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The Wintersmith Poem

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Abstract
During one of her adventures, witch in training Tiffany Aching encounters the Wintersmith after dancing in the "dark morris". The Wintersmith is the personification of winter and upon meeting Tiffany, he falls in love. Determined to enchant Tiffany he becomes adamant that he will make himself human. After hearing a poem sung by children describing what makes a human the Wintersmith gathers the elements required. This paper looks at the claims of the poem to see if there are sufficient amounts of each element within the human body to accomplish what the poems say it can.

Keywords: *Book; Biology; Chemistry; Body Composition; Tiffany Aching; Terry Pratchett; Wintersmith*

Introduction
In Terry Pratchett's novel 'Wintersmith' [1], Tiffany Aching meets the Wintersmith, an entity determined to become fully human. When encountering a group of children, he asks them about how to become human. They reply in a poem that goes:

Iron enough to make a nail
Lime enough to paint a wall
Water enough to drown a dog
Sulphur enough to stop the fleas
Potash enough to wash a shirt
Gold enough to buy a bean
Silver enough to coat a pin
Lead enough to blast a bird
Phosphor enough to light the town
Strength enough to build a home
Time enough to hold a child
Love enough to break a heart [1].

Up until the final three lines each element and compound is something obtainable physically whereas the last three ingredients are thing attributed to humans and are something unattainable by the Wintersmith. The poem raises the question of does the human body really have enough of each of these elements to create the other things? This paper will explore the claims made in this poem using the assumption of an average male as the Wintersmith is also a male.

Iron enough to make nail
First is iron, in the human there are 4 g of iron. Iron is a component of haemoglobin which is found in red blood cell these carry oxygen around the body. Iron is also important for the creation of some hormones [2]. A nail consists of around 1-2 g of iron so this would be feasible.

Lime enough to paint a wall
Limes provide the body with vitamin C, which boosts the immune system. It also provides protection against free radicals and it can prevent kidney stones. The maximum recommended number of limes consumed a day is three, which would make 0.0887 litres of lime juice. Supposing we were painting a wall of 12 cm by 20 cm you would need 0.1 litres of lime coloured paint. This is more than what would be available so this claim is false [3].

Water enough to drown a dog
Water is essential for humans as it can help the body regulate its temperature, provide a medium for chemical reactions and it can act as a lubricant and shock absorber [4]. Human beings contain 42 litres of water; this would be enough to drown a dog especially if it was a smaller dog like a Chihuahua.

Sulphur enough to stop the fleas
Humans have 140 g of sulphur; this is used to fix DNA and it can protect cells from damage [5]. It is also an element found in two amino acids methionine and

cysteine. Fleas can be killed by sulphur powder as it messes with the energy production in the flea as it can break through the exoskeleton which dehydrates them [6].

Potash enough to wash a shirt

Potash contains potassium carbonate (K_2CO_3) which is used to wash shirts. From this we can assume that Pratchett is referring to the potassium content and in humans there are 140 g. In humans potassium is vital in controlling the levels of liquid in cells [7]. To clean a shirt in a washing machine you would need two tablespoons (30 g) of detergent. To work it out how much potassium this detergent contains you would work out the molar mass of the compound and then divide the potassium content by it:

$$\frac{M(total\ K)}{M(K_2CO_3)} = \frac{78}{138.205} = 0.56$$

To work out the grams of potassium you do the percentage of potassium in potassium carbonate times by the grams in detergent:

$$0.56 \times 30 = 16.9\text{g}$$

This is less than what is in a human being (140 g) therefore this claim is also incorrect.

Gold enough to buy a bean

In humans there are 0.2 mg of gold; this is used to maintain healthy joints, and it helps electrical signals travel across the body. 0.2 mg of gold cost ~1.2 cents, which would be enough if you were to buy one bean [8]. However, it is important to note that gold prices fluctuate depending on market prices so someone may be able to buy more than bean or not at all.

Silver enough to coat a pin.

Silver is not naturally occurring in humans however it can be absorbed into our skin. The average amount in humans is around 70-88 μg. Too much silver can cause it to accumulate and form non-life threatening granules underneath the skin [9].

Lead enough to blast a bird

The maximum amount of lead that can be in humans without causing significant harm is 25 $\mu g/\mu L$ for adults. The average is from 0.48-5.00 $\mu g/\mu L$. High levels of lead can result in lead poisoning this can cause high blood pressure, headaches, cramps, and some may struggle sleeping. In extreme cases lead poisoning can result in death [10]. Lead (II) azide can be used as an explosive, even a small amount can trigger an explosion from stimuli such as sparks, flames and friction therefore there is lead enough to explode a pigeon [11].

Phosphor enough to light the town

Humans have around 560 g of phosphorus. Phosphorus is important for filtering waste products in the kidneys and around 85 % of bone and death are composed of phosphor [12]. Phosphor, the chemical used in the lightbulbs, is different from phosphate although its name is originated from it. The body itself does not have phosphor therefore this component is missing.

Strength enough to build a home

Throughout history humans have built many things by hand therefore they have enough strength to build a house whether that is from wood or brick.

Time enough to hold a child

To hold a child takes about a minute and even in the busiest of lives we all have a spare minute to hold a child so that line is true as well.

Love enough to break a heart

Although there is no direct link between having a broken heart due to loss of love there is a phenomenon that has been described as 'Broken heart syndrome' also known as Takotsubo cardiomyopathy. This happens because of intense emotional and physical stress which results in a rapid surge of adrenaline that causes the left ventricle to expand and weaken leading to heart failure [13]. It has been observed numerous times that the death of a loved one, normally in married couples, results in a few weeks later the other partner dying. Therefore, love can be enough to break a heart.

Conclusion

Overall there is not enough of some elements like gold and silver to make a human. If you were to exclude these elements from the body, there would be dire consequence as each element plays a vital in the function of the body. Therefore, the poem is incorrect in its claim that the human body has enough of each element or compound to complete the tasks stated.

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