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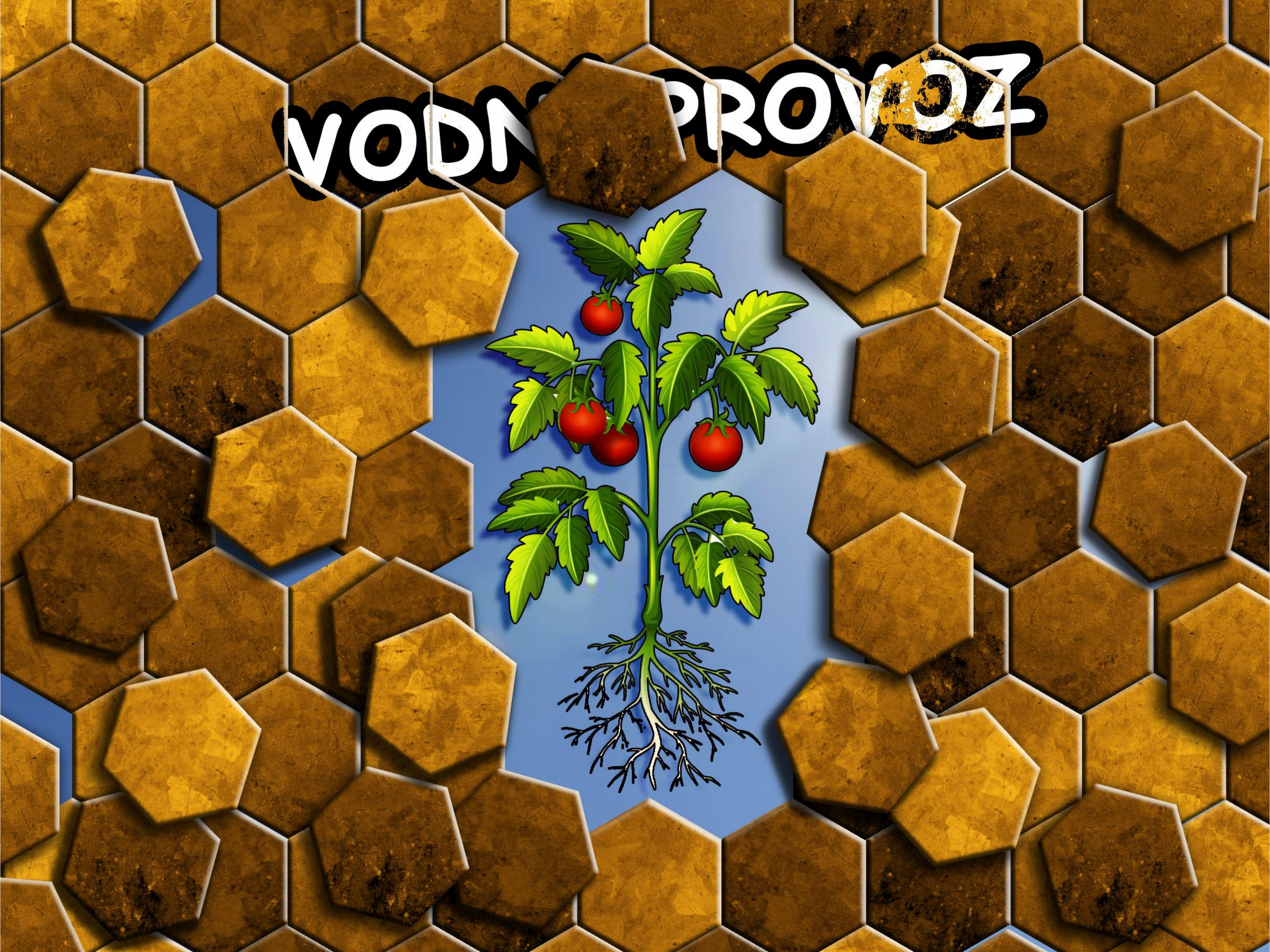
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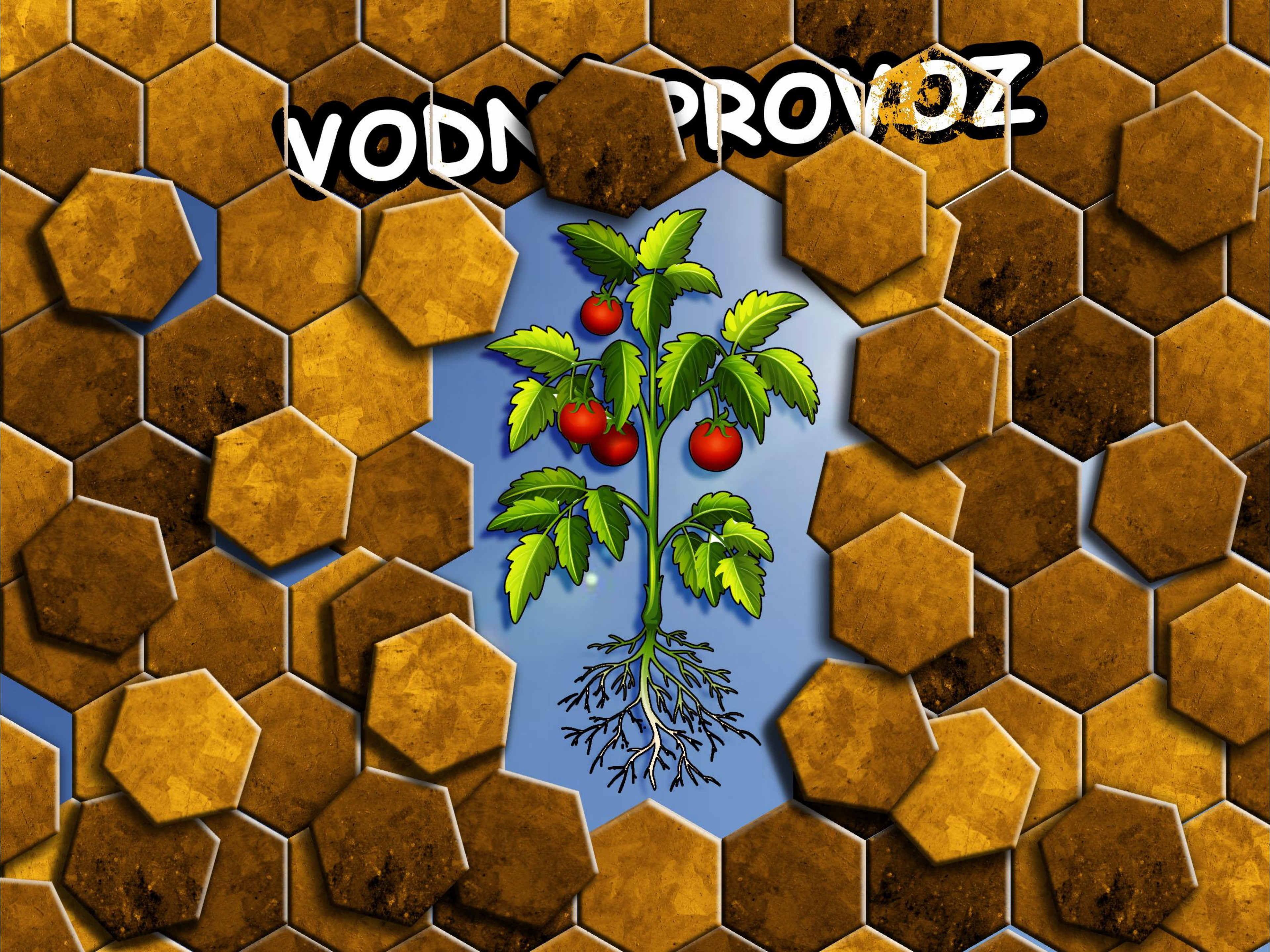
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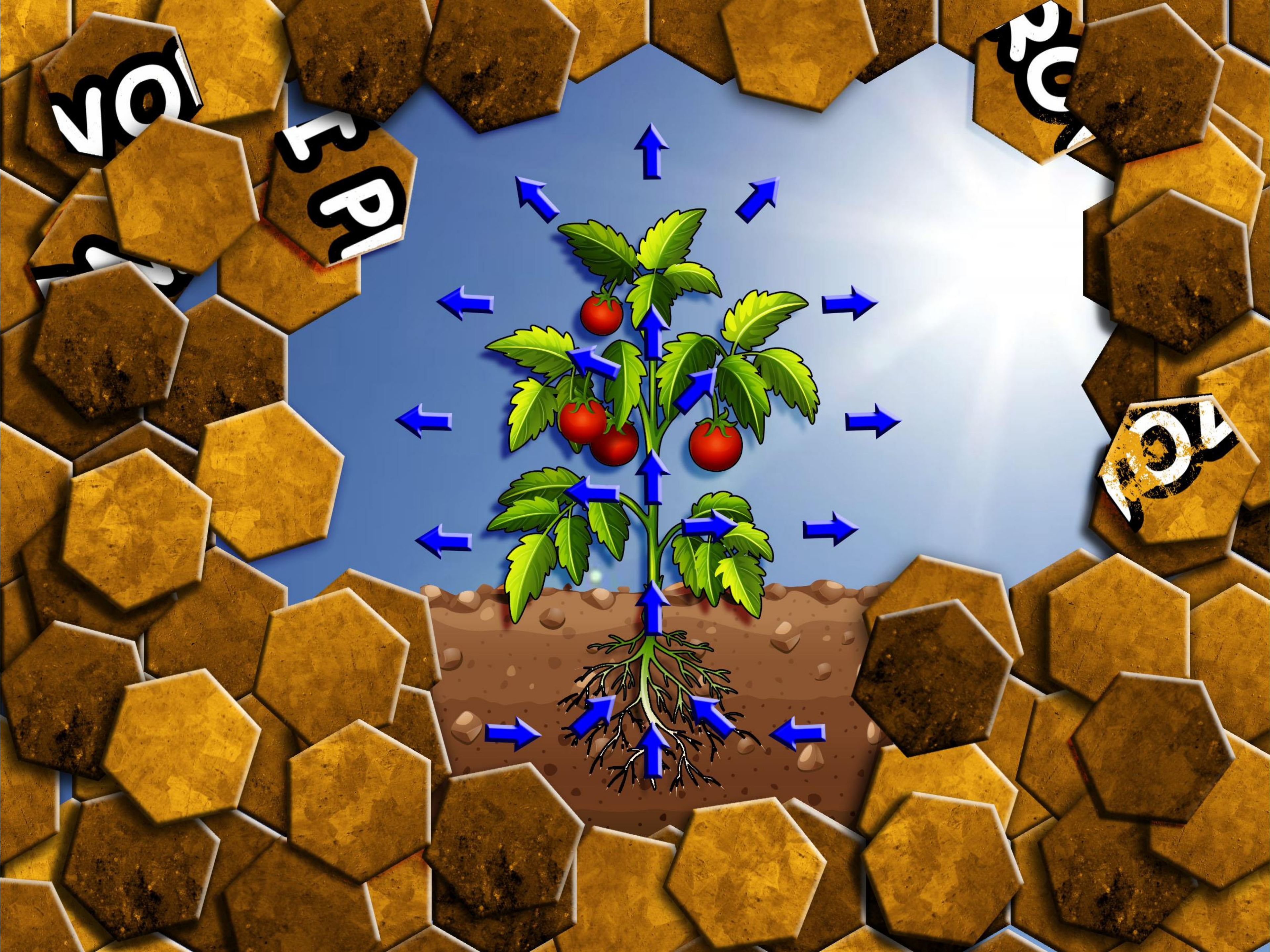

