

## **Bakalářská práce**

# **Textual patterns in popular scientific news**

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## Zadání bakalářské práce

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#### **Zásady pro vypracování:**

Cílem práce je prozkoumat výskyt a jazykové charakteristiky textových vzorců v populárně vědeckých zprávách. K tomuto účelu bude shromážděn korpus aktuálních populárně vědeckých textů z různých oborů. Poté v nich student identifikuje výskyt textových vzorců typu problém-řešení. Tyto potom rozebere s ohledem na pořadí jejich složek, jejich roli v textu a jejich jazykové charakteristiky s obzvláštním zřetelem k evaluativním výrazům.

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1. Fahnestock, Jeanne. 1986. "Accommodating Science: The rhetorical life of scientific facts?". *Written Communication* 3(3), 275-296.
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## **Poděkování**

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## **Anotace**

Tato bakalářská se zabývá textovými vzorci v populárně vědních článcích. Zvláštní pozornost je věnována vzoru Problem-Solution a jeho lingvistickým charakteristikám se zvláštním zřetelem na hodnotící slova. Cílem práce je zjistit četnost výskyt vzoru Problem-Solution v populárně vědních článcích. Teoretická část se věnuje definici populárně vědních článků, popularizaci vědy, intertextualitě a epideiktickému argumentu. Dále se tato část práce zabývá textovými vzory, strukturami a jazykovými prostředky, kterými se tyto vzory a struktury vyznačují. Obsahem praktické části práce je analýza týkající se výskytu textového vzoru Problem-Solution na korpusu populárně vědních článků. Vzhledem k malému výskytu vzoru Problem-Solution v těchto článcích, si práce klade za náhradní cíl porovnat dva za tímto účelem vybrané populárně vědní články s odlišnou textovou strukturou a zjistit jejich podobnosti nebo odlišnosti. Tyto články jsou rozebrány a porovnány z pohledu v teoretické části vybraných textových vzorů a struktur.

## **Klíčová slova**

Populárně vědní články, intertextualita, textový vzor, Obrácená pyramida, Problem-Solution vzor, sémantické kategorie, hodnotící slova

## **Annotation**

This bachelor's thesis deals with text patterns in popular scientific news. Special attention is paid to the Problem-Solution pattern and its linguistic characteristic, with particular attention to evaluative words. The thesis aims to determine the frequency of occurrence of the Problem-Solution pattern in popular scientific news. The theoretical part is devoted to the definition of popular scientific news, the popularization of science, intertextuality and the epideictic argument. Furthermore, the theoretical part deals with text patterns, structures and linguistic features that characterize these patterns and structures. The content of the practical part of the work is an analysis of the occurrence of the Problem-Solution text pattern in the corpus of popular science articles. Due to the small occurrence of the Problem-Solution pattern in these articles, the thesis sets itself the alternative goal of comparing two popular science articles with a different text structure selected for this purpose and to find their similarities or differences. These articles are analyzed and compared from the point of view of the theoretical part of selected text patterns and structures.

## **Keywords**

Popular scientific news, intertextuality, text pattern, Inverted pyramid, Problem-Solution pattern, semantic categories, evaluative words

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## **List of abbreviations**

i.e.	that is (id est in Latin)
P-S pattern	Problem-Solution pattern
SP	science popularization
SPN	scientific popular news

## **Introduction**

The bachelor thesis aims to examine the occurrence of the Problem-Solution pattern and other patterns, the role of their parts and linguistic features in popular scientific news. The Problem-Solution pattern is a pattern where a part of a text represents a problem that requires a reaction in the form of a solution.

I divide the thesis into theoretical and practical portions. The theoretical section consists of an Introduction, introducing chosen text patterns and sources I draw from, and two chapters - The Popular Scientific News and The Text Pattern and Linguistic Features. Chapter 2 comprises two subchapters: Defining popular science news and Science popularisation. I address the closer definition of popular scientific news in The Defining Popular Scientific News. Further, chapter 2 deals with the science popularisation process, interconnected with intertextuality and a kind of persuasive speech discussed in subsequent sequences. Intertextuality is closely connected with creation because the text does not exist by itself (independently) but is linked with other texts.

Chapter 3 addresses the structure of popular science news in the context of text patterns and contains five subchapters. I focus on news text structure, which copies the structure of the Inverted pyramid from top to bottom and highlights the text being text-based rather than time-based. Semantic categories divide an article into text parts without closely specified order and copy the Inverted pyramid structure. The Problem-Solution pattern divides the text into stages, where the main stages exactly copy the order of the main stages of the pattern, and the rest of the pattern has a looser order. The chapter closes with Linguistic characteristics and evaluative words.

I identify the occurrence and the frequency of the Problem-Solution text pattern in a corpus of popular scientific news in the practical part of the thesis. Articles used in this work are collected from different scientific fields in popular scientific journals that I select randomly from online science journals. I conduct a preliminary survey of the occurrence of the Problem-Solution in the articles. I discover only a trivial occurrence of Problem-Solution patterns, so I use a qualitative method to determine in detail the occurrence and characteristics of other patterns in two other popular science articles. I identify text patterns and then compare them. I look for differences or agreements between the chosen articles.

# **1 Introduction to the theoretical part**

The theoretical part of the thesis defines the term "popular science news," popularisation of science, related intertextuality and epideictic arguments to investigate the occurrence of text patterns and linguistic characteristics of text patterns in popular science news. The theoretical part of the thesis further focuses on the Inverted pyramid, Text time vs Field time, semantic categories and the Problem-Solution pattern, its parts and their role in the text, and especially on linguistic features regarding evaluative words.

The thesis focuses on the above theories concerning their subsequent application when examining the occurrence of the Problem-Solution and other patterns. The work applies theories to compare selected articles (A and B) in the qualitative practical portion. Special attention is paid to the Problem-Solution text pattern in the given articles and the linguistic characteristics of textual patterns, especially evaluative words.

Before analysing selected articles (A and B) for this purpose, the discussed theory is applied to popular scientific articles 1-3 to introduce the simplified form of the Problem-Solution pattern to the reader before the subsequent more complex analysis of the article (A). Furthermore, based on knowledge from the theoretical part, I assess similarities or differences between articles A and B regarding text patterns and language characteristics. I apply the theory of the Problem-Solution text pattern in the practical part to a corpus of popular science articles from different scientific fields collected to examine the occurrence of the Problem-Solution pattern.

Through qualitative analysis of articles A and B, I determine whether the absence or presence of these text structures and patterns influences the purpose of popular science articles (to inform). In addition, I compare the usage of patterns or structures in these articles (which I would not discover with the qualitative method) and whether some of these patterns are equivalent to or subordinate to other text patterns or structures. Emphasis is given to analysing articles using the Problem-Solution pattern, its parts, their roles and linguistic characteristics, with particular attention to evaluative words.

The thesis draws from Hoey, Myers, Fahnestock, Martin and Rose and others to assess the language characteristics and compare the evaluative words in chosen articles. A comparison of the structure of the articles draws on Van Dijk's work on semantic categories (T. Van Dijk, 1988, 49-59). I compare articles A and B according to Samuel Morton's news structure, the Inverted pyramid. The evaluation of the occurrence of the Problem-Solution patterns and their features is based on the analysis of Hoey's text pattern (Hoey 2001, 119-141). I draw the movements in time in the individual phases from Martin and Rose's Text and Time analysis (Martin and Rose 2008, 119-141). The deontological appeal and the two arguments based on it draw on Fahnestock's work (Fahnestock 1986, 278-288). For the theories mentioned above, I also draw on Haupt's dissertation, which comprehensively covers all the mentioned topics, the theories of the scientists in question, and many others.

## **2 Popular scientific news**

This chapter aims to define the concept of popular science news. Furthermore, the chapter focuses on the process of scientific news popularisation that features intertextuality – the interconnectedness of texts and epideictic arguments. Popularisation creates PSN structures and textual patterns.

### **2.1 Defining popular scientific news**

The subchapter defines the aspects of popular science articles. The work draws from Haupt's work, which provided a comprehensive basis for the given topic. First, the subchapter addresses the definition of popular science articles. Although many scientific statements are on the subject, they are primarily chunks and too vague. Haupt's work thus provides a possible comprehensive viewpoint of popular scientific news definitions and the entire theory of text patterns, enriched by the opinions of many other interested scientists.

