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ULTRAMARINE

THE BLUE FROM ONE VALLEY

The mines at Sar-e-Sang sit in a valley of the Hindu Kush, in the Badakhshan region of northeastern AFGHANISTAN, and they have been worked for thousands of years. What comes out of them is lapis lazuli, a deep blue rock that Renaissance workshops ground into the most costly pigment in Europe. Because it reached Italian ports by ship from the East, the colour took a Latin name, ULTRAMARINUS, meaning beyond the sea, and the name attached itself to the pigment rather than to the stone. For most of a millennium, every ounce of true blue in a European ALTARPIECE began in that one narrow valley.

SPELL Spell: **ULTRAMARINUS**

ULTRAMARINUS

SPELL Spell: **ALTARPIECE**

ALTARPIECE

KNOWN The Badakhshan region, where the Sar-e-Sang valley lies in the Hindu Kush, belongs to which country?

AFGHANISTAN

OPEN Every ounce of true blue in Europe came from one narrow valley. What is something you own that came a very long way to reach you?

Open response - use practitioner judgment

WHERE THE BLUE LIVES

Lapis is a rock, not a single mineral, and only part of it is blue. The colour lives in LAZURITE, a feldspathoid of the sodalite group whose aluminosilicate framework is built of open cages. Trapped inside those cages sit TRISULFUR RADICAL anions, and this caged ion is the CHROMOPHORE, the structure that actually absorbs light: it takes in the red and yellow end of the spectrum and lets blue pass. Everything else in the rock dilutes that blue. White CALCITE, brassy flecks of PYRITE, and grains of DIOPSIDE all grind up together with the lazurite, so a pale stone is blue thinned by its neighbours.

SPELL Spell: TRISULFUR

TRISULFUR

SPELL Spell: LAZURITE

LAZURITE

KNOWN What is the term for the structure inside a material that absorbs light and so gives the material its colour?

CHROMOPHORE

KNOWN What do chemists call a species that carries an unpaired electron, like the trisulfur ion caged inside lazurite?

RADICAL

SEMI_OPEN Besides lazurite, which two minerals grind up with it and thin the blue of the rock?

NEEDS 2 OF CALCITE / PYRITE / DIOPSIDE

OPEN The blue comes from an ion trapped inside a cage of rock. What is something whose best part is hidden inside?

Open response - use practitioner judgment

MATH The caged trisulfur ion absorbs most strongly near 600 nanometres, in the orange-red band, while the blue light it lets pass sits near 450 nanometres. How many nanometres separate those two wavelengths?

150

CENNINI'S DOUGH

Grinding the rock alone therefore yields a GREYISH powder. Around 1400 CENNINO Cennini set down the separation in his handbook *Il Libro dell'Arte*: melt pine RESIN, gum MASTIC, WAX, and a little OIL into a stiff dough, knead the powdered stone through it, then work that dough under warm lye, an ALKALINE solution, until the blue particles release and sink. The first extraction gives the saturated pigment, and each later working yields a paler grade. Coarse particles hold the deepest colour, so grinding this pigment too fine destroys the very quality it was bought for.

SPELL Spell: CENNINO

CENNINO

SPELL Spell: GREYISH

GREYISH

SPELL Spell: ALKALINE

ALKALINE

SEMI_OPEN Name two of the ingredients melted together and kneaded into the dough that pulls the blue out of the stone.

NEEDS 2 OF RESIN / MASTIC / WAX / OIL

OPEN What would you expect to happen in the warm lye as the blue particles released from the dough and sank?

Open response - use practitioner judgment

PRICED BY THE OUNCE

The cost reshaped how pictures were made. Fifteenth-century contracts did not simply commission a painting; they named the grade of blue by its price per ounce, fixed who would supply it, and sometimes limited how much could be spent. A workshop put it where it would be seen and read, usually the Virgin's mantle, laid over a cheaper underlayer, while AZURITE, SMALT, and INDIGO carried the sky, the lesser DRAPERY, and the shadows. Michelangelo's UNFINISHED ENTOMBMENT in London still shows a blank reserve where the Virgin should sit, and one long-standing explanation is that the blue never arrived.

SPELL Spell: DRAPERY

DRAPERY

SPELL Spell: UNFINISHED

UNFINISHED

KNOWN What is the title of the unfinished London panel that still shows a blank where the Virgin should sit?

ENTOMBMENT

SEMI_OPEN Name two of the cheaper blues that carried the sky, the lesser drapery, and the shadows.

NEEDS 2 OF **AZURITE / SMALT / INDIGO**

OPEN A blank was left where the Virgin should sit, possibly because the blue never came. What have you left unfinished while waiting for one thing to arrive?

Open response - use practitioner judgment

MATH Contracts fixed the blue by its price per ounce. Suppose a contract sets ultramarine at 8 florins an ounce and allows the workshop 6 ounces for the Virgin's mantle. How many florins does the blue alone cost?

48

A DIFFICULT PIGMENT

The pigment is also less forgiving than its price suggests. Its REFRACTIVE index sits close to that of drying oil, so in oil paint it turns weak and semi-transparent, while in egg TEMPERA, where pigment is bound in yolk instead, it keeps its full body. And although it tolerates alkali well enough for wall painting, dilute acid pulls the cage structure apart, releasing hydrogen SULFIDE and leaving a grey granular haze that conservators call ultramarine sickness. Some of the dulled blues in old altarpieces are not dirt or fading at all but the chromophore destroyed from within.

SPELL Spell: TEMPERA

TEMPERA

SPELL Spell: SULFIDE

SULFIDE

KNOWN What is the term for the index that measures how strongly a material bends the light passing through it?

REFRACTIVE

OPEN Some dulled blues in old paintings are not dirt but the colour destroyed from within. What do you think looks worn but is actually broken?

Open response - use practitioner judgment

THE PRIZE AND THE LAUNDRY

You can buy that colour now for the price of any ordinary tube. In 1824 a French industrial society offered 6,000 francs to anyone who could make the pigment artificially, after blue deposits were noticed in the linings of glass kilns. The prize went in 1828 to Jean-Baptiste GUIMET, whose process fired a charge of KAOLIN, SODA, SULFUR, and SILICA; Christian Gmelin in Germany published a rival method and disputed the credit. Within a generation the blue that once needed a contract clause was cheap enough to tint laundry BLUEING, where a trace of it makes yellowed white cloth read as white again.

SPELL Spell: GUIMET

GUIMET

SPELL Spell: BLUEING

BLUEING

SEMI_OPEN Name two of the materials fired together in the charge that made the artificial blue.

NEEDS 2 OF KAOLIN / SODA / SULFUR / SILICA

OPEN A trace of the blue makes yellowed cloth read as white. What is something that seems like the wrong colour but does the job?

Open response - use practitioner judgment