAL FORMULA [2 POINTS EACH]	List what test results helped you identify this powder [1 POINT EACH] **NOTE: give points if they get at least 2 of the things listed**	Who (may be multiple suspects, one suspect, or no one) does this powder incriminate? [1 POINT EACH]
1	**Sodium chloride, NaCl**	**White regular crystal, soluble in water, soluble in NaOH, no reaction with HCl, yellow flame test, yellow with iodine, no reaction with Benedict's**	—
2	**Magnesium sulfate, MgSO4**	**Cylindrical crystal, soluble in water, not soluble in NaOH (or leaves precipitate in**	—

		NaOH), no reaction with HCl, white-ish flame test, yellow with iodine, no reaction with Benedict's	
3	Glucose, C6H12O6	Irregular white crystal, soluble in water, soluble in NaOH, no reaction with HCl, melts in flame test, yellow with iodine, reacts with Benedict's (turns blue/green/brown)	—
4	Calcium sulfate, CaSO4	Lumpy powder, not soluble in water, not soluble in NaOH, no reaction with HCl, yellow/red-ish flame test, yellow with iodine, no reaction with Benedict's	Gina
5	Sodium acetate, NaC2H3O2	Fine powder, soluble in water, not soluble in NaOH, no reaction with HCl, yellow flame test, yellow with iodine, no reaction with Benedict's	Gina and Amy
6	Sodium bicarbonate, NaHCO3	Fine powder, soluble in water, soluble in NaOH, fizzes with HCl, yellow flame test, yellow with iodine, bubbles with Benedict's	Jake and Amy

Section 3: Polymers

Retrieve samples of fibers 1, 2, 3, and 4 from the supplies table. Identify each fiber from the crime scene and complete the table below. Then, answer the questions.

| Fiber number	What is the identity of the fiber? [2 POINTS	List what test results helped you identify	Who (may be multiple suspects, one suspect,

	EACH]	this fiber [1 POINT EACH]	or no one) does this fiber incriminate? [1 POINT EACH]
1	**Cotton**	**Not self-extinguishing, leaves no ash**	**Gina**
2	**Polyester**	**Melts, leaves hard bead of ash, smoke smells sweet-ish, not self-extinguishing**	**Gina and Jake**
3	**Wool**	**Self-extinguishing, burns slowly, smells like burning hair, leaves black ash**	**Gina**
4	**Nylon**	**Not self-extinguishing, melts, smells like celery, leaves liquidy or hard ash**	**No one**

[1 POINT] What is the name of the pigment that colors hair and skin?
Melanin

Two hair samples were also found at the crime scene. The physical samples are not available, but microscope photos of the two hair samples are below. Identify the type of these hairs from the photos. Then, answer the questions below.
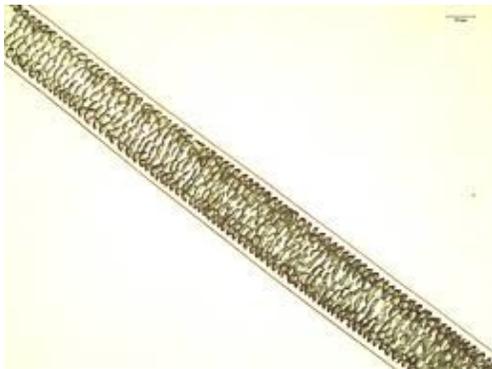
Hair 1:

[1 POINT] What type of hair is this? **Squirrel**

[2 POINTS] List the features that helped you identify what type of hair this is.
Discontinuous medulla, smooth cuticle

[1 POINT] Who (may be multiple suspects, one suspect, or no one) does hair 1 incriminate?
Gina

Hair 2:
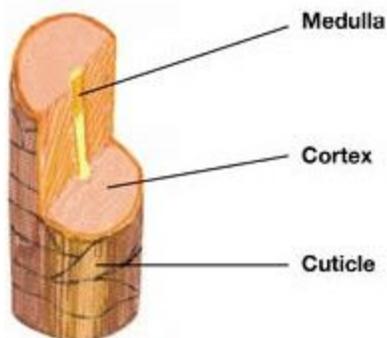

[1 POINT] What type of hair is this?
Human

[2 POINTS] List the features that helped you identify what type of hair this is.
Scaly cuticle with imbricate scales, amorphous medulla that is thin or not visible

[1 POINT] Who (may be multiple suspects, one suspect, or no one) does hair 1 incriminate?
Jake, Gina, and Amy

[3 POINTS] Label this diagram of a hair.