Haupt's statement is based on Bhatia's definition of news as a genre that aims to inform lay readers about current world events without subjective bias (Bhatia 1993:20 in Haupt 2014, 12). Haupt develops this definition further: "Further specifying this definition, I define science news as a reporting genre whose mutually recognised purpose is to inform nonspecialist readers about a recent scientific finding in a brief, comprehensible, engaging, positive, and purportedly objective manner." (Haupt 2014, 12). I, therefore, understand the verb "*inform*" as the first and central aspect of popular science articles. In his work, Haupt further narrows this aspect by referring to Brown and Yule: "The verb inform, and the reference to recent scientific finding as a content specification highlights the transactional aspects of the genre" (Brown and Yule 1987 in Haupt 2014, 12).

Based on the given outline, I define popular science articles as news that should be constructed of the following aspects: Informative, addressed to lay readers, impartial, clear, and positive. The first aspect refers to being informed about new knowledge in the field of science based on recent research or discovery. The aspect of addressing readers and comprehensibility are linked together. Although still an area of science, it is a genre subject to mass media, and information must be adapted to nonspecialist readers. Haupt associates the positive aspect of the definition with Fahnestock's description of the popularisation discourse. Fahnestock classifies the popularisation discourse as an epideictic argument: Firstly, she understands celebratory and scientific progress as beneficial to humanity and thus fulfils the positive aspect of the definition. Secondly, she assumes the journalist presents credible scientific knowledge to the ignorant reader (Haupt 2014, 13). The work analyses Fahnestock and the description of the popularisation discourse in more detail in the next part of this chapter and applies it to selected articles in the practical part of the thesis.

### **2.2 Science popularisation, intertextuality, epideictic arguments**

This subsection details the process of science popularisation (SP) and its traditional and modern concepts. Furthermore, the subsection explains the concept of intertextuality and its forms. The

process of popularisation is based on creating a new text from one or more existing texts and is thus related to intertextuality. This part of the work focuses on science popularisation and intertextuality because they influence the structure and text patterns of science popular news.

### 2.2.1 Science popularisation

The subsection clarifies the popularisation process to help understand the text structures and patterns discussed in this work.

"In general terms, Science popularisation (SP) can be defined as a process of contextualisation of knowledge from scientific contexts (such as laboratories and research institutes) to mass media" (Motta-Roth, 2009, based on Bernstein, 1974 in Scherer 2010, 26). Scientific knowledge is thus disseminated among an uninformed audience, who, thanks to broader general knowledge, can better participate in the decision-making of political questions in the field of science (Scherer 2010, 26).

The traditional view of SP consists of scientific and popularising discourse. The popularising discourse mediates the insights and knowledge of scientific discourse. This information is affected by distortion and self-aggrandisement (Myers, 2003:266 in Scherer 2010, 27) and assigns more authority to scientists. The current view is of the popularisation of science as a cycle driven by the mutual influence of society and science. Public interest stimulates publishing a news article on a particular topic, which interests scientists and those doing intensive research. The research results subsequently form the basis for novel scientific news. **Figure 1** illustrates the cycle of activities from the current point of view: 1. Media inform about new research. 2. Author of scientific news who takes responsibility for explaining the principles and essence of discovery. 3. The need for readers to understand the benefit of research and to support scientific research further. (Motta-Roth, 2009:4,8 v Scherer 2010, 27 - 28).

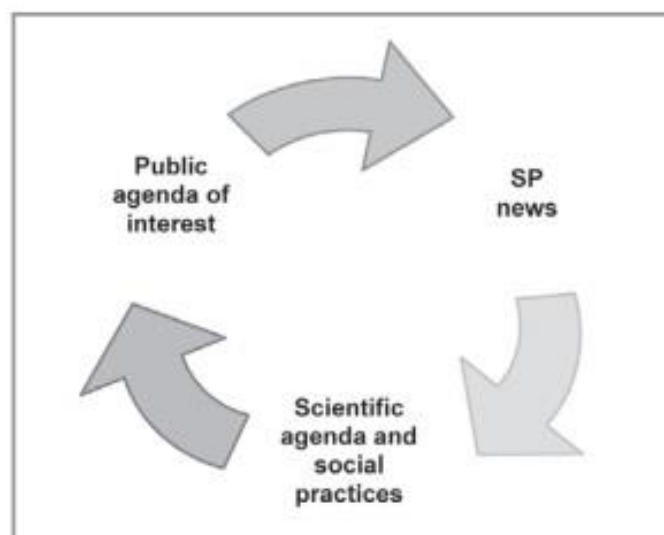


Figure 1: Cycle of activities that interrelates science and society, adapted from Motta-Roth (2009:8) in Scherer 2010, 28



### 2.2.2 Intertextuality

This section explains the concept of intertextuality, its forms and its application in science popularisation (creation of SPN). The work includes intertextuality under science popularisation because intertextuality acts as a mechanism of popularisation that participates in the creation of texts of PNS and thus influences the final form of these texts. According to Haupt, looking at the field of science and news through intertextuality evokes the main features of the genre, which are the audience (as one of the sources of intertextuality) and the content. Haupt further refers to Martin and White, according to whom intertextuality plays a role in evaluation (Haupt 2014, 13).

Intertextuality, on a general level, denotes the state that texts are conceived from other texts. Kristeva, in her work, characterises intertextuality as a relation of a text with other texts surrounding it (Scherer 2010, 29). Barthes goes even further and allegorises the author's death, meaning there is no longer an original text.

Scherer further distinguishes between **explicit and implicit intertextuality**. **Explicit** intertextuality refers to a text that mentions the sources from which it drew at the end of the literature sources or by enumerating scientific articles. Furthermore, Scherer uses the term **intertext** within explicit intertextuality. An intertext is a text that mentions another text in itself and relies on the knowledge or familiarity of an audience with the text and society's knowledge or awareness of the given text (Scherer 2010, 29-30). "Intertexts, in SP news, usually refer to academic texts in which the research is shared with a specialised audience as well as to different voices evoked by the journalist in order to describe, interpret, explain, and/or evaluate the research" (Motta-Rothe et al., 2008, in Scherer 2010, 30).

**In contrast to explicit intertextuality, implicit intertextuality** uses the knowledge of another text in the given text and alludes to this knowledge but does not indicate the sources of the mentioned text. For example, Scherer relates jokes that contain criticism or irony about previous writings (Scherer 2010, 29).

Haupt agrees with Motta-Rothe that popular science articles refer to research texts. Within the sequence of the "generic chain", they are thus borne of the predecessor. Through this intertextual relationship, popular science articles depend on scientific articles for their content. Thus, one genre is a necessary, indispensable predecessor of the other (Swales 2008, 18 in Haupt 2014, 14). However, the central part of scientific articles can be processed through other genres (Haupt 2014, 14). In the non-scientific realm are intertexts recollected from official documents and opinions of society about the research (Motta-Roth et al. 2008 in Scherer 2010, 30).

### 2.2.3 Epideictic arguments

The section discusses one of the aspects of the definition of popular scientific news, namely the positive aspect within the framework of intergeneric intertextuality. More closely, the positive

aspect, which represents a positive benefit of science to readers, is defined by Fahnestock in her work within the epideictic argument, from whom the work draws (Fahnestock 1986, 277-279). The thesis also draws on Haupt's dissertation (Haupt 2014). The work addresses the inclusion of the positive aspect to apply it in the practical part to selected articles A and B and thus discover whether they meet the conditions for popular scientific news.

The subsection explains the context of the definition. Fahnestock distinguishes three types of persuasive speech – forensic, deliberative and epideictic. Forensic speech, according to Fahnestock, is devoted to laws and includes a speech about the nature and cause of events in the past. Deliberative oratory is used in legislatures and calls for future action. Epideictic oratory is speech that praises or vilifies, and its judgments are valid now, in the present.

The positive aspect lies in the two appeals that epideictic arguments use. Fahnestock labels these two arguments the "wonder" and the "application". Wonder corresponds to the deontological argument, while application corresponds to the teleological one. Science accommodators recast scientific knowledge with the help of wonder and appeal to make scientific knowledge more understandable to lay readers. The deontological appeal assigns a recognisable value to knowledge for the reader by extolling that scientific knowledge. It often uses terms like *never before*. According to Haupt, this criterion eliminates news articles that report scientific findings that are ethically questionable or immoral. This category includes, for example, the celebration of the beauties and wonders of nature. The positive aspect lies (for readers) either in the wonders of nature or the benefits of scientific discoveries or research.

