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The Shadow and the Flash

By Jack London

Part 3

Teacher's notes

Author: Daniel Barber

Level: Advanced

Age: Young adults / Adults

Aims: In this lesson the students will:

1. recap the story so far;
2. do a science quiz about the properties of light;
3. listen to a scientific explanation;
4. study and practise intonation in lists;
5. listen for detail;
6. read about real-life invisibility and share information.

Materials: One copy of the worksheet per student; one set of reading texts for every three students (Reading texts 1, 2 and 3); Track 1 (the first part of Part 3), Track 2 (extracts), Track 3 (the rest of Part 3) and Track 4 (full audio) downloaded from onestopenglish; one copy of the full transcript per student

Summary: The story is about two competitive scientists who take different routes to achieving invisibility, with tragic results. It is told in five parts. In Part 3, the men explain the science behind their diverging approaches and reveal that they are already some way to achieving the impossible.

Activity 1

Aims: to recap the story so far; to activate the students' prior knowledge of the properties of light; to check understanding of key vocabulary

1. Elicit from the students the names of the two main characters, their similarities and differences, their relationship and the challenge they have set themselves. Ask them to explain how the scientists are planning to achieve invisibility. Make sure that they mention both methods (perfect transparency and perfect blackness).

2. Tell them that they are going to listen to Lloyd and Paul explaining the science behind their approaches but, before they do, they are going to see how much they know about the science of light. Put the students in pairs, hand out the worksheet, and ask them to answer the questions in Activity 1.

3. When all have finished, they can compare their answers with another pair before listening to Track 1 to check their answers.

Key: *1. There are seven colours. They are red, orange, yellow, green, blue, indigo and violet; 2. a. absorbs; reflected; b. reflects; c. reflects; absorbed; d. refracts*

Note: *Seven colours is a simplification. White light is actually made up of the infinitely divisible continuum of colours of the visible spectrum. Consider setting them the follow-up task (see below) of researching the colours of the rainbow.*

Activity 2

Aim: to raise awareness and practise intonation in lists

1. Tell the students that British children are sometimes taught a mnemonic (a sentence to help remember something) to help them memorize the seven colours of the rainbow and their order. It is a sentence in which the first letters of each word are the same as the first letters of the seven colours: Richard Of York Gave Battle In Vain (red, orange, yellow, green, blue, indigo, violet). Ask if the students know any similar mnemonics. Invite a few students to tell the class about them.

2. Ask students to look at sentences a and b from the story in Activity 2. Ask what they have in common. (*They both contain lists.*) Ask them to listen to the extracts and decide whether the intonation goes up or down on each item of the lists. They can mark words

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with a rising intonation ↑ and with a falling intonation ↓. Play Track 2 twice.

Key: *All items except the last have a rising intonation. The last have a falling intonation. A rising intonation indicates that there remain more items and the list is not finished. The falling intonation at the end indicates to the listener that the list is complete.*

3. Put the students into pairs. Have them tell each other the seven colours of the rainbow in order (without looking at their notes, of course!). Suggest that they use this list to practise intoning it naturally.

4. Get the students to invent a sentence mnemonic for remembering the eight planets of the solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune (and, if you're feeling inclusive, Pluto, which used to be a planet but is now classified as a 'dwarf planet'). Here's an example if the students struggle to invent their own: **M**y **V**ery **E**asy **M**ethod **J**ust **S**peeds **U**p **N**aming **P**lanets!

Activity 3

Aim: to listen for specific information

1. Ask the students to read the questions in Activity 3 and to check that they understand the words in bold. **Plate glass** is another word for the flat glass used in windows. A **test tube** is a small glass tube that chemists use to do chemical experiments (a drawing will clarify). A **reagent** is any substance used to create a chemical reaction.

2. Play Track 3. Afterwards, allow the students time to compare their answers, then hand out the transcript for them to check their answers.

Key: *1. because a black object will cast a visible shadow; 2. A transparent object lets all rays of light through, casts no shadow, and does not reflect light-waves.; 3. He causes him to bump his head against a perfectly transparent piece of glass.; 4. A company (the St. Gobain Company) in France made it.; 5. There is a change in colour, or the chemicals become clear.; 6. It will cause a living body to turn transparent.*

3. Ask the class who they think is winning the race for invisibility at this point in the story: Paul or Lloyd. Also, find out whose idea they like best and why.