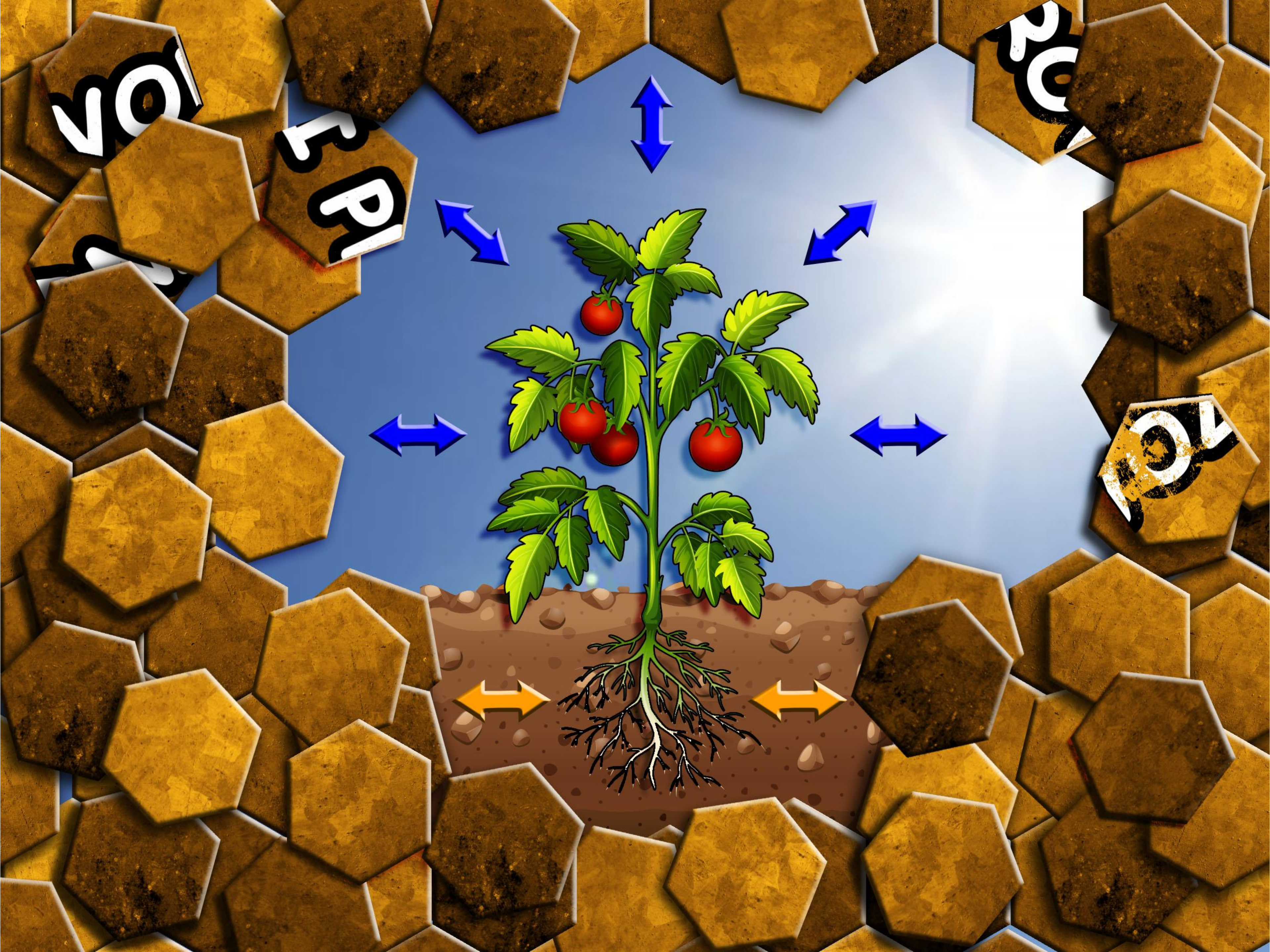
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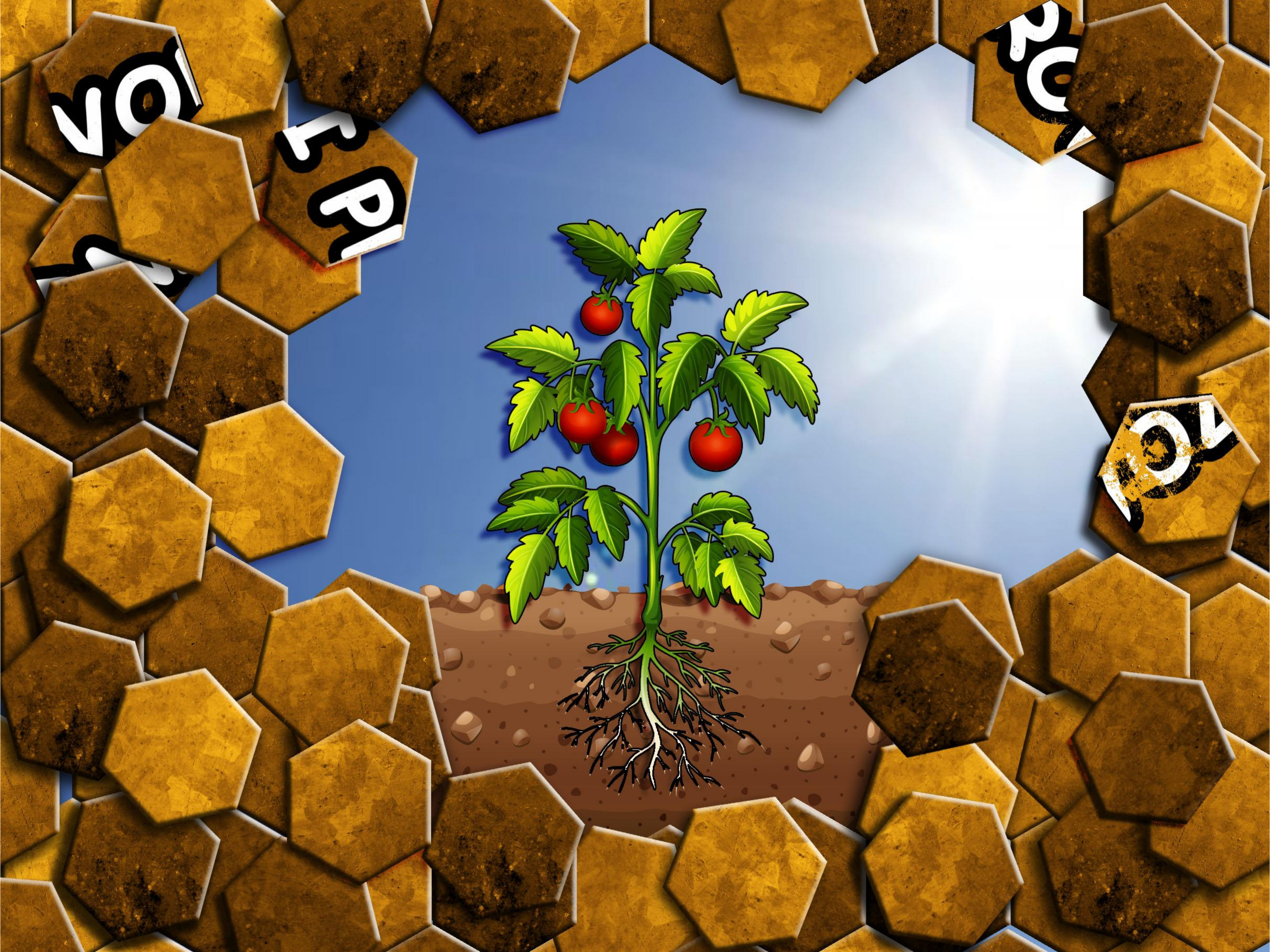