The teleological appeal assigns value to knowledge based on humanity's future profit from this knowledge. Thus, according to Fahnestock, a deontological appeal would celebrate, for example, astronauts' flight into space as a celebration of technology and human endeavour. In contrast, a teleological appeal would assign value to flight if it pointed to its by-products. "If a scientific subject cannot be recast under these appeals, it is not likely to make its way to a wider audience" (Fahnestock 1986, 279). These appeals are typical for biology and medicine, which is why they are over-presented in scientific journalism. In contrast, the areas of mathematics, chemistry and physics are more challenging to present to uninformed readers.

### 3 Text patterns

The chapter discusses the theory and structure of the Inverted pyramid as one of the fundamental aspects of news articles. Special attention is devoted to the Text time vs Field time structure, which copies the Inverted pyramid structure and illustrates that newspaper articles are atemporal and, therefore, text-based. Afterwards, the chapter addresses semantic categories, which divide the text into individual categories but do not mention their further arrangement. The work spotlights the Problem-Solution text pattern, broken down into parts concerning their order and function. Finally, the chapter focuses on linguistic characteristics, especially evaluative words.

#### 3.1 Inverted pyramid

The first sub-chapter focuses on the Inverted pyramid theory and its origin. The work explains its parts and functions in detail. The theory from this subsection is applied in the practical part of the bachelor's thesis to selected Articles A and B.

A hierarchical structure began to be applied to attract the reader's attention within journalistic discourse, which ranks information according to the principle of relevance from top to bottom. The structure can be divided into several parts. The primary division is based on three parts, where the upper part (**Lead**) is the shortest and, simultaneously, the most important from the point of view of the given information. The second part (**Body**) is the most extensive, while the third part (**Tail**) is the shortest and contains the least relevant information.

**The Lead** of an Inverted pyramid is mainly made up of a headline and a lead of an article (not all articles feature a lead as a subtitle). It is graphically distinguished – by size, type, and font colour. The upper part of the inverted pyramid should contain essential information for the communication to be successful. The Lead provides a brief summary of the critical event of an article. The Lead consists of information "which in the news are encapsulated by the journalists' five Ws and an H: who, when, where, why, how" (Bell 1991, 86). Furthermore, a lead should arouse the reader's curiosity and interest, influencing the recipient's decision whether to continue reading.

The middle part of the structure, the **Body**, contains supporting information about the main event. In this section, there is not only a story and issue; journalists also include arguments, background, details, and evidence. The final element of the Inverted pyramid, the **Tail**, may include the journalist's assessment or other related information or opinions. The Tail is designed so that the journalist can, for example, separate it from the article if there is a lack of space without affecting the structure of the article.

The inverted pyramid originated in American journalism at the end of the 19th century (Bell 1991, 97-98). The rise of modernity allowed for mass printing, and with it came the emergence of new genres and a change in textual structures and patterns used up to that time (Martin and Rose 2008, 75). Previously, news reports were written exclusively in chronological order and from the

perspective of one actor (Bell 1991, 97). The mass of the press made it possible to produce up-to-date news.

The inverted pyramid is influenced by the space allocated to the article in the newspaper. Thus, in the fight with other journalists for the reader's favour, the journalist must choose which information is relevant to the topic of the given article and which information to evaluate. As mentioned, thanks to the bottom-up structure, a journalist who fights for the reader's attention places the most critical information in the upper part of the pyramid. Thanks to the hierarchical structure, he gradually presents them to the reader piece by piece towards the Tail of the structure.

### **3.2 Text time vs Field time**

Another aspect of the SPN arrangement is the way it works with time. The sub-chapter arranges the science popular news text according to temporal reality and the text arrangement in time. This structure is exemplified by the Text time vs Field time, which replicates the structure of an inverted pyramid, illustrating that newspaper articles follow a developing story rather than a timeline.

Science news differs from other narrative news because it focuses on the purpose of the text of an article, which is to inform. The text follows the line of discovery/research about which it informs, as well as arguments, comments and possible use of the given knowledge in the future. Popular scientific news is "constructed by the author to convey the message effectively" (Kando 1997, 1).

Martin and Rose state another difference between text and time structure news – the so-called switching from one voice to another (switching voice to voice) to introduce various issues. The aspect began to appear in popular news with a change in textual patterns with the rise of technology that led to mass printing. Journalists use aspects to capture the attention of readers. The events the article informs about develop due to switching voice to voice in text structure news. Martin and Rose call this aspect Text time vs Field time structure. In time structure news, on the other hand, switching voice to voice represents individual actors in time sequences as the story unfolds.

Haupt highlights the term "atemporal arrangement" of text structure news instead of the canonical order of other narrative types (Haupt 2004, 32). Compared to other types of popular news, popular science news is mainly characterised by three-time sequences, which the Text time vs Field time structure illustrates. The first time sequence refers to the time when the journalist informs readers about the discovery and the comments or predictions of the persons/scientists involved and other scientists from the given field of science. The second time sequence covers the actual research or discovery the journalist reports on. The third time sequence covers the future when a scientific discovery or research may bring further benefit or use.

The main sequence is in the present. According to the testimony of the people involved, it goes to the sequence of the recent past - the time of research/discovery, or it moves from the present to the future according to the people's predictions. The structure covers one more sequence that extends

indefinitely. The sequence runs from the past through the present to the future and contains information about generally valid facts under normal conditions. On the one hand, this information familiarises the reader more closely with the given topic by providing him with basic knowledge about the topic. On the other hand, the discovery or research in the given area stands out against the background of this information.

### 3.3 Semantic categories

The subsection contemplates the theory of semantic categories, which divides the text into categories according to its meaning. The structure of the semantic categories is hierarchical, like the Inverted pyramid or Text time vs Field time. The overall arrangement of the semantic categories in the text is not fixed and thus has a looser structure. The thesis draws from the works of Van Dijk (Van Dijk 1988, 52-59) and Haupt (Haupt 2014, 28-32). The subsection describes the news discourse categories he outlines in subsequent paragraphs.

**The Headline** is part of every popular scientific news article. The Headline is graphically distinguished from the rest of the text and summarises its topic. Text may or may not contain a lead. The Lead can stand alone and be graphically distinguished, but it can also be part of the first sentence of the text itself. The Headline and Lead stand at the beginning before the text. The signs of distinguishing categories may vary in different cultures, but the categories remain the same.

**The Main Event** provides information about the main event and thus dominates the other categories. **Consequences** provide information about the events caused by the Main Event. Some information from the Main Event may be put into a category called Context. Van Dijk states that the information in Consequences is sometimes more critical than in the Main Event. In this case, Consequences have the same hierarchical position as Main Event.

Context describes the actual **Situation** that encompasses the other particular news event, and context usually functions as the main event in other or previous events. Background differs from Context in that it provides basic information about the Main Event, may contain historical or political events/background about the Main Event, and is more extensive (Van Dijk 1988, 54). Van Dijk divides Background into **History and Previous Events**. History consists of matters in the past that are not closely related to Main Event. At the same time, Previous Events directly precede Main event (Haupt 2014).

**Verbal Reactions** is a news schema category consisting of relevant participants' opinions, predictions or conclusions for which they were asked.

Van Dijk proposed a form of discourse on a global level – a macrostructure with a schema consisting of hierarchically- arranged categories. A schema can be specific to different types of discourse and thus assume a different form in different cultures and societies. As an example of a discourse type with a fixed conventional schema, he points to classical poetry as opposed to modern poetry, which

does not have such a schema. His description of the schema of hard news is compatible with the schema of popular scientific news.

### **3.4 Problem-Solution pattern**

The subsection details the Problem-Solution text pattern, its parts and their role/function in the text. From the point of view of the text mentioned above pattern, in the section of this sub-chapter, the work focuses on its linguistic characteristics with particular attention to evaluative words.