Medulla

Cortex

Cuticle

Plastics:

[4 POINTS] What are the burn test results of the following plastics? **1 point per plastic. Give points for listing at least 2 of each plastic's results. PVC must include green flame to earn point.**
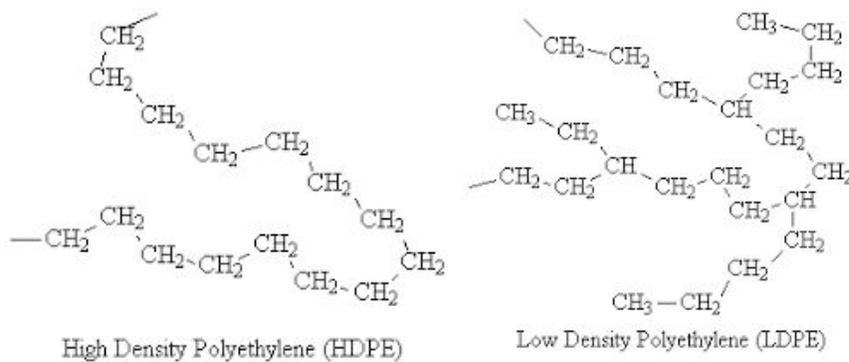
PETE: **Yellow flame, plastic drips, burns slowly, light smoke**
PMMA: **Bright flame, no smoke**
PVC: **Green flame, does not drip, self-extinguishing, chars**
HDPE: **Blue, yellow tipped flame, burns slowly, plastic drips, smells like candle wax**

[2 POINTS] Draw the structure of HDPE versus LDPE.

High Density Polyethylene (HDPE)   Low Density Polyethylene (LDPE)

Give points as long as LDPE has more branching

Section 4: Fingerprints

Jake's, Amy's, and Gina's fingerprints are shown below.

JAKE   **AMY**   **GINA**

[3 POINTS] Identify each suspect's fingerprint type. **1 point per correct answer.**
Jake: **Plain whorl**
Amy: **Ulnar loop**
Gina: **Plain whorl**

[3 POINTS] How common is each fingerprint type? (What percent of Americans have each type?) **Give points for being within 10%. 1 point per correct answer.**
Jake's type: **20%**
Amy's type: **64%**
Gina's type: **20%**

[1 POINT] The following print was found at the crime scene. Whose print does it match?

Gina's print

[3 POINTS] Identify the circled minutiae on this fingerprint.

[2 POINTS] What features must match for two fingerprints to be considered matches?
The fingerprint pattern AND 8-12 minutiae must match.

[2 POINTS] What does IAFIS stand for? What is it?
Integrated Automated Fingerprint Identification System. IAFIS is a national automated system maintaintained by the FBI that stores over 73,000 prints from known/suspected terrorists, 70 million prints/criminal histories in criminal master file, 31 million civil prints from people purchasing firearms, and more.

Give 1 point for the acronym and one for any accurate description of what it is.

Section 6: Other physical evidence

[3 POINTS] What does PCR stand for? Who invented it? What is PCR's purpose?
Polymerase Chain Reaction. Invented by Kary Mullins. Used to amplify a few fragments of DNA to get a large enough sample that can be used for testing.

Give 1 point for each correct answer to each question.

[1 POINT] Which DNA bases are purines? Which are pyrimidines?
Purines = adenine and guanine
Pyrimidines = cytosine and thymine

[1 POINT] What's the formula to calculate the angle of impact of a blood spatter?
$\theta = \sin^{-1}(W/L)$
w = width of spatter
L = length of spatter
$\sin^{-1}$ =arcsin
θ = the angle

Give points as long as the formula is right and they specified what W and L are.

[3 POINTS] Define refractive index. What are the refractive indices of water and pyrex glass (borosilicate glass)?
Refractive index describes how much light is bent, or refracted, when it enters a material. Refractive index of water is 1.333. Refractive index of pyrex is 1.517.

Give 1 point for each correct answer to each question. Refractive index of water must be exactly 1.3. Refractive index of pyrex can be within 0.2.

[2 POINTS] What's the common name and the family of the insects that are usually first to arrive at a dead body?
Blowflies, family Calliphoridae. Give 1 point for common name and 1 for family.

Section 6: Analysis

[15 POINTS] Based on the evidence, identify the suspect who stole the watch.

5 points: <u>Gina</u> stole the watch

1 per correct item, up to 4:
- **Gina did it because**
  - **Her fingerprint matched**
  - **The squirrel hair matched**
  - **The cotton, polyester, and wool matched**
  - **The pen matched**
  - **The calcium sulfate matched her plaster sculptures**
  - **The sodium acetate matched her heating packs**

- DO NOT give points for saying the human hair matched

1 point per correct item, up to 3:
- Jake didn't do it because
  - The pen did not match
  - The fingerprint did not match
  - The squirrel hair did not match and human hair could've been from any of the suspects
  - Only polyester matched of the 4 fibers
  - Only sodium bicarbonate matched of the 3 powders from the scene

1 point per correct item, up to 3:
- Amy didn't do it because
  - The pen did not match
  - The fingerprint did not match
  - The squirrel hair did not match and human hair could've been from any of the suspects
  - None of the 4 fibers matched
  - Only sodium bicarbonate and sodium acetate matched of the 3 powders from the scene