Activity 4

Aim: to read about three real-life examples of invisibility and share information (unless you have access to computers in the classroom, this activity should be set as homework)

1. Ask if anyone knows of any real-life examples of invisibility, in its broadest sense, of course. To help start the flow of ideas, you could suggest that camouflage is a type of invisibility and elicit a few instances of this strategy in the animal kingdom and amongst humans.

2. Explain to the students that they are going to read different texts about invisibility in the real world but that they are all going to answer the same questions about them. Indicate Activity 4 on the worksheet. Split the class into three groups: A, B and C. Ask students As to click on link A and read about the Invisibility Cloak, students B should click on link B to find out about the Stealth Bomber and students C should read link C about the Hatchet Fish, then answer the three questions. This can be done either in class or as homework. After they have finished reading (or in the next class), they can compare their notes and confirm each other's answers within their groups.

3. Regroup the students into threes, each person with a different text. Ask them to tell each other about what they have read and together decide the following:

- Are there any similarities between the three examples in how and why they achieve invisibility?
- Which is closest to true invisibility, do you think? Which is furthest?
- Which would you like to know more about? What would you like to know?

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4. Conduct a whole-class round-up of the discussion.

Follow-up tasks

1. After reading the transcript for Part 3, the students continue writing their summary.

2. Tell the students to find out about rainbows. They can choose any or all of the following questions to research. You may want them to prepare a presentation for the next class.

- How are rainbows formed?
- Why is it said that rainbows have seven colours?
- What beliefs surround rainbows in popular mythology?

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Worksheet

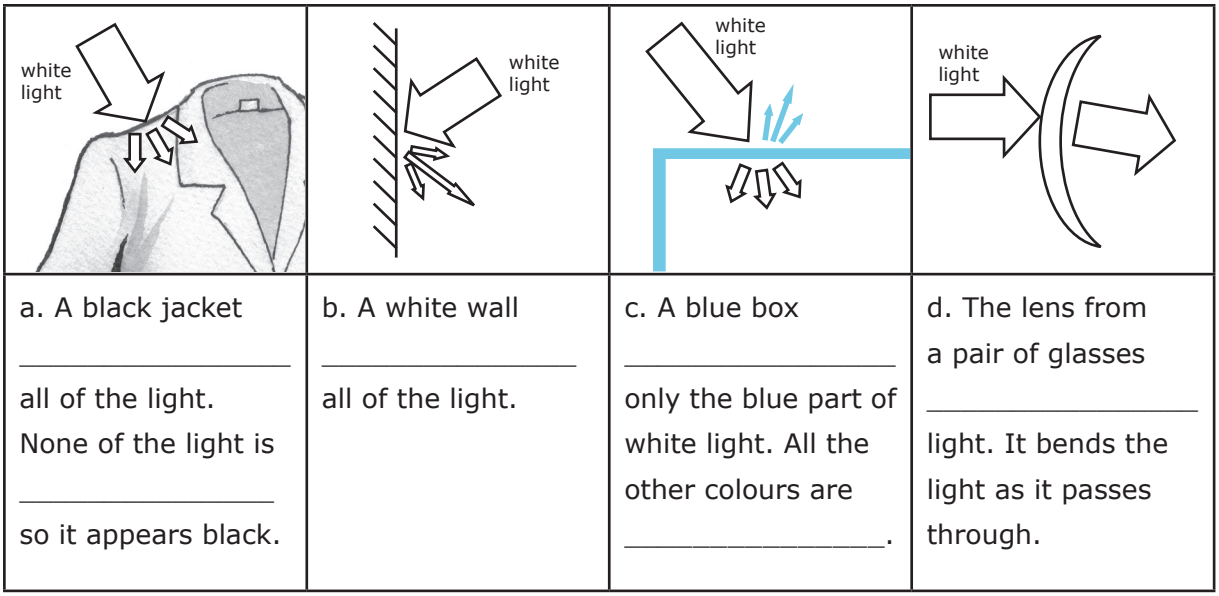
Activity 1

Science Quiz

How much science do you remember from school? Do this quiz in pairs to find out.