At the beginning of this subsection, the work explains the reason for marking the text pattern and its aspects/properties. Hoey, the originator of the Problem-Solution text pattern, ranks this pattern in the group of culturally popular patterns of text organisation and ranks it among the most frequently-used text patterns. Hoey labels the Problem-Solution a text pattern because its arrangement is closer to a hierarchical structure than schemes or scripts. The hierarchical structure is a manifestation of the interaction of writer and reader, where the writer adopts one of the possible strategies in which he (gradually) answers a sequence of questions that he anticipates the reader has. Conversely, schemas trigger a static representation of knowledge in the reader, and scripts evoke it in the reader. (The sequence/order in which events occur).

Hoey uses the term "organisation" rather than "structure" to express that a specific sequence of elements/parts of patterns is preferred; any other sequence of these parts/elements can be applied. The label "culturally popular" refers to the absence of universal status, and they are found only in some cultures. The designation "popular" refers to possible variations of these patterns, where some occur more often while others are rare/less.

#### **3.4.1 Definition and features of Problem-Solution text patterns**

The subsection analyses the individual components/parts of the Problem-Solution text pattern and their function in the text. The author calls these individual parts of the text pattern "stages." Although Hoey begins the pattern with the text of the article itself, I consider it essential to mention the Headline of the articles at the beginning of the section because it cannot be overlooked that the given texts are primarily subject to news discourse. This Headline thus often contains one or more pieces of information that express the stages of the following Problem or even indicates the stage of possible Result.

Very often, the pattern begins with **Situation**. The Situation function is to provide background information on the event. From this stage, it is still unclear whether it is a Problem-Solution pattern because it does not contain any signal that triggers it. As stated by Hoey, this stage can also belong to patterns retrospectively.

The pattern is initiated in the following stage, which contains an aspect of Situation requiring a response. Hoey denotes this step as the **Problem**. The Problem is recognisable by signal words denoting the Situation mentioned above. The work returns to signal words in more detail in the

relevant chapter, Linguistic features and evaluative words. The problem can be expressed both explicitly and implicitly and requires a response from the actors, thus further developing the textual pattern. In this part, the reader already knows or anticipates what follows and what he can expect from the subsequent text.

The reaction to the Problem is the **Response**. In this part of the text, the author answers the reader's questions from the Problem stage in the last portion. At the same time, this stage reflects the interaction between the writer and the reader. The reader thus learns how the actors attempt to solve the given problem. Hoey presents an intermediate stage between the Problem and the Response, which he calls the Plan. The transitional stage indicates what likely follows the Problem, the appropriate reaction of the given actor, or what reaction should follow. In some patterns, the stage can fulfil the function of notifying the reader that there is a shift from one stage to another without explicitly or implicitly expressing the content of the given Plan. The notification of the transition from one stage to another can be implemented, for example, by a signal as simple as the actor expressing, *I have a plan*.

The Response results in a reaction of the actors in the form of a **Result** or **Evaluation**, depending on the content of the text. If positive, the Result leads to the termination of the text pattern. However, not all texts are predictable. The Result can also be negative. In this case, two variants of the text pattern can occur, which is discussed in the following section on the types of Problem-Solution text patterns. From the reader's viewpoint, a Positive Result is the ideal ending of the text pattern when the text of the article can be summarised: *And in the end, everything turned out well*. As discussed in the section below, a Negative Result can trigger a specific Problem-Solution text pattern. Repeating the stages changes the Negative Result to a Positive Result. In some texts, a Negative Result occurs as the final phase of the pattern and thus closes the text with a negative ending. This ending can be expected in a different genre than popular scientific news, which is intended to inform readers about scientific advances and thus motivate readers to support scientists in further research.

### 3.4.2 Structures of Problem-Solution patterns

The section deals with the possible structures of the Problem-Solution text formula. As mentioned above, text formulas do not have a fixed structure. The text can thus create more variations of the Problem-Solution pattern thanks to two stages – Plan and Recommended Responses, which may or may not occur in the formula. A formula can also create a different variation due to a different Result. Hoey lists the **Plan** as an intermediate stage. In some samples, Plan is absent and replaced with a concrete Response.

In some cases, the Recommended Response offers a set of different actions that do not lead to a direct Response. The stages are thus repeated in a pattern until a specific Response leading to a Result is reached (Hoey 2001).

**Figure 2** illustrates the base form of the order of pattern stages. On the top is the optional Situation, which means that the stage may or may not be in the pattern. Although it provides the background of the main event, its absence from the pattern is possible depending on the importance of the information about the rest of the pattern. Problem stage – the subsequent stage requires an answer. From this stage, it is apparent to the reader which text pattern occurs in the text. The Problem is followed by Plan, which is unnecessary for the text pattern. Regardless of the existence or absence in the text, a Plan is followed by a Response. In commercials and editorials, the actual Response is replaced by Recommended Response. "In narratives and such context, Plan/Recommended Response is felt to be a stage on the way" (Hoey 2001, 128). The text pattern is subsequently terminated in three ways: Positive Evaluation, Positive Result that can lead to Positive Evaluation or Positive Result combined with Positive Evaluation.

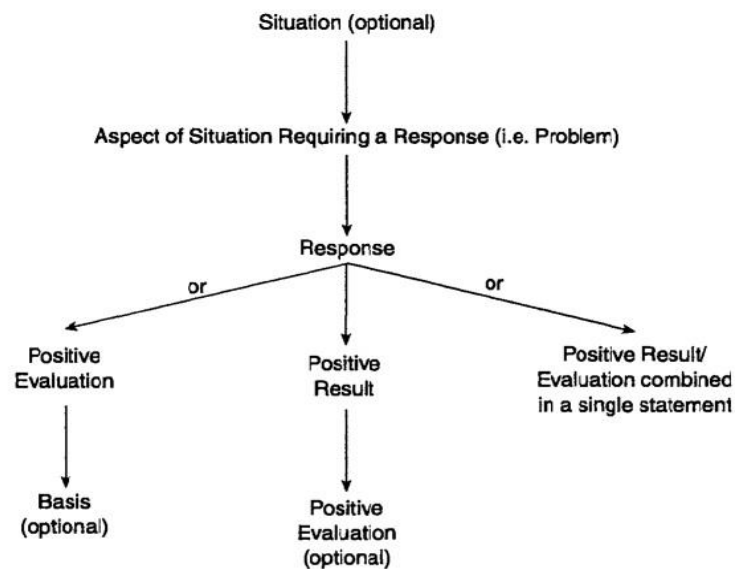


Figure 2: Basic P-S pattern

**Figure 3** illustrates the Recycling Problem-Solution pattern. The pattern might be the same as the base pattern, starting with Situation, which is optional in all Problem-Solution patterns. The right side copies all three options from the previous figure, and the left shows a difference in response to Response. When the Result or Evaluation is negative, actors return to the stage Problem and find a different Response that could lead to a Positive Evaluation or Positive Result.



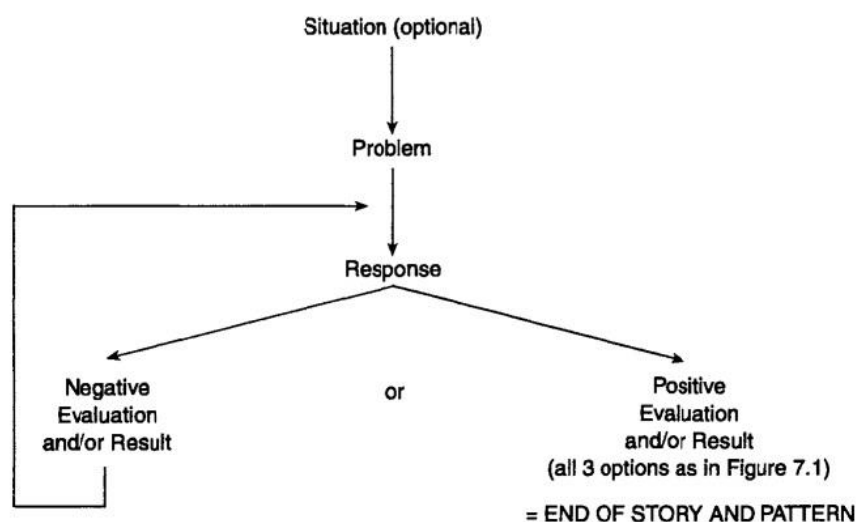


Figure 3: Recycling P-S pattern

The Interlocking Problem-Solution pattern is shown in **Figure 4**. Some of the texts feature more than one prominent/central actor. It can be an antihero or even an entire group of central actors. The Situation of the first actor evokes the Problem for the second actor leading to his Response that causes the Problem for the first actor. The Problem of the first actor is followed by a Response leading to Positive Results for the second actor and him.