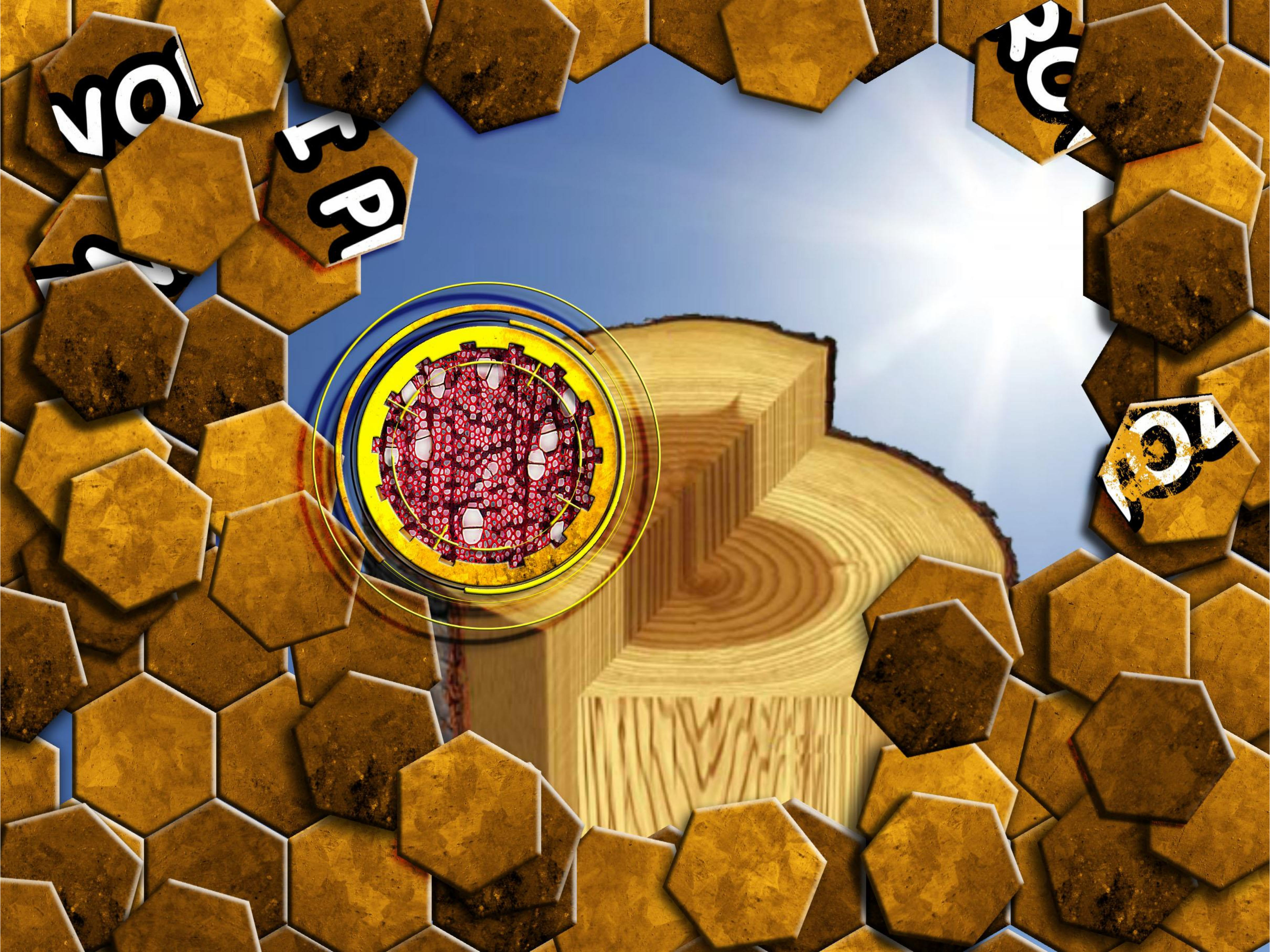
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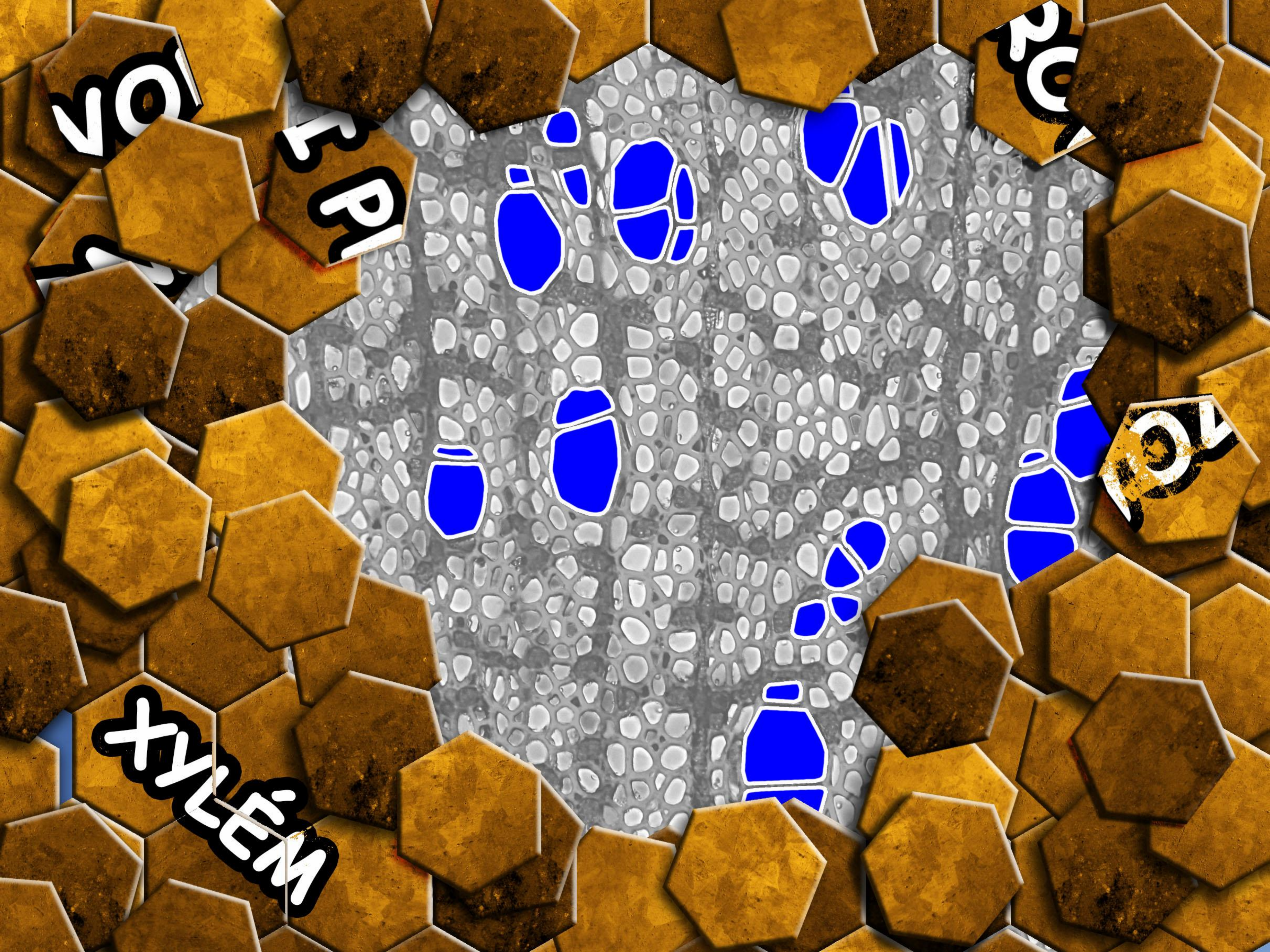
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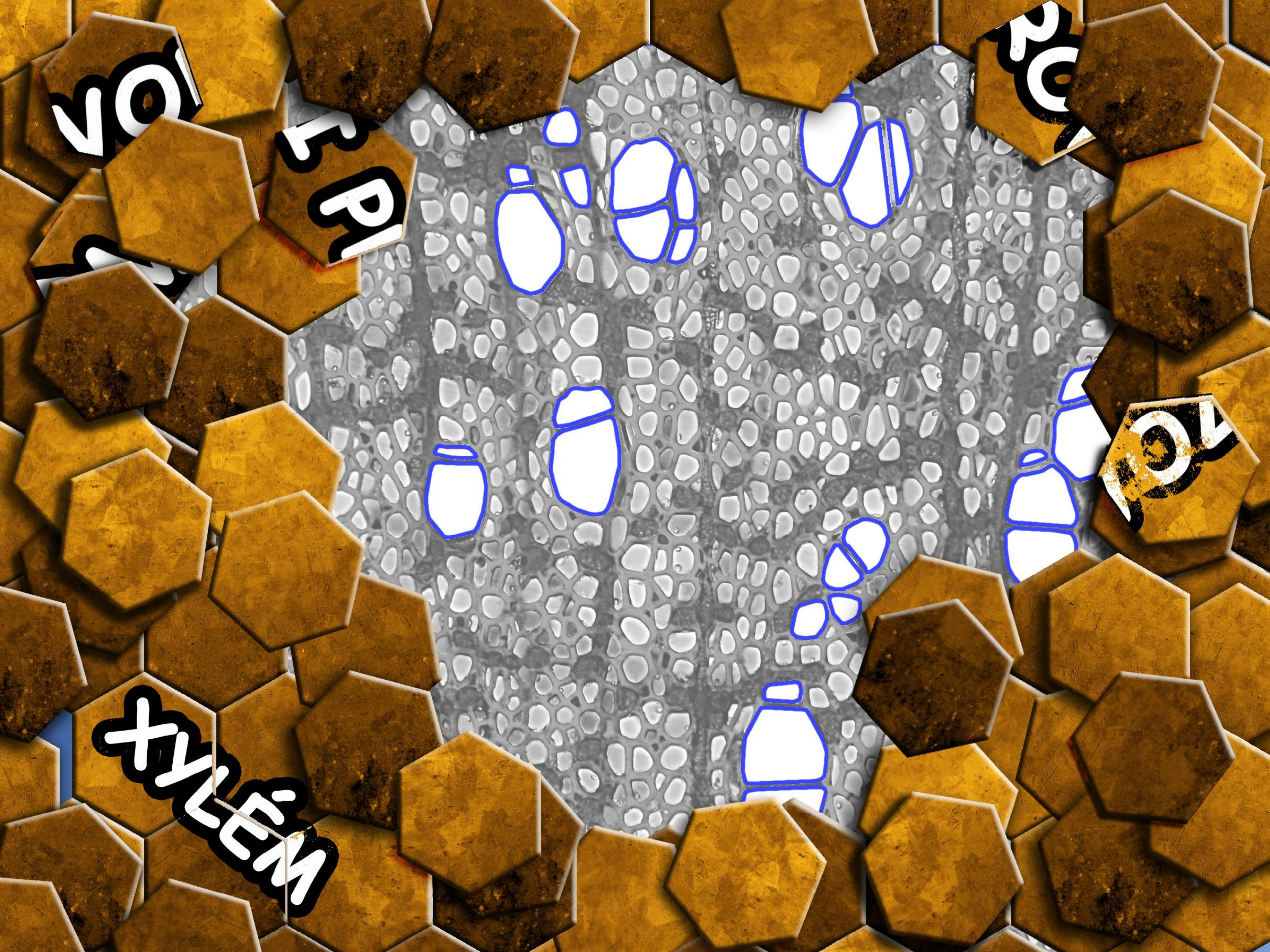
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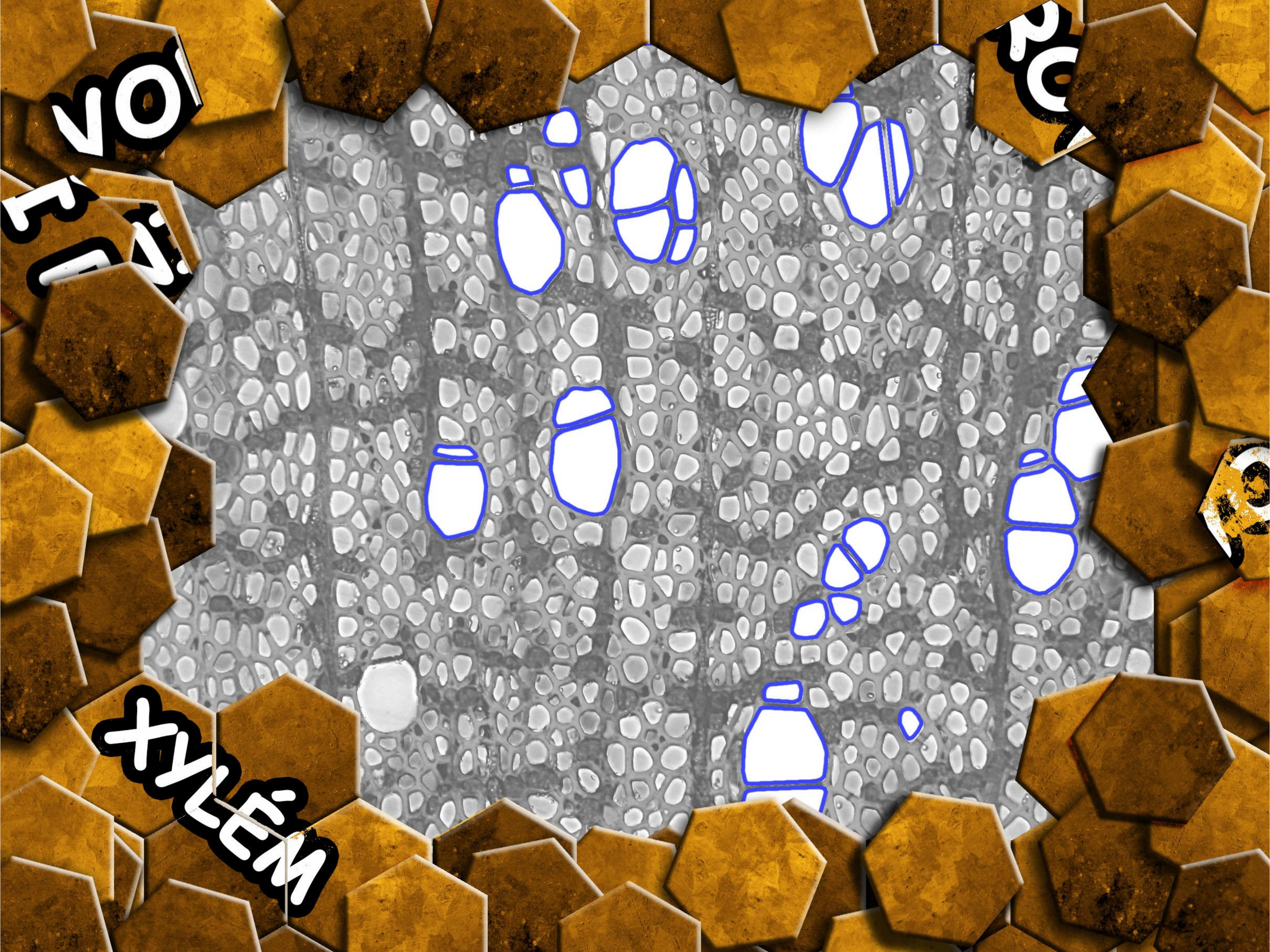
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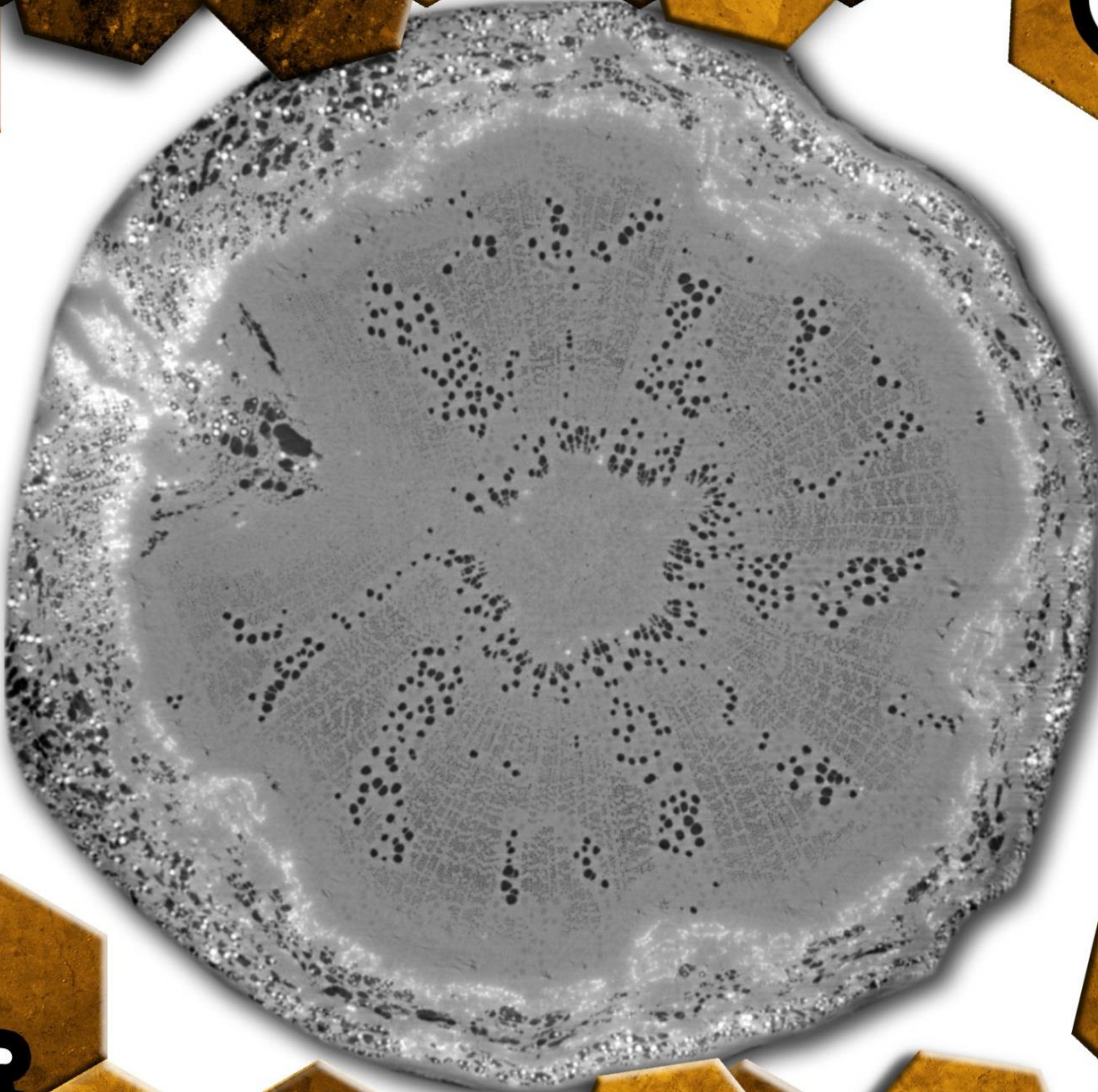
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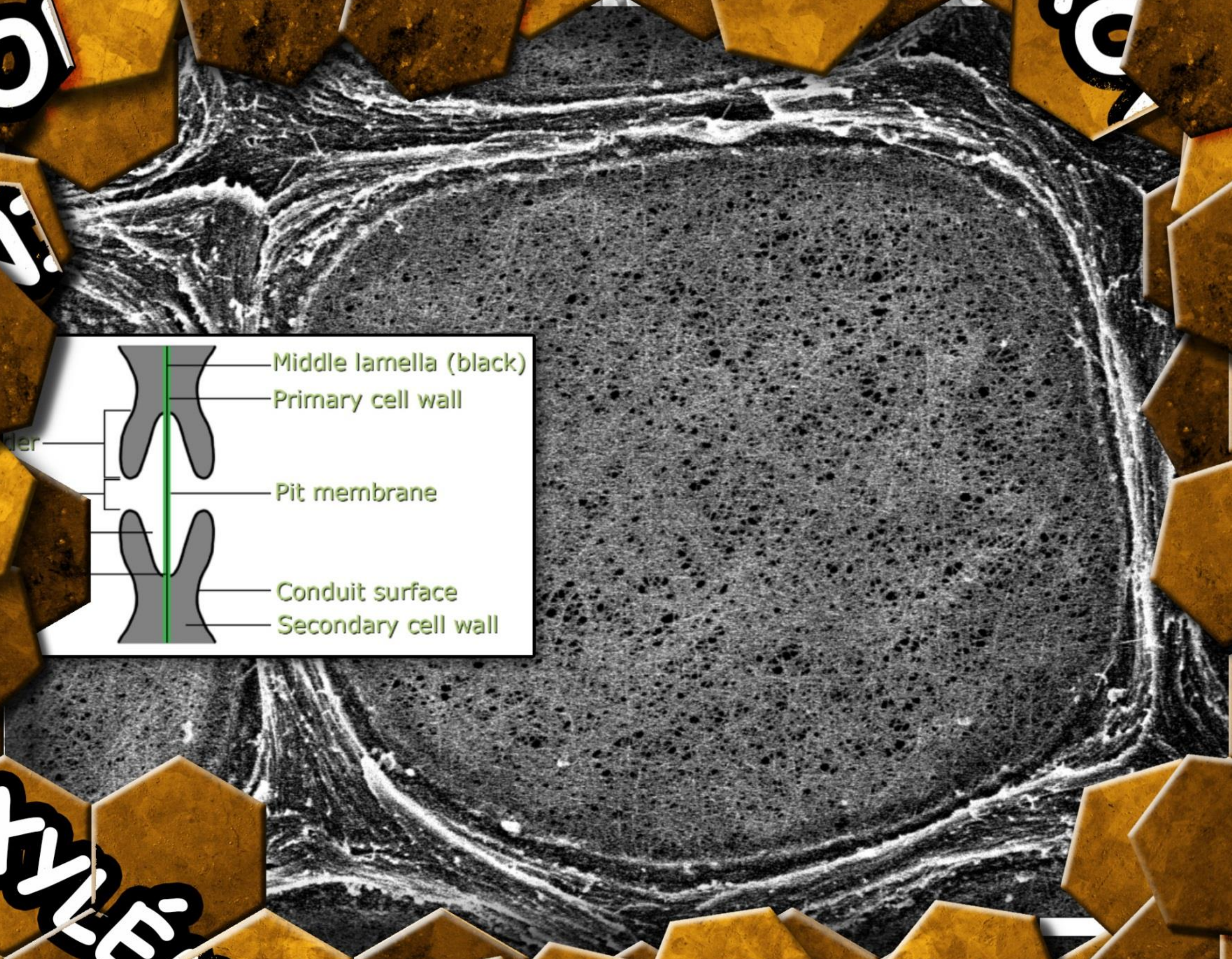
Middle lamella (black)
Primary cell wall
Pit membrane
Conduit surface
Secondary cell wall