1. How many colours make up white light? (Clue: Think of a rainbow.) _____
   What are they? _____
2. Fill the gaps under the diagrams using the words below.

reflects	reflected	refracts	refracted	absorbs	absorbed



a. A black jacket	b. A white wall	c. A blue box	d. The lens from a pair of glasses
_____ all of the light. None of the light is _____ so it appears black.	_____ all of the light.	_____ only the blue part of white light. All the other colours are _____.	_____ light. It bends the light as it passes through.

Listen to Lloyd and check your answers.

Activity 2

What do these sentences have in common?

a. His experiments covered all sorts of pigments, such as lamp-blacks, tars, carbonized vegetable matters, soots of oils and fats, and the various carbonized animal substances.

b. The white light strikes against it, and, with one exception, all its component colors – violet, indigo, green, yellow, orange, and red – are absorbed.

Mark the items in the lists with ↑ if they have a rising intonation and ↓ if they have a falling intonation.

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Worksheet

Activity 3

Listen to the second part of the story. Answer the questions.

1. Why does Paul believe that Lloyd's method will fail?
2. How does Paul define transparency?
3. How does he convince the narrator that perfect transparency exists?
4. Where is the plate glass from?
5. What happens when he mixes the chemicals in the test tube?
6. What will the reagent that he is planning to create be able to do?

Activity 4

Your teacher will tell you to read one of the following texts (A, B or C). When you have finished, answer the questions (1-3) below.

A. the Invisibility Cloak: http://news.bbc.co.uk/1/hi/world/asia-pacific/2777111.stm

B. the Stealth Bomber: http://en.wikipedia.org/wiki/Stealth_Bomber

C. the Hatchet Fish: http://en.wikipedia.org/wiki/Marine_hatchetfish

1. What are the advantages of being invisible in this case?
2. What technique(s) does it use to achieve invisibility?
3. What are its limitations?

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Transcript and glossary

Track 1

I visited Lloyd's laboratory a number of times after that, and found him always deep in his search after the absolute black. His experiments covered all sorts of pigments, such as **lamp-blacks**, **tars**, carbonized vegetable matters, soots of oils and fats, and the various carbonized animal substances.

Track 2

"White light is composed of the seven primary colors," he argued to me. "But it is itself, of itself, invisible. Only by being reflected from objects do it and the objects become visible. But only that portion of it that is reflected becomes visible. For instance, here is a blue tobacco-box. The white light strikes against it, and, with one exception, all its component colors – violet, indigo, green, yellow, orange, and red – are absorbed. The one exception is BLUE. It is not absorbed, but reflected. Wherefore the tobacco-box gives us a sensation of blueness. We do not see the other colors because they are absorbed. We see only the blue. For the same reason grass is GREEN. The green waves of white light are thrown **upon** our eyes."

"When we paint our houses, we do not apply color to them," he said at another time. "What we do is to apply certain substances that have the property of absorbing from white light all the colors except those that we would have our houses appear. When a substance reflects all the colors to the eye, it seems to us white. When it absorbs all the colors, it is black. But, as I said before, we have as yet no perfect black. All the colors are not absorbed. The perfect black, guarding against high lights, will be utterly and absolutely invisible. Look at that, for example."

He pointed to the **palette** lying on his work-table. Different shades of black pigments were brushed on it. One, in particular, I could hardly see. It gave my eyes a **blurring** sensation, and I rubbed them and looked again.

"That," he said impressively, "is the blackest black you or any mortal man ever looked upon. But just you wait, and I'll have a black so black that no mortal man will be able to look upon it – and see it!"

Track 3

On the other hand, I used to find Paul Tichlorne **plunged** as deeply into the study of light polarization, **diffraction**, and interference, single and double refraction, and all manner of strange organic compounds.

"Transparency: a state or quality of body which permits all rays of light to pass through," he defined for me. "That is what I am seeking. Lloyd **blunders up against** the shadow with his perfect opaqueness. But I escape it. A transparent body casts no shadow; neither does it reflect light-waves – that is, the perfectly transparent does not. So, avoiding high lights, not only will such a body cast no shadow, but, since it reflects no light, it will also be invisible."