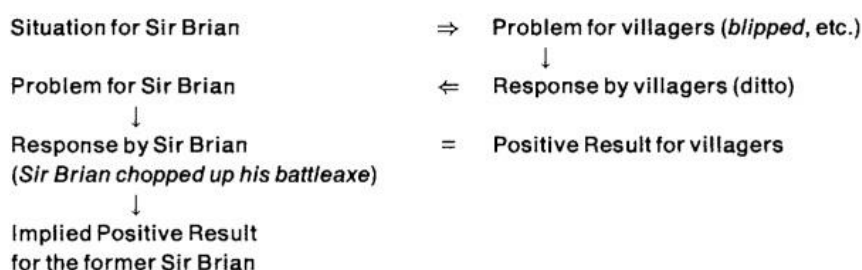


Figure 4: Interlocking Problem-Solution pattern in Hoey 2001, 140

### 3.5 Linguistic features of the patterns

This part of the work deals with linguistic features such as the syntax, lexical and grammatical features essential for science news and popular scientific news as its subgenre. Science popularisation uses specific syntax to bring the research to a broader audience. Individual movements between stages are marked with lexical and grammatical signals (Haupt 2018, 168). The Problem-Solution text pattern is based on evaluative signals characterising its stages, thus enabling readers to identify them.

#### 3.5.1 Lexical and grammatical signals of the Problem-Solution pattern

Grammatical and lexical features are crucial and indispensable for popular science news and popularising science. By enabling the emergence of the Problem stage, without which the Problem-Solution pattern could not arise, signals are vital to this pattern.

Writers use language signals to mark movements from one individual part to another part of the text pattern. The reader thus can recognise what follows next in the text. Using signals in individual parts of the text pattern, the reader can understand the given information, including its relationship to other text parts.

The first usage of lexical and grammatical signal words is in creating popular scientific news to transfer information from scientific articles to popular science articles. The reason is a change in the target readers when the author targets a broader audience of readers who, unlike experts, have different background information and the reason for reading. As Fahnestock points out, it is not only a matter of translating technical terms into lay terms. For example, Fahnestock gives words from technical jargon like *mandible*, which becomes *jaw*, or *carrion*, which changes into *dead animal* (Fahnestock 1986, 280).

For comparison, Fahnestock gives an example of the text of an article from a scientific journal intended for experts and its version for readers. The first excerpt, 1a, comes from the original text of the scientific journal. The second excerpt, 1b, compares transferring information to readers.

*(1a) No other protein sources are used by T. hypogea [the bee species under consideration], and pollen transporting structures have been lost, making this species an obligate necrophage.* (Roubik 1982, p. 1059 in Fahnestock 1986, 208)

This original text becomes in Science 82,

*(1b) Though other bees have teeth, this is the only species that cannot carry pollen.* (“Vulture Bees,” 1982, p. 6 in Fahnestock 1986, 208)

The Fahnestock sample shows the use of lexical and grammatical features when changing information when targeting a different audience and an effort to engage readers and convey information in an understandable form.

Hoey's work on the Problem-Solution topic serves as a basis for other scientists, especially linguists, who further develop the use of linguistic signals of the Problem-Solution text pattern. In their work, when one author refers to another can also be seen how intertextuality affects scientific works. Influential linguists dealing with linguistic features within the framework of Problem-Solution include Halliday or the previously mentioned Martin and Rose.

Authors use lexical and grammatical signals to mark the transition from one part of the text pattern to the next part. The signals mentioned above with evaluative signals, which I will cover later, allow the reader to anticipate what to expect next in the article. According to Halliday, shifts from one stage into another are signalled in themes realised through lexical change. This stage shift can sometimes involve lexical signals such as using adverbs for change in time, the conjunction *so* for signalling Effect and Reaction, and the conjunction *but* denoting Problem (Martin and Rose 2008, 83). Martin and Rose mention the frequent use of lexical features indicating a change in actors,

activities, place, or judgment when moving from one pattern stage to another. (Martin and Rose 2008, 87).

Another significant linguistic feature distinguishing popular scientific news from other news is the use of tenses. Popular science articles begin in the present tense when the author reports on scientific research or discovery. Other articles may start at any point in the story. Popular scientific news contains more of the past tense, which refers to a recent discovery about which it informs the readers. An essential part of the text is the comments of scientists directly involved in or evaluating the research. As one of the few, these comments are primarily given in the present simple tense in direct speech. The future tense appears mostly only in the form of a prediction of the possible use of research. On the contrary, other news uses the past tense, usually as a flashback as the story unfolds and follows the storyline (Martin a Rose 2008, 75).

Myers mentions other linguistic features of science popular news from the point of view of syntax. Popularisation tends to organise the statements into sequences using simple sentences. In contrast, research articles use complex sentences to form simultaneous order of arguments. Authors of popular scientific news try to rewrite the passive voice into the active voice where possible. Nevertheless, there are a lot of passive voices in popularisation. Some parts of the text patterns, such as describing technical things, over the passive voice used, are given with active voice to emphasise the work of scientists (Myers 1994, 185-186).

### **3.5.2 Evaluative signals**

The subsection focuses on evaluative words, the most significant linguistic signals of the Problem-Solution pattern. There is no fixed framework for the distribution of evaluative words. However, scientists agree on their main properties and use. There is also agreement on the importance of evaluative words for the occurrence of the Problem-Solution pattern.

The author uses lexical signals and evaluative words to distinguish the individual stages and as a guide to what will follow. Lexical signals evoking problems can be, for example, *injury*, *storm*, *accident* or negative evaluative signals *aggressively*, *terminally ill*, *desperate*. Signal words thus evoke the need for Response in the reader. To illustrate the lexical signals and negative evaluative words evoking problem, I present an excerpt from a text of popular scientific news.

*"Even then, the official count is astonishingly low: just eight deaths for the entire last week of December, which is "not matching media reports and what is being seen on social media," says Louise Blair, who tracks China's COVID-19 outbreak ... "* (Science org., Dennis Normile).

Combining lexical signals such as *"deaths, not matching"* and negative evaluative words such as *astonishingly low* alert the reader of the problem. At the same time, the reader expects an adequate Response or Plan in the next part. Conversely, some non-evaluative signals such as *war*, *poverty*, *disease* can evoke negative expectations. For example, the word *poverty* may not have a negative

meaning, but it may mean a vow of poverty. Hoey thus draws attention to the necessity/need to understand these signals in the given context (Hoey 2001, 126).

For example, a different term with the same meaning can be found in Martin, who distinguishes between two types of evaluation or appraisal with terms inscribed and evoked. The former expresses an explicitly expressed assessment. The latter evokes the reaction intended by the author in the reader with its choice of lexical words. Martin cites *genocide* and *thrill-killing* as examples of evoked signals (Hoey 2001, 126).

The individual distribution of signals differs according to the authors and intertwines with each other in the text. I find the overall essence and fundamental importance of use in popular science articles to be the same for the authors.

## 4 Introduction to the practical part

The original aim was to investigate the occurrence and linguistic characteristics of text patterns in popular science news. Particular attention had to be paid to the Problem-Solution pattern. However, a preliminary analysis showed that the occurrence of the Problem-Solution pattern is negligible in the articles. So I decided to narrow down the aim to comparing two selected articles from different scientific fields with a different Problem-Solution pattern structures. Analyzing other structures and text patterns in the entire corpus of selected articles is not possible due to the scope of the work. The list of articles examined for the occurrence of the Problem-Solution pattern and their sources is in Appendix 2.

The practical part compares text organisation, particularly patterns, time structure, inverted pyramid and language characteristics regarding evaluative words in two selected articles. Furthermore, the work compares two arguments, the wonder and the application, based on the epideictic type of speech. As proof that both selected articles fall into popular scientific reporting, they are analyzed from the perspective of Haupt's definition in section 5.

The thesis draws from Hoey, Rose, Myers and others to assess the language features and compare the evaluative words in chosen articles. A comparison of the structure of the articles draws on Van Dijk's work on semantic categories. When focusing on journalistic news, the practical part should not forget to compare the structure of Articles A and B according to Samuel Morton's Inverted pyramid. The evaluation of the occurrence of the Problem-Solution patterns and their features is based on the analysis of Hoey's text pattern (Hoey 2001, 119-141). The movements in time in the individual phases are drawn from Martin and Rose's Text and Time analysis (Martin and Rose 2008, 119-141). The deontological appeal and the two arguments based on it draw on Fahnestock's work (Fahnestock 1986, 278-288).