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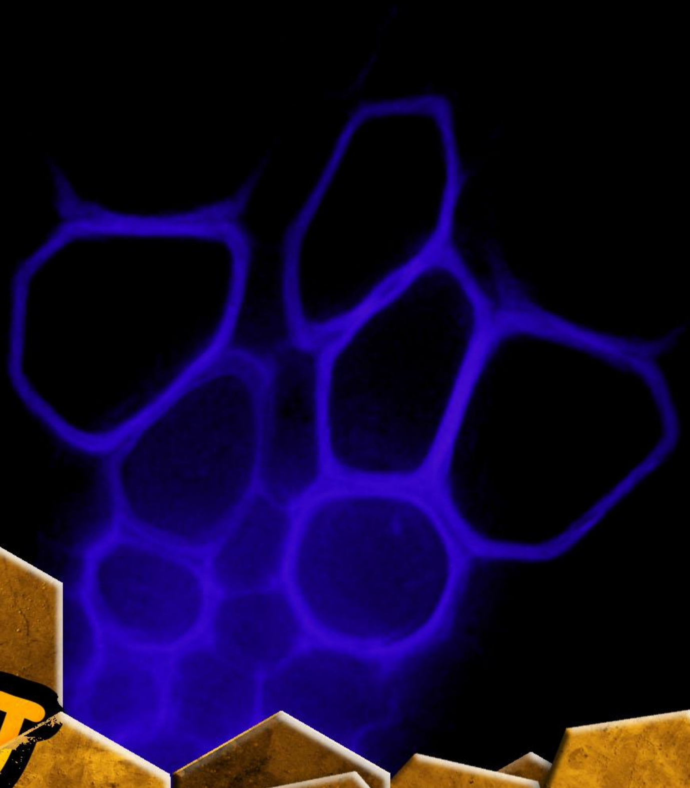