We were standing by the window at another time. Paul was engaged in polishing a number of lenses, which were ranged along the **sill**. Suddenly, after a pause in the conversation, he said, "Oh! I've dropped a lens. Stick your head out, old man, and see where it went to."

Out I started to thrust my head, but a sharp blow on the forehead caused me to **recoil**. I rubbed my bruised brow and gazed with **reproachful** inquiry at Paul, who was

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laughing in **gleeful**, boyish fashion.

"Well?" he said.

"Well?" I echoed.

"Why don't you investigate?" he demanded. And investigate I did. Before thrusting out my head, my senses, automatically active, had told me there was nothing there, that nothing intervened between me and out-of-doors, that the aperture of the window opening was utterly empty. I stretched forth my hand and felt a hard object, smooth and cool and flat, which my touch, out of its experience, told me to be glass. I looked again, but could see positively nothing.

"White **quartzose** sand," Paul rattled off, "sodic carbonate, **slaked lime**, **cutlet**, manganese peroxide--there you have it, the finest French plate glass, made by the great St. Gobain Company, who made the finest plate glass in the world, and this is the finest piece they ever made. It cost a **king's ransom**. But look at it! You can't see it. You don't know it's there till you run your head against it.

"Eh, old boy! That's merely an object-lesson; certain elements, in themselves **opaque**, yet so compounded as to give a resultant body which is transparent. But that is a matter of inorganic chemistry, you say. Very true. But I dare to **assert**, standing here on my two feet, that in the organic I can duplicate whatever occurs in the inorganic.

"Here!" He held a test-tube between me and the light, and I noted the cloudy or muddy liquid it contained. He emptied the contents of another test-tube into it, and almost instantly it became clear and sparkling.

"Or here!" With quick, nervous movements among his **array** of test-tubes, he turned a white solution to a wine color, and a light yellow solution to a dark brown. He dropped a piece of litmus paper into an acid, when it changed instantly to red, and on floating it in an alkali it turned as quickly to blue.

"The litmus paper is still the litmus paper," he **enunciated** in the formal manner of the lecturer. "I have not changed it into something else. Then what did I do? I merely changed the arrangement of its molecules. Where, at first, it absorbed all colors from the light but red, its molecular structure was so changed that it absorbed red and all colors except blue. And so it goes, **ad infinitum**. Now, what I **purpose** to do is this." He paused for a space. "I purpose to seek – ay, and to find – the proper **reagents**, which, acting upon the living organism, will bring about molecular changes **analogous** to those you have just witnessed. But these reagents, which I shall find, and for that matter, upon which I already have my hands, will not turn the living body to blue or red or black, but they will turn it to transparency. All light will pass through it. It will be invisible. It will cast no shadow."

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Glossary

lamp-black the traces of smoke left inside a lamp that has held a bare flame
tar a sticky black substance left after something has burnt
soot the black powder left after something has burnt
upon (formal) on
palette a board an artist uses for mixing paints
blur to make something difficult to see because the edges are not clear
plunge dive
diffraction (scientific) the process by which light waves change when they pass over an object or through a narrow space
blunder up against to face a problem because of an error in thinking
sill a window sill; a narrow shelf at the bottom of a window
recoil to move quickly back from something unpleasant
reproachful showing criticism in a way meant to make someone feel ashamed
gleeful happy and excited, often because of someone else's bad luck
aperture (formal) an opening for light to pass through, like a window or a camera lens
quartzose made of quartz
slaked lime (technical) calcium hydroxide Ca(OH)2
cutlet (technical) broken pieces of glass of mixed colours and types
a king's ransom a very large amount of money
opaque difficult to see through; the opposite of transparent
assert (formal) to state firmly that something is true
array a large group of people or things that are related in some way
enunciate (formal) to pronounce words clearly so that they can be easily understood
ad infinitum (Latin) infinitely, for ever
purpose (old-fashioned, formal) to intend
reagent (scientific) a substance used in a chemical reaction
analogous (formal) similar