Compared articles are referred to as Article A and Article B. The articles are divided into sections due to the text patterns analysis of the work. The thesis uses another three articles of the same genre to help demonstrate the simplified forms of the Problem-Solution pattern if the pattern occurs to compare Articles A and B. Three articles used to demonstrate the simplified forms of the pattern will be referred to as Articles 1-3. The designation of all articles used in this work is given in **Table 1**. The full text of Articles 1-3 and A and B is attached in Appendix 1. The first article comes from SciNews, and the other comes from Science News.

Table 1: Overview of the articles used in the thesis

Referred as	The name of the article
Article A	<i>Viruses Can Kill Wasp Larvae That Grow Inside Infected Caterpillars</i>
Article B	<i>Two New Species of Venomous Snakes Discovered</i>

Article 1	<i>Climate change: Future-proofing coffee in a warming world</i>
Article 2	<i>Human cells make a soaplike substance that busts up bacteria</i>
Article 3	<i>First map of proteins in tumour cells pinpoints cancer therapy targets</i>

## **5 Fulfilment of the criteria of popular scientific articles**

This subchapter examines chosen Articles A and B and whether they fulfil the criteria for popular science news. Haupt defines popular science news as a genre whose purpose is to inform readers about current events about recent scientific findings in a non-biased way. Furthermore, the information should be presented to readers in a concise, understandable and engaging manner in a positive tone (Haupt 2014, 12).

The aspect of being informed about scientific findings is manifested in the text of the article by the occurrence of one major event from the field of science about which the article informs. It is, therefore, not a list of multiple events such as we find in narratives.

The impartiality of the article manifests itself in apparent objectivity in that it promotes interest in science in general and not only in a specific subject. Objectivity is evident, although each article is always, to some extent, the subjective interests of its author. Other aspects of the news genre, such as brevity, comprehensibility and clarity, are also reflected in popular science articles. The news genre thus adopts the newspaper structure of the Inverted pyramid, which places the most important summary of information at the beginning. However, the authors crumble some of the information through the rest of the text in purpose to attract readers

The positive aspect consists in the celebration of a scientific event, whether it is a discovery, its further use and thus a benefit to humanity, or the celebration of the beauty of nature. Even though the section goes through a checklist related to items in the definition in the theoretical part, the section does not deal with intertextuality and science popularization. Although these topics are important from the point of view of popular science articles, the scope of their analysis is for separate work.

Both articles fulfil the criteria of the definition of science popular news. Not only Article A but also Article B inform readers about scientific research or findings. Article A informs on the survival of the various species and how evolution is helpful. Article B reports on the diversity of animal species and nature as such. The essential information copies the structure of an inverted pyramid. The text of the articles is clear and concise so that a broad audience can understand the information.

## 6 The Problem-Solution patterns and Semantic categories of Articles A and B

The chapter overviews the Problem-Solution pattern, Semantic categories, and signal words overview of Articles A and B. This analysis aims to determine the presence or absence of a Problem-Solution pattern and its form if a pattern occurs. From the analysis, the work determines whether the presence or absence of the Problem-Solution pattern affects the presence or absence of semantic categories. A more detailed analysis of individual patterns, their parts, semantic categories and evaluation expressions will be dealt with individually in the following chapters of this work. For this purpose, the thesis uses an overview of the Problem-Solution pattern structures and semantic categories.

### 6.1 Article A

This subchapter divides the text of Article A in **Table 2** into the overview of Problem-Solution patterns and their arrangement in the text. The pattern division aims to gain an overview of its structure. Furthermore, the analysis incorporates the text into Van Dijk's semantic categories for comparison with the stages of the Problem-Solution pattern. The division pinpoints the presence or absence of a relation between the Problem-Solution pattern and semantic categories and different emphasis on the information in the text. The following chapters analyse the patterns and their parts in detail.

**Table 2** is divided into seven columns in the first line. The first column shows the section numbers in which the relevant text of Article A is located. Columns 2 to 4 indicate the full-fledged Problem-Solution pattern from the perspective of the individual participants. The second line of the fourth paragraph indicates under numbers one and two the other two text patterns that the actor of the given column creates. The fifth column features the general Problem-Solution pattern. The penultimate column lists the relevant text. The last column indicates the classification of the text into Van Dijk's semantic categories.



Table 2: Overview of the Problem-Solution pattern structures and Semantic categories - Article A

Section	Viruses	Wasps	Caterpill.	General P-S pattern	The text of Article Article A	Semantic categories
			1. Wasps			
			2. Viruses			
1.	General Situation	General Situation	1. General Situation 2. General Situation	General Situation	<i>Viruses can kill wasp larvae that grow inside infected caterpillars</i>	Headline
2.	Particular Situation	X	1. X 2. General Situation	Part. Situation	<i>A new study is a take on the adage, "The enemy of my enemy is my friend."</i>	SubHeadline
3.	X	Particular Situation	1. Problem 2. General Situation	Problem	<i>When parasitic wasps come calling,</i>	Lead
4.	X	X	1. Particula Situation 2. General Situation	Situation	<i>some caterpillars have a surprising ally: a viral infection.</i>	
5. A	Problem	Particular Situation	1. Problem 2. X	Problem	<i>Insects called parasitoid wasps lay their eggs inside young moth larvae, turning the caterpillars into</i>	Background
5. B	Problem	X	1. Problem 2. Problem	Problem	<i>destined-to-die incubators for possibly hundreds of wasp offspring. That's bad news for viruses trying to use the caterpillars as replication factories. For the caterpillars, viral infections can be lethal,</i>	
6.	X	X	1. Method 2. Particular Situation	Method	<i>but their chances of survival are probably higher than if wasps choose them as a living nursery</i>	Consequences
7.	Method	Problem	1. Method 2. Particular Situation		<i>Now, a study shows how certain viruses can help caterpillars stymie parasitoid wasps.</i>	
8.	Method	Problem	1. Method 2. Particular Situation		<i>A group of proteins dubbed parasitoid killing factor, or PKF, that are found in some insect viruses</i>	Background
9.	Method	Problem	1. Method 2. X		<i>are incredibly toxic to young parasitoid wasps,</i>	
10.	X	X	1. X 2. X	X	<i>researchers report in the July 30 Science.</i>	
11.	Method	Problem	1. Possible Solution 2. Particular Situation	X	<i>The new finding shows that viruses and caterpillars can come together to fight off a common wasp enemy, says study coauthor Madoka Nakai, an insect virologist at Tokyo University of Agriculture and Technology.</i>	Consequences
12.	Problem	Particular Situation	1. X 2. X	Problem	<i>A parasitoid wasp would kill a host that the virus needs to survive,</i>	
13.	Method	Problem	1. X 2. X	Method	<i>so the virus fights for its home. "It's very clever," Nakai says.</i>	
14.	X	Problem	1. X 2. Method	Alternative Method	<i>What's more, some moth caterpillars make the wasp-killing proteins themselves, the team found. It's possible that in the distant Past, a few moths survived a viral infection and "got some presents" in the form of genetic instructions for how to make the proteins, says study coauthor Salvador Herrero, an insect pathologist and geneticist at the University of Valencia in Spain.</i>	Main Event
15.	X	Problem	1. Positive Evaluation 2. Partially Positive Evaluation	Solution	<i>Those insects could have then passed the ability down to offspring. In this case, "what doesn't kill you makes you stronger," Herrero says.</i>	
16.	X	Problem	1. Positive Evaluation 2. Positive Evaluation	Situation	<i>Previous studies had shown that viruses and insects, including moths, can swap genes with each other.</i>	Background
17.	X	X	1. X 2. X	Situation	<i>The new finding is one of the latest examples of this activity,</i>	Evaluation
18.	X	X	1. X 2. X	X	<i>..., says Michael Strand, an entomologist at the University of Georgia in Athens who was not involved in the work.</i>	Comment
19.	X	X	1. X 2. X	X	<i>"Parasite-host relationships are very specialised," he says. "Factors like [PKF] are probably important in defining which hosts can be used by which parasites." But whether caterpillars stole the genetic instructions for the proteins from viruses or if viruses originally stole the instructions from another host remains unclear, Strand says.</i>	Comment