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frontiers
in Plant Science

METHODS
published: 09 April 2015
doi: 10.3389/fpls.2015.00211

An improved method for the visualization of conductive vessels in *Arabidopsis thaliana* inflorescence stems

Radek Jupa [1], Vojtěch Didi [2], Jan Hejátko [2] and Vít Gloser [1]*

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Dye perfusion is commonly used for the identification of conductive elements important for the study of xylem development as well as precise hydraulic estimations. The tiny size of inflorescence stems, the small amount of vessels in close arrangement, and high hydraulic resistivity delimit the use of the method for quantification of the water conductivity of *Arabidopsis thaliana*, one of the recently most extensively used plant models. Here, we present an extensive adjustment to the method in order to reliably identify individual functional (conductive) vessels. Segments of inflorescence stems were sealed in silicone tubes to prevent damage and perfused with a dye solution. Our results showed that dyes often used for staining functional xylem elements (safranin, fuchsine, toluidine blue) failed with *Arabidopsis*. In contrast, Fluorescent Brightener 28 dye solution perfused through segments stained secondary cell walls of functional vessels, which were clearly distinguishable in native cross sections. When compared to identification based on the degree of development of secondary cell walls, identification with the help of dye perfusion revealed a significantly lower number of functional vessels and values of theoretical hydraulic conductivity. We found that lignified but not yet functional vessels form a substantial portion of the xylem in apical and basal segments of *Arabidopsis* and, thus, significantly affect the analyzed functional parameters of xylem. The presented methodology enables reliable identification of individual functional vessels, allowing thus estimations of hydraulic conductivities to be improved, size distributions and vessel diameters to be refined, and data variability generally to be reduced.

Keywords: conductive elements, dye perfusion, fluorescence, Fluorescent Brightener hydraulic conductivity, vessel, xylem

Introducti

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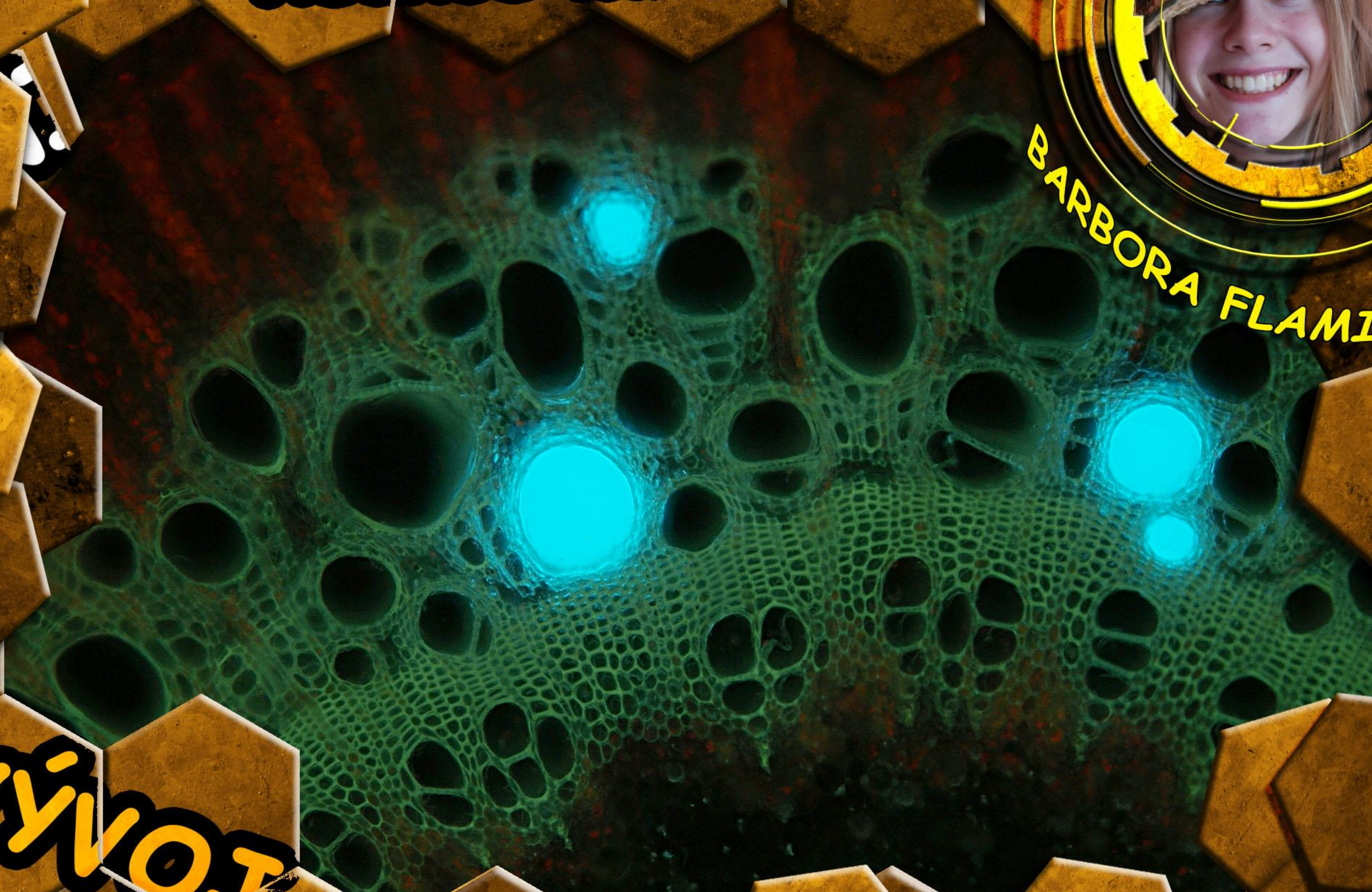

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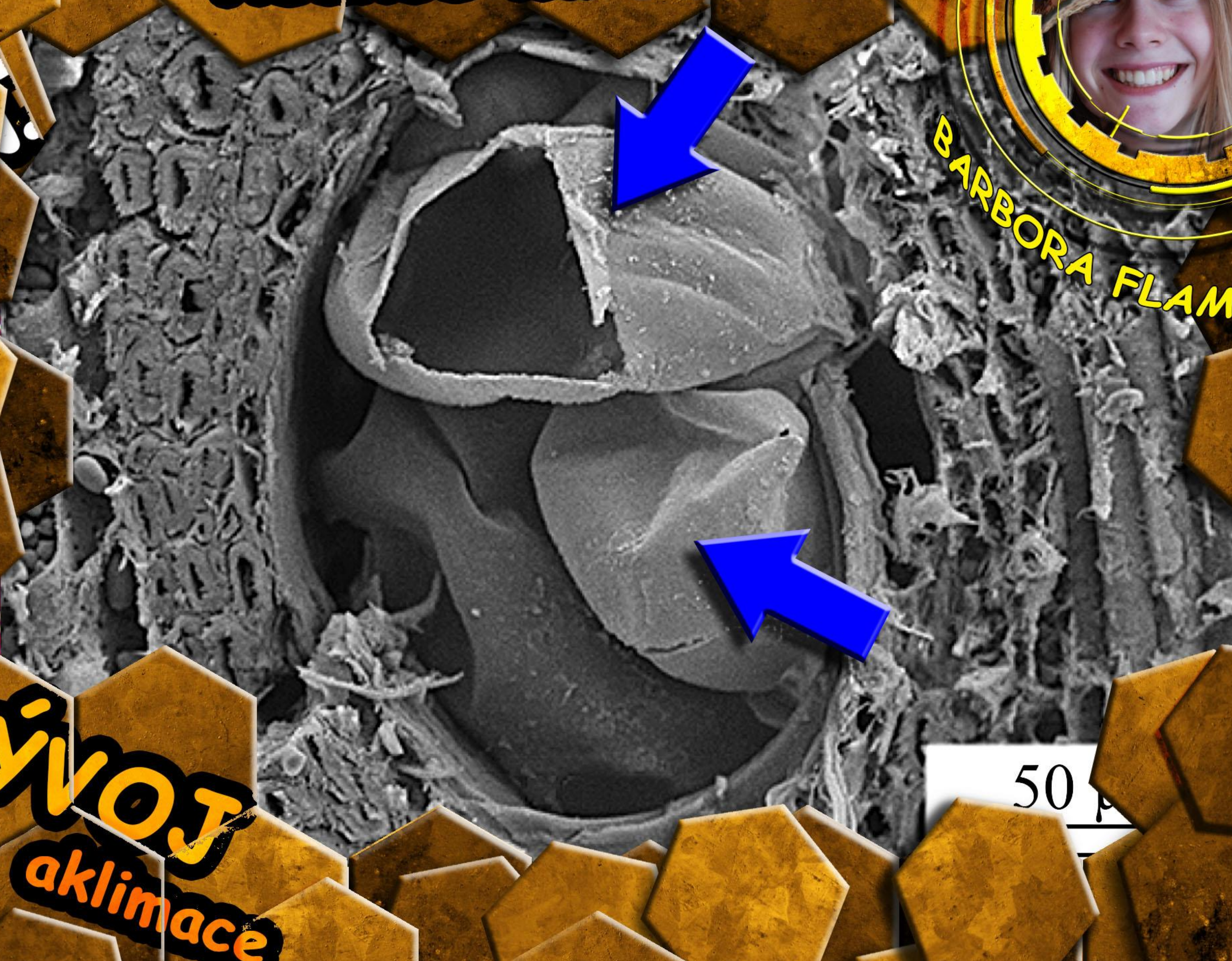

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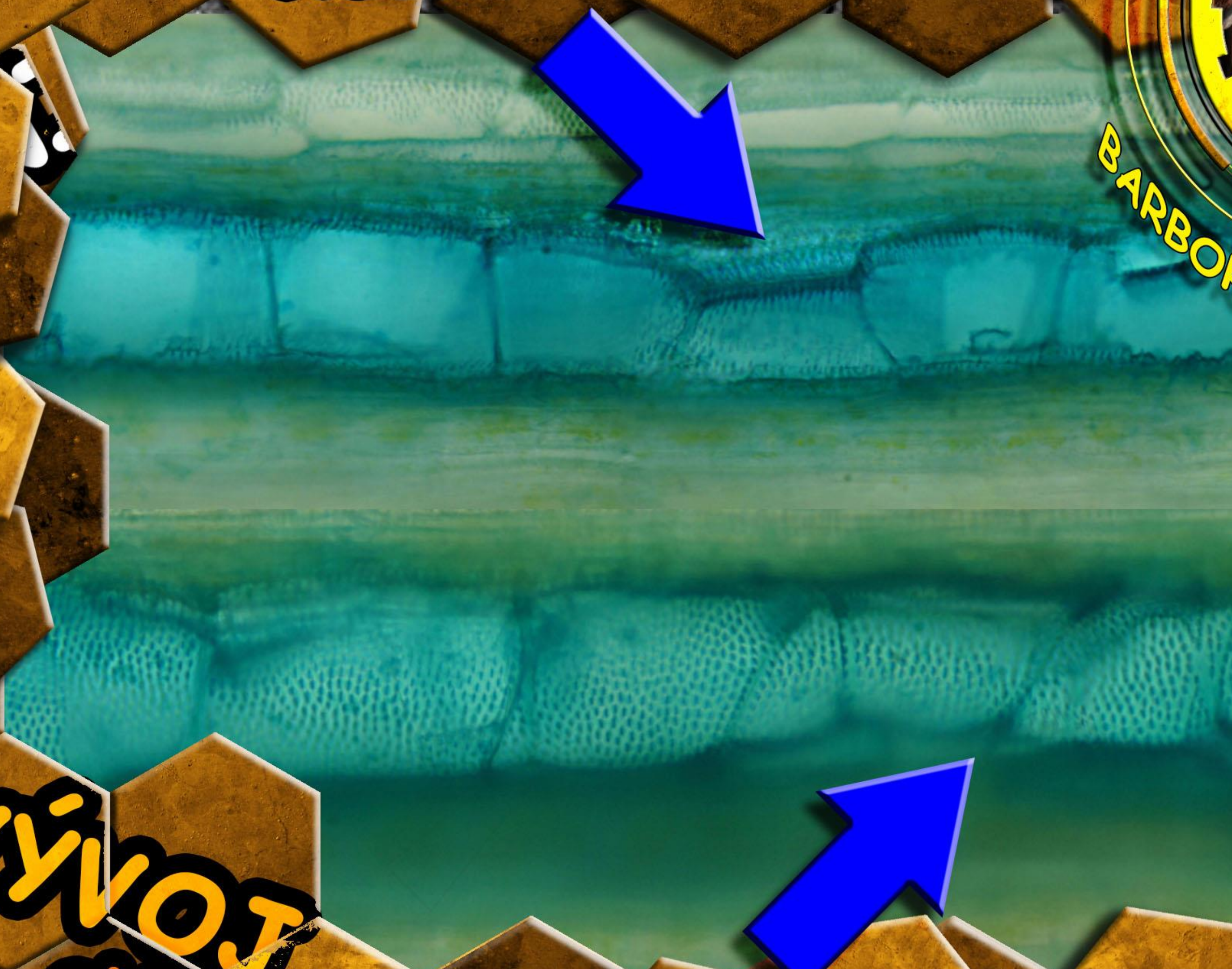

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Environmental and Experimental Botany

Contents lists available at S

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Original article

Effects of limited water availability on xyl
Humulus lupulus L

Radek Jupa[a,*], Lenka Plavcová[b,c], Barbora Flamiková[a]

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Drought
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Stem
Tyloses
Variable diameter
Vessel

ABSTRACT

The transport and distribu
Although the negative ef
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plant stems.

1. Introduction

In the last few decades, a gradual decline in water a
has become apparent in many regions worldwide due to
mean air temperatures and concomitant changes in the
cal cycle (IPCC, 2013). Droughts are likely to become mo
in future, as suggested by the results of diverse clim
that further emphasize a continuous decrease in rainfa
unequal distribution of precipitations, and more fre
tions in water availability as serious effects of ong
change (Christensen et al., 2007; Sterl et al., 2008;
2013).

* Corresponding author.
E-mail address: r.jupa@mail.muni.cz (R. Jupa).

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Research paper

Partitioning of vessel resistivity in three liana species

Milan Balaz[1,4], Radek Jupa[1], Steven Jansen[2], Alexander Cobb[3] and Vit Gloser[1]

[1]Department of Experimental Biology, Masaryk University, Faculty of Science, Kotlářská 2, 611 37 Brno, Czech Republic; [2]Institute of Systematic Botany and Ecology, U
Albert-Einstein-Allee 11, D-89081 Ulm, Germany; [3]Singapore-MIT Alliance for Research and Technology, #09-03 CREATE Tower, 138602, Singapore; [4]Corresponding
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Vessels with simple perforation plates, found in the majority of angiosperms, are considered the evolutionarily mos
conduits, least impeding the xylem sap flow. Nevertheless, when measured, their hydraulic resistivity (R, i.e., inverse va
hydraulic conductivity) is significantly higher than resistivity predicted using Hagen–Poiseuille equation (R_{HP}). In our study w
aimed (i) to quantify two basic components of the total vessel resistivity – vessel lumen resistivity and end wall resistivity, and
(ii) to analyze how the variable inner diameter of the vessel along its longitudinal axis affects resistivity. We measured flow
rates through progressively shortened stems of hop (*Humulus lupulus* L.), grapevine (*Vitis vinifera* L.), and clematis (*Clematis
vitalba* L.) and used elastomer injection for identification of open vessels and for measurement of changing vessel inner dia-
meters along its axis. The relative contribution of end wall resistivity to total vessel resistivity was 0.46 for hop, 0.55 for grape-
vine, and 0.30 for clematis. Vessel lumen resistivity calculated from our measurements was substantially higher than
theoretical resistivity – about 43% for hop, 58% for grapevine, and 52% for clematis. We identified variation in the vessel
inner diameter as an important source of vessel resistivity. The coefficient of variation of vessel inner diameter was a good pre-
dictor for the increase of the ratio of integral R_{HP} to R_{HP} calculated from the mean value of inner vessel diameter. We discuss
the fact that we dealt with the longest vessels in a given stem sample, which may lead to the overestimation of vessel lumen
resistivity, which consequently precludes decision whether the variable vessel inner diameter explains fully the difference
between vessel lumen resistivity and R_{HP} we observed.

Keywords: *Clematis vitalba*, *Humulus lupulus*, hydraulic conductivity, resistivity, variable diameter, *Vitis vinifera*, xylem.

Introduction

Vessels with simple perforation plates are the principal xylem
conduits in a majority of angiosperms and are believed to
impede sap flow less than conduits with evolutionarily older
plate types (Becker et al. 1999, Brodribb and Feild 2000,
Sperry 2000, Meinzer 2002, Sack et al. 2003, Sperry et al.
2003, Brodribb et al. 2005). However, even in species bearing
vessels with simple perforation plates, experimental measure-
ments of hydraulic conductivity (K, volume flow rate of water
per pressure gradient, $m^4 s^{-1} MPa^{-1}$) on stem segments with-
out open vessels (i.e., vessels lacking both end walls) typically
yield values less than half those predicted by the Hagen–
Poiseuille (HP) equation

ideal capillaries

(Giordano et al. 1978, Tyree and Ew
Ewers 1992, Hargrave et al. 1994, Mart
Tyree and Zimmermann 2002, Sperry
et al. 2011). This discrepancy at least p
flicting adaptive pressures on xylem stru
ciency and safety against embolism, re
size, length, density, and three-dimen
conduits (Wheeler et al. 2005, Hacke e
2006, Chave et al. 2009).

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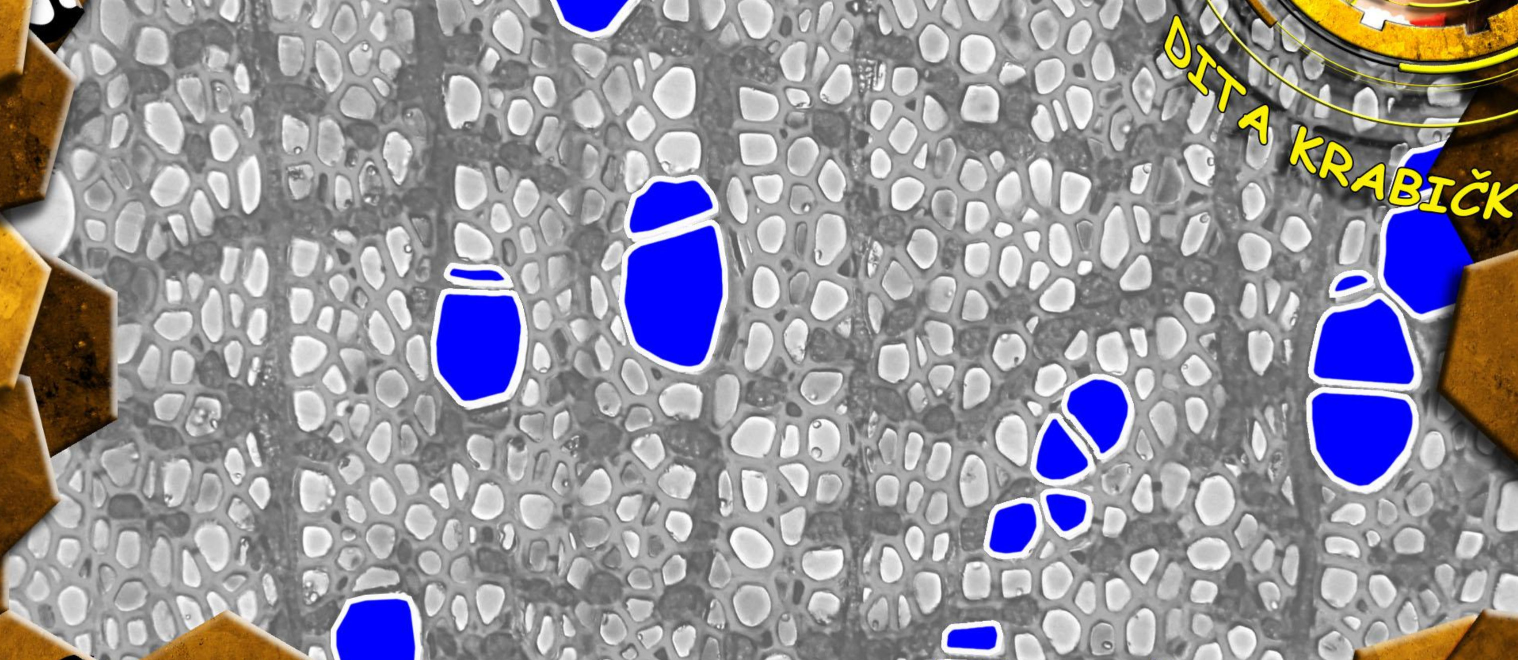

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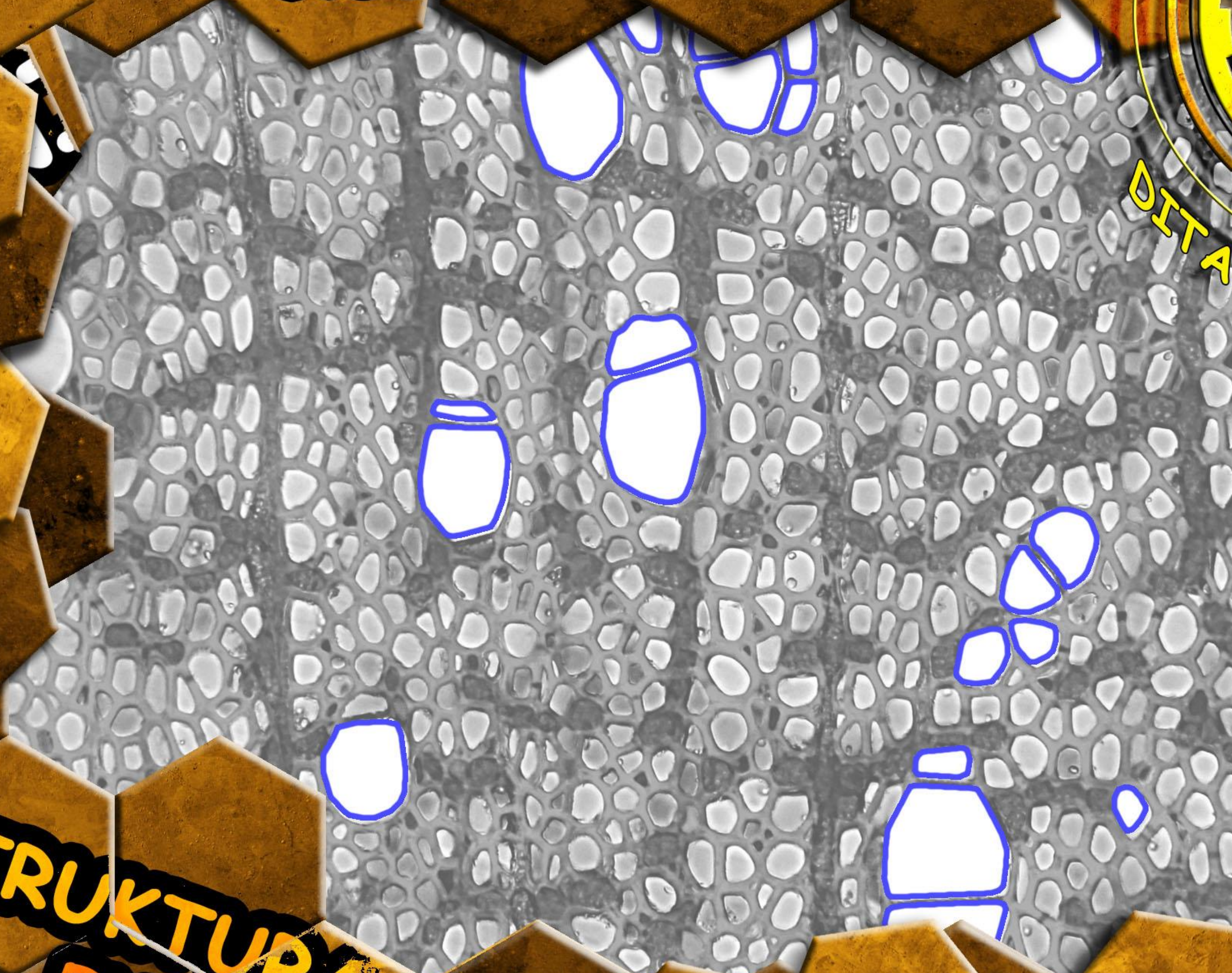

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DOI: 10.1111/ppl.13435

ECOPHYSIOLOGY, STRESS AND ADAPTATION

Do angiosperm tree species adjust intervessel lateral contact in response to soil drought?

Radek Jupa[1,2] | Dita Krabičková[1] | Roman Plichta[2] | Stefan Mayr[3] | Vít Gloser[1]

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Abstract

During soil drought (i.e. limited soil water availability to plants), woody species may adjust the structure of their vessel network to improve their resistance against future soil drought stress. Impacts of soil drought on intervessel lateral contact remain poorly understood despite of its significance to xylem transport efficiency and safety. Here, we analysed drought-induced modifications in xylem structures of temperate angiosperm trees with a focus on intervessel lateral contact. Anatomical analyses were performed both in stems of seedlings cultivated under different substrate water availability and annual rings of mature individuals developed during years of low and high soil drought intensities. In response to limited water availability, a decrease in vessel diameter (up to −20%) and simultaneous increase in vessel density (up to +60%) were observed both in seedlings and mature trees. Conversely, there were only small and inconsistent drought-induced changes in intervessel contact frequency and intervessel contact fraction (typically up to ±15%) observed across species, indicating that intervessel lateral contact is a conservative trait. The small adjustments in intervessel lateral contacts were primarily driven by changes in the contact frequencies between neighbouring vessels (i.e. vessel grouping) rather than by changes in proportions of shared cell walls. Our results demonstrate that angiosperm tree species, despite remarkable adjustments in vessel dimensions and densities upon soil drought, exhibit surprisingly invariant intervessel lateral contact architecture.

1 | INTRODUCTION

Soil drought (i.e. a period of limited soil water availability to plants) is a phenomenon with adverse effects on plant growth, development, and health (Lipiec et al., 2013; Mittler, 2006). In the last decades, increasing frequency and extent of soil droughts combined with intensive heat waves affected the health of forest stands and contributed to their decline in various regions of the earth (Allen et al., 2010, 2015; Hartmann et al., 2018). Severe soil droughts can affect the species composition and structure of forests, alter ecosystem functi
and may have enormous consequences for carbon se
cycling (Allen et al., 2015; Millar & Stephenson, 2
global and regional climate models predict that soil
to become even more frequent in th
et al., 2007; Hari

understanding of tree responses to water shortage is urgently needed for assessing and reducing the impacts of ongoing climatic change on forests (Coll et al., 2018; Sousa-Silva et al., 2018).

Tree resistance to soil drought is tightly linked with
tions (Choat et al., 2012, 2018; McDowell
xylem provides long-distance transport
towards leaves in a system of capillary-
cheids),

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Význam kůry pro spolehlivou funkci xylému dřevin

Bakalářská práce

DORA ŘÍHOVÁ

RNDr. Radek Jupa, Ph.D.

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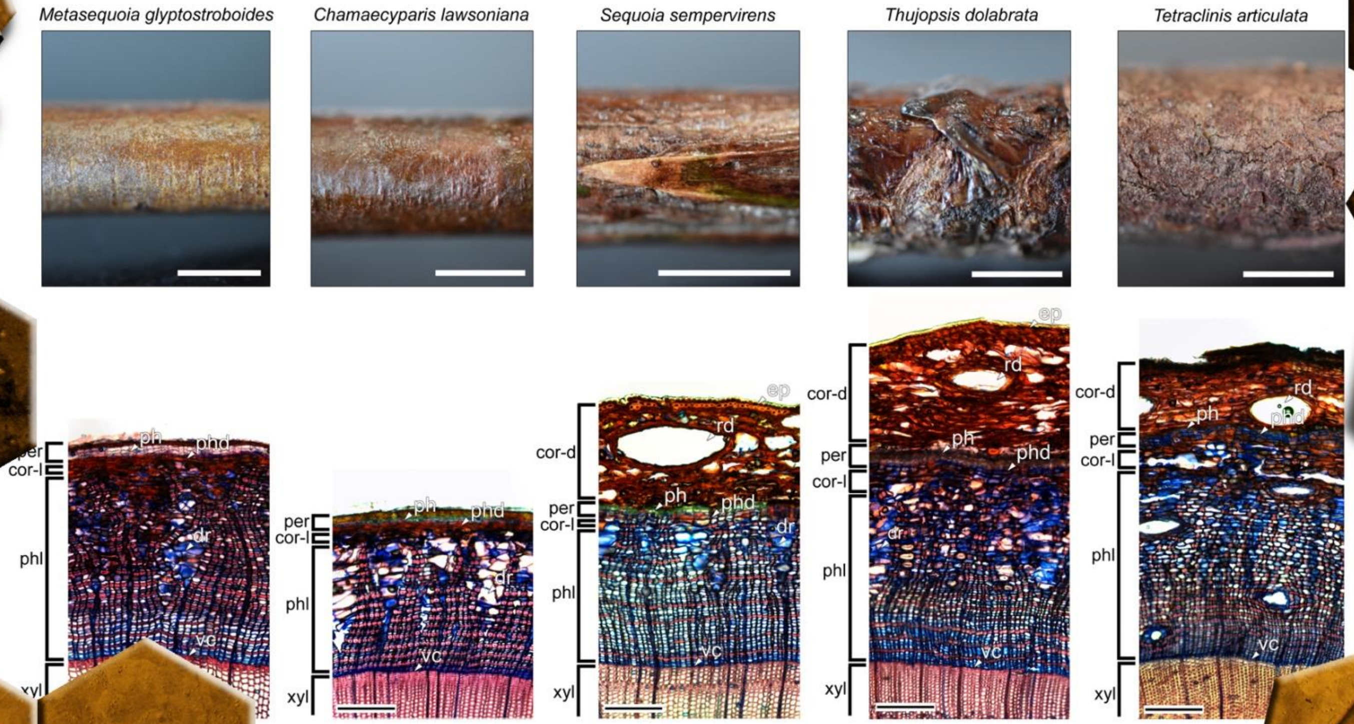

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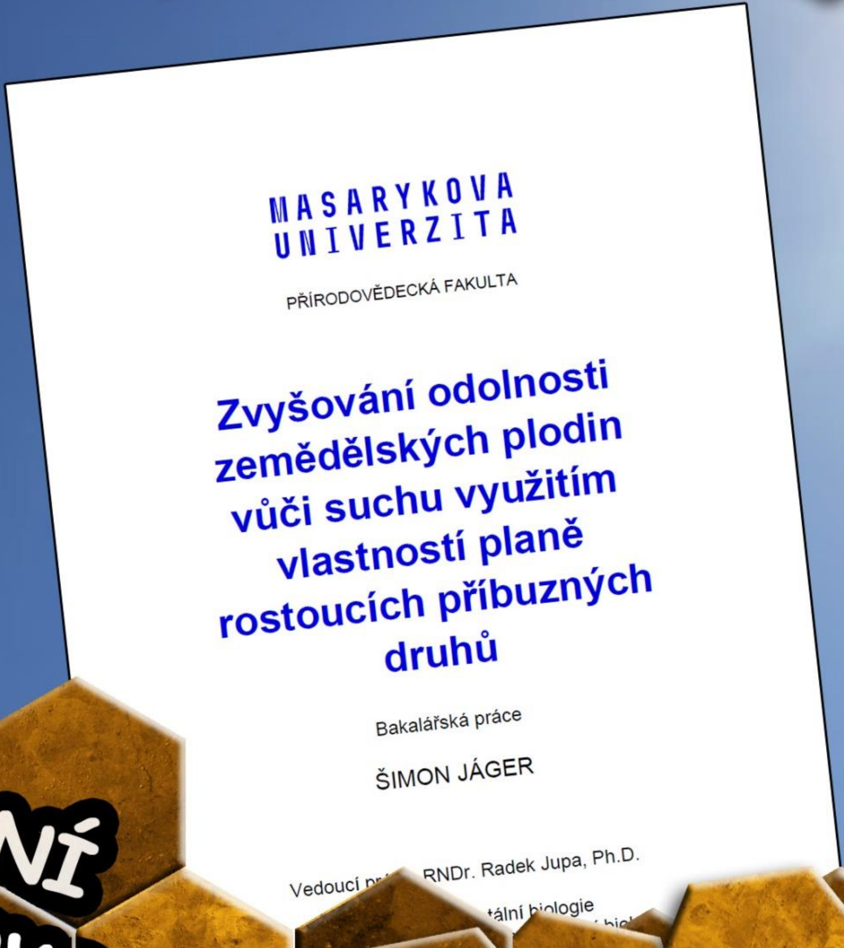

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Bakalářská práce

ŠIMON JÁGER

Vedoucí pr RNDr. Radek Jupa, Ph.D.

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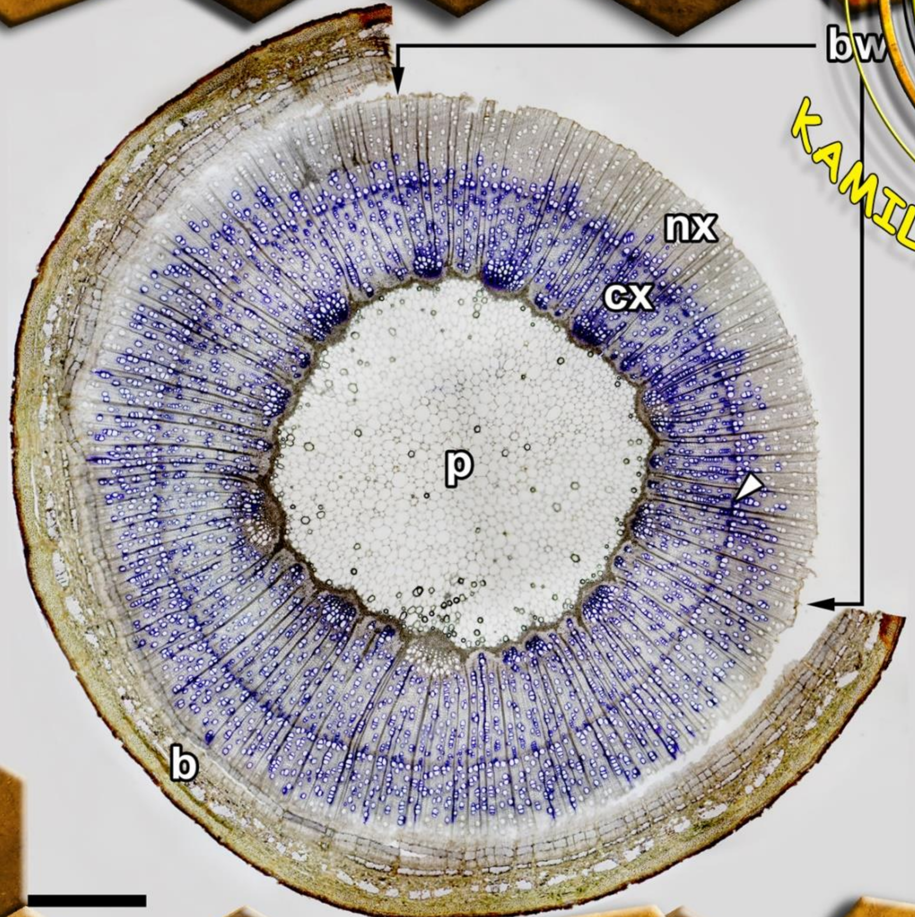

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KAMILA POKORNÁ

Tree Physiology, 2023, 1–12
https://doi.org/10.1093/treephys/tpad132
Research paper

Bark wounding triggers gradual embolism spreading in two diffuse-porous tree species

Radek Jupa* and Kamila Pokorná

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*Corresponding author (r.jupa@mail.muni.cz)

Handling Editor: Teemu Holtta

Xylem transport is essential for the growth, development and survival of vascular plants. Bark wounding may increase the risk of xylem transport failure by tension-driven embolism. However, the consequences of bark wounding for xylem transport are poorly understood. Here, we examined the impacts of the bark wounding on embolism formation, leaf water potential and gas exchange in the terminal branches of two diffuse-porous tree species (*Acer platanoides* L. and *Prunus avium* L.). The effects of bark removal were examined on field-grown mature trees exposed to increased evaporative demands on a short-term and longer-term basis (6 h vs 6 days after bark wounding). Bark removal of 30% of branch circumference had a limited effect on the xylem hydraulic conductivity when embolized vessels were typically restricted to the last annual ring near the bark wound. Over the 6-day exposure, the non-conductive xylem area had significantly increased in the xylem tissue underneath the bark wound (from 22–29% to 51–52% of the last annual ring area in the bark wound zone), pointing to gradual yet relatively limited embolism spreading to deeper xylem layers over time. In both species, the bark removal tended to result in a small but non-significant increase in the percent loss of hydraulic conductivity compared with control intact branches 6 days after bark wounding (from 6 to 8–10% in both species). The bark wounding had no significant effects on midday leaf water potential, CO_2 assimilation rates, stomatal conductance and water-use efficiency of the leaves of the current-year shoot, possibly due to limited impacts on xylem transport. The results of this study demonstrate that bark wounding induces limited but gradual embolism spreading. However, the impacts of bark wounding may not significantly limit water delivery to distal organs and leaf gas exchange at the scale of several days.

Keywords: drought, gas exchange, hydraulic conductivity, tree injury, water potential, xylem.

Introduction

Long-distance xylem transport of water and solutes represents a process of vital importance for all vascular plants (Tyree and Zimmermann 2002, Choat et al. 2018). Xylem transport is carried out under a negative pressure gradient in a system of non-living xylem conduits (vessels or tracheids; Stroock et al. 2014). Under these physiological conditions, the water column in the xylem conduits is under permanent tension, and the transport is prone to failure by embolism (Zwieniecki and Secchi 2015, Choat et al. 2018). Extensive formation of tension-driven embolism is typically associated with drought stress exposure when increased tension in the xylem accelerates embolism spreading in the network of xylem conduits. During embolism spreading, air expands from one xylem conduit to a neighboring one through pits, resulting in an inability of such a conduit to transport water (Zwieniecki and Secchi 2015). Extensive spreading of embolism finally results in the critical loss of xylem conductivity and, consequently, limits water livery to distal organs. The impaired water supply suppress carbon uptake (Nardini and Sall al. 2020) and, in extreme cases,

conduits at a given tension. In particular, the mutual connectivity of xylem conduits (e.g., vessel grouping and intervessel pitfield fraction) and pit ultrastructure (e.g., torus-to-aperture overlap, intervessel pit membrane dimensions and size of pore constrictions in intervessel pit membranes) belong to the prominent determinants of embolism spread within xylem (Wheeler et al. 2005, Bouche et al. 2014, Li et al. 2016, Kaack et al. 2021, Levionnois et al. 2021). By contrast, very little is currently known about the functional significance of bark for undisturbed xylem transport. However, several lines of evidence suggest that bark integrity and its functional properties may mitigate uncontrolled increases in xylem tension and, together with xylem structural traits, affect xylem vulnerability to embolism.

The bark is a multifunctional structure of complex ontogenetic origin, which refers to a collection of all tissues outside the secondary xylem (Angyalossy et al. 2016). In the bark, the inner and outer bark regions are distinguished bas their differences (Rosell 2019 formed by a hig

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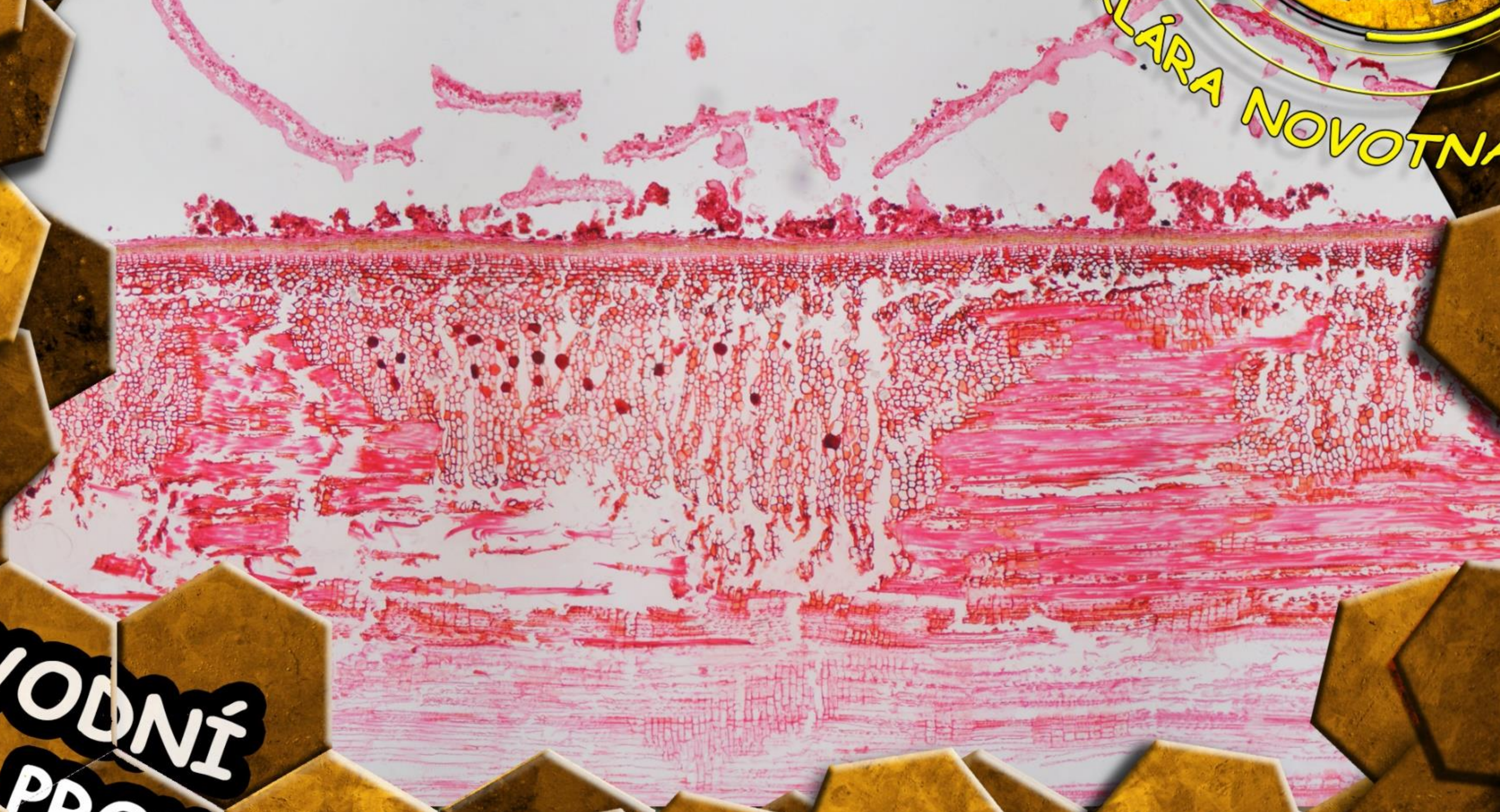

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VODNÍ PROVOZ

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zajímavé

aplikační potenciál

TÉMA PRÁCE:

perspektivní

individuální přístup

PRÁCE: zábavná

možno začít ihned

různorodá

aktivní spolupráce

moderní metody

VÝSTUPY: Bc. Mgr. a Ph.D. práce

odborné publikace

ceny dekana, environmentální soutěže, ...


VODNÍ PROVOZ

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