20.	Method	Problem	1. Positive Evaluation 2. X	Situation	Researchers discovered in the 1970s that virus-infected caterpillars could kill parasitoid wasp larvae using an unknown viral protein.	Background
21.	X	X	1. X 2	Alternative Method	In the new study, Herveiro and colleagues identified PKF as wasp-killing proteins. The team infected moth caterpillars with one of three insect viruses that carry the genetic blueprints to make the proteins. Then the researchers either allowed wasps to lay their eggs in the caterpillars or exposed wasp larvae to hemolymph — the insect equivalent of blood — from infected caterpillars.	Main Event
22.	X	Problem	1. Positive Evaluation 2. Particular Situation	Alternative Method	Virus-infected caterpillars were poor hosts of the parasitoid wasp <i>Cotesia kariya</i> ; most young wasps died before they had the chance to emerge from the caterpillars into the world. Hemolymph from infected caterpillars was also an efficient killer of wasp larvae, typically destroying more than 90 percent of offspring.	Main Event
23.	X	Problem	1. Positive Evaluation 2 X.	Positive Eval.	<i>C. kariya</i> wasp larvae also didn't survive in caterpillars, including the beet armyworm ( <i>Spodoptera exigua</i> ), that make their own PKF.	Main Event
24.	Problem	Method	1. X 2. X	Negative Eval.	When the researchers blocked the genes for the proteins in these caterpillars, the wasps lived,	
25.	Partially Positive Solution	Partially Negative Solution	1. Solution 2. Partially Positive Result	Positive Eval.	a sign that the proteins are key for the caterpillars' defenses.	Main Event
26.	Partially Neg. Result	Partially Positive Result	1. Possible Negative Result 2. X	Result	Some parasitoid wasps, including <i>Meteorus pulchricornis</i> , weren't affected by PKF from the viruses and also beet armyworms, allowing the wasp offspring to thrive inside caterpillars.	
27.	X	X	1. X 2. X	X	That finding suggests that the wasp-fighting ability is species-specific, says Elisabeth Herniou, an insect virologist at CNRS and the University of Tours in France who was not involved in the work.	Comment
28.	X	X	1. X 2. X	X	Pinpointing why some wasps aren't susceptible could reveal the details of a long-held evolutionary battle between all three types of organisms.	Expectation
29.	X	X	1. X 2. X	X	The study highlights that "single genes can interfere with the outcome of [these] interactions," Herniou says. "One virus may have this gene and the other virus doesn't have it," and that can change what happens when virus, caterpillar and parasitoid all collide.	Consequences

**Table 2** indicates the occurrence of the Problem-Solution pattern in Article A. The text contains three participants that form parallel and equivalent Problem-Solution patterns in one text pattern at a time. Article A refers to an alliance of caterpillars with viral infections against parasitic wasps. Parasitic wasps use caterpillars as destined-to-die incubators. Viruses use caterpillars as replication factories and are less dangerous than parasitic wasps. The research focuses on the circumstances of caterpillars' survival in alliance with viruses. Furthermore, the analysis shows that although the text contains several P-S text patterns, their parts, unlike the semantic categories, do not cover the entire text.

This part of the chapter aims to analyse the Overview of the Problem-Solution pattern Structures and Semantic Categories of Article A. The division of the text into semantic categories and their comparison concerning the division of the text into individual Problem-Solution stages based on the Overview of the Problem-Solution patterns and Semantic Categories of Articles A and B elaborates in chapter 7. Readers read the text as the whole text pattern with the reactions of all participants without any changes in the order. The first part of the text, section 1, can be interpreted differently.

The first possibility is to consider this part of the text the General Situation. The stage provides the background information of the story and consists of the statement valid through time. The general phase does not yet indicate or trigger any pattern because negative evaluative or lexical signals are general. They cannot be assigned to a pattern without additional text. There is a second possibility which Hoey describes as the Statement of Response to a Problem, which often appears in the first sentence in advertisements and popular science writing (Hoey 2001, 134).

Section 2 provides the Particular Situation with a close description of the situation. Readers can anticipate from the negative lexical signal word *the enemy* what a text pattern will occur in the text. The Problem stage occurs in section 3, and from now on, readers are acknowledged that parasitic wasps causing the problem. The Problem follows in sections 5A and 5B with an embedded Situation in section 4. The Problem in sections 5A and 5B gives closer details about parasitic wasps and how they use caterpillars as destined-to-die incubators. As the pattern consists of three participants, the latter section opens the Problem from the perspective of viruses. The wasps are attacking caterpillars, causing problems for viruses that use caterpillars as replication factories.

Sections 6 up nine feature the middle stage, the Response - of caterpillars and viruses, possibly called the Plan. The sections describe a possible plan to counter the wasps, thanks to an alliance of caterpillars and viruses. The answer does not fully solve the problem. Moreover, section 12 reminds readers of the dangers of parasitic wasps to viruses and caterpillars.

And then, section 13 provides a part of the Response/Plan as the writer anticipates the question readers might have in this part about the Response and tries to answer them. The subsequent section 14 offers an alternative to the prime Response/Plan. Caterpillars can make their wasps killing protein from what profit also viruses as they do not need to fight wasps. Section 15 offers the Solution as an insect passed the ability to create wasps killing protein down to offspring. However, the text pattern is not closing yet. In sections 16, 17 and 20, a situation is embedded.

Sections 21 and 22 constitute a recycling text pattern with the Alternative Response/Plan. The first Method in the text pattern did not lead to the Positive Evaluation; therefore, readers are offered an alternative Response/Plan. Although the subsequent section 23 provides the Positive Evaluation of the alternative Response/Plan, the Negative Evaluation follows in section 24 to swap to the Positive Evaluation in section 25. Recycling text patterns are enclosed when no more possibilities could lead to a Positive Result. A positive assessment in Sections 23 and 25 do not provide a satisfactory result. The stage evaluates protein production by caterpillars as another possible alternative solution. The text pattern ends in section 26 with the Result. The Positive Evaluation did not follow the first Response/Plan in the text.

Article A, through the prism of the reader, i.e. a holistic view of the text, provides an insight into the world of nature and its laws of survival. The readers learn the most crucial information at the

beginning of the article and guess what will happen in the following text. The author of the article introduces three participants who are trying for the essential thing - to survive. The author translates individual information gradually to keep the reader in suspense. For this, the author alternates individual stages of the text pattern. At the same time, the author presents the reader with two possible solutions to induce wonder at the all-powerful nature, life and science. In the end, the author crowns this astonishment with the scientist's statement about the contribution of the study.

## 6.2 Article B

The subchapter focuses on the overview of the Problem-Solution pattern and Semantic Categories of Article B. **Table 3** aims to gain an overview of text pattern structures. The first column indicates the number of the given part of the text for better orientation. Individual stages of the General Problem-Solution pattern are in the second column. The third column contains the analyzed text of the article. The column on the right divides the text of the article into semantic categories.

Table 3: Overview of the Problem-Solution patterns and Semantic categories of Articles A and B

Section	General P-S pattern	Overview of the Problem-Solution Patterns and Semantic Categories of Articles A and B	Semantic categories
1	Main Event	<i>Two New Species of Venomous Snakes Discovered</i>	Headline
2	—	<i>Missing</i>	Missing
3	General Situation	<i>1. Scientists have described two new species of pit vipers in the genus <u>Gloydus</u> from Zayu in Tibet and Heishui in Sichuan, China.</i>	Lead
4	General situation	<i>2. Pit vipers of the genus <u>Gloydus</u> are venomous snakes distributed mainly in northern Asia, but extending into southern Europe in the case of a species called the <u>Halys pit viper</u> (<u>Gloydus halys</u>). These small-bodied snakes are quite common and have radiated into various habitats.</i>	Background
5	General situation	<i>3. At present, more than 20 <u>Gloydus</u> species mainly belonging to three groups — i.e., the <u>Gloydus blomhoffii</u> complex, <u>Gloydus intermedius-halys</u> complex, and <u>Gloydus strauchi</u> complex — are scientifically recognised.</i>	Background
6	General Situation	<i>4. The two new species, named the Nujiang pit viper (<u>Gloydus lipipengi</u>) and the Glacier pit viper (<u>Gloydus swild</u>), belong to the <u>Gloydus strauchi</u> complex.</i>	Main Event
7. A	—	<i>5. "The Nujiang pit viper has a grayish brown back with irregular black ring-shaped crossbands, wide, grayish-brown stripes behind the eyes, and relatively short fangs."</i>	Main Event
7. B	—	<i>said Dr. Jing-Song Shi from the Institute of Vertebrate Paleontology and Paleoanthropology at the Chinese Academy of Sciences and the Shenyang Normal University and colleagues. Published Oct 6, 2021</i>	Comment
8	—	<i>6. "The Glacier pit viper is blueish-gray, with zigzag stripes on its back, and has relatively narrow stripes behind its eyes."</i>	Main Event

9	—	7. <i>The Nuijiang pit viper is known only from one locality — Muza village, Zayu, Tibet.</i>	Background
10	—	8. <i>The Glacier pit viper can be found in east part of Qinghai-Tibet Plateau and Hengduanshan mountains, Heishui country, north Sichuan, about 15 km away from Dagu Holy-glacier National Geological Park.</i>	Main Event
11. A	—	9. <i>The discovery of the latter species suggests</i>	Consequences
11. B	—	<i>the glaciers <u>might be</u> considered as key factors to the isolation and speciation of the alpine pit vipers in the southwest China.</i>	Expectation
12	—	10. <i>"We were also astonished by the sceneries we encountered during the field work," the researchers said. Published Oct 6, 2021</i>	Evaluation
13	—	11. <i>"During the expeditions, we experienced striking views of sacred, crystal-like glacier lakes embraced by mountains, as well as colourful broadleaf-conifer forests and morning mists falling over the village."</i>	Evaluation
14	—	12. <i>"During our expedition, we met a lot of hospitable Tibetan inhabitants and enjoyed their kindness and treats, which made the expedition more unforgettable."</i>	Evaluation

**Table 3** above indicates the absence of the Problem-Solution pattern. Article B, same as Article A, deals with animal species. Article B describes two new species of *Gloydius viper*: the Nuijiang pit viper and the Glacier pit viper. Readers are acquainted with both species' appearance, description and location. The difference between articles A and B lies in the main participants and the content of the article. Article A features 3 participants who, due to solving problems, create complex text patterns. Article B contains only one homogeneous group of participants, namely researchers. These actors present their discovery to the reader as a story that flows without a hitch. Due to the absence of a Problem-Solution pattern, it is impossible to compare individual occurrences of stages and shifts against the semantic categories.

## **7 The comparison of the semantic categories of Articles A and B**

The present chapter compares the structure of Articles A and B based on Van Dijk's hierarchically arranged semantic categories. The comparison will examine whether and how semantic categories are always applied in scientific news articles and how the purpose of a scientific article to inform readers is affected. The work gradually compares the individual semantic categories in the following sections. At the same time, the work evaluates the similarities or differences of the compared semantic categories. The division of Articles A and B texts into semantic categories can be found in The Overview of the Problem-Solution Pattern Structures and Semantic Categories in Table 2 and Table 3.

### **7.1 Headline, SubHeadline, Lead**

Headline, Subheadline and Lead provide a summary. Article A consists of Headline; *Viruses can kill wasp larvae that grow inside infected caterpillars*. SubHeadline; *A new study is a take on the adage, "The enemy is my friend,"* and Lead; *"When parasitic wasps come calling, some caterpillars have a surprising ally: a viral infection."* The functions of these categories in Article A are exact: they arouse curiosity or interest so readers will clearly understand what to expect from the article.

Article B includes the Headline, *"Two New Species of Venomous Snakes Discovered"*, and the Lead, *"Scientists have described two new viper species of the genus Gloydius of Zayu in Tibet Heishui in Sichuan in China."* The title of Article B provides readers only with information about the discovery and the Lead with information about a new species of particular genes of vipers. Readers cannot get a closer idea of the content of the article.

Suppose the work compares the Headline, SubHeadline and Lead of Articles A and B. In that case, Article A provides more detailed information about the following content of the article. On the other hand, the Headline of Article B is more austere. However, it still gives the reader the most crucial information about the following content of the article. The semantic categories of Articles A and B thus fulfil their primary function: to attract the readers and inform them of the most important things.

### **7.2 Main Event, Consequences**

Like the previous comparison of the categories, this section compares the Main Event of Articles A and B and how this category dominates the description of the reported news event. Readers of Articles A are introduced to research through the Main Event. Researchers have found that some caterpillars produce proteins that kill wasps larvae. The researchers conducted further experiments. These experiments found that this particular protein is lethal to certain species of wasps. However,

some species of these wasps have survived. The researchers concluded that the wasps' ability to fight is species-specific.

The Main Event of Article A is defined in section 4; *Team found....* Also, in section 7: *In a new study, Herrero ... identified ...* or section 8. Moreover, this category appears in sections 9 and 10. As mentioned in the theoretical part, the Consequences follow up the Main Event and summarise events caused by them. The Consequences of Article A describes the possible cooperation of entirely different subjects in terms of survival. It thus opens up another wide field of potential research which represents consequences. References to the Consequences can be found in the following sections: 2. *Now the study shows how...* and section 3, *New findings show....* The occurrence of the Main Event in the article is abundant and provides a sufficient description of the reported event. The Consequences undersection the importance of research and arouse the interest of readers to learn more about the topic.

The Main Event of Article B deals with the description of two newly discovered vipers and a description of their nature. Furthermore, this category describes the research environment that directly impacts the discovery and thanks to which the discovery was made. The Main Events of Article B appear in section 6: *The two new species, named the Nujiang pit viper ...*, sections 7. A, 8 and 10: *The Glacier pit viper can be found in....* Section 10 might seem like the Background. However, this section does not represent generally valid truth but is a part of the research.

The difference between Articles A and B is indisputable. The description of the Main Events and the Consequences in Article A are comprehensive. The Main Event in Article B, in contrast, consists of descriptions of personal experiences during the research, and the research is not specified closer. The Consequences are austere and tell readers that researchers have more expectations from the discovery.

### **7.3 Background, Comments (Evaluation, Expectation)**

This subchapter compares the Background and the Comment of Articles A and B. The Background usually follows a section dealing with the Main Events and Consequences. The Background provides information that is not as essential as the Main event but consists of historical, political or other information necessary for understanding the Main Event. The Background often follows the last semantic category – the Comment. Journalists' views on this category vary, yet many use it in their articles. The Comment consists of two subcategories: Evaluation and Expectation. As mentioned in the theoretical part, Evaluation consists of evaluative opinions about the content of the article, and expectation contains the possible consequences of the current events.

Article A provides the Background in sections 5 A and 5 B; *Insects called parasitoid wasps lay their eggs* in sections 8, 9 and 16; *A group of proteins. Previous studies had shown.* Furthermore, in section 20, *Researchers discovered in the 1970s.* Noninitiated audiences are given general information about the written subject. Chosen Article A features the Comment category in section 18; *says Michael Strand, an entomologist at the University of Georgia in Athens who was not involved in the work...* Furthermore, another comment can be found in section 19 and section 20, *says Elisabeth Herniou, an insect virologist at CNRS and the University of Tours in France who was not involved in the work.* In this category, we distinctly see a sufficient number of opinions from nonbiased parties. Evaluation occurs in section 17; *The new finding is one of the latest examples of this activity.* Section 28 defines the Expectations; *Pinpointing why some wasps aren't susceptible could reveal the details of a long-held evolutionary battle between all three types of organisms.*

Article B features the Background in section 4; *Pit vipers of the genus Gloydius are venomous snakes* or section 5; *At present, more than 20 Gloydius species* or further in sections 9 and 10. As with Article A, in Article B, the Comment and Expectations occur only once throughout the text. Article B has the Comment in section 7 B; *said Dr Jing-Song Shi from the Institute of Vertebrate Paleontology.* Expectation occurs in section 11 B; *The discovery of the latter species suggests that research, might be considered as key factors to.* Article B contains the Evaluation in three sections, namely sections 12, 13 and 14. At the expense of research assessment, the reader is offered an evaluation of the nature of the research. The Evaluation provides little information about the research evaluation or the opinion of impartial research experts.

Comparing Articles A and B, both articles are equal in their purpose but differ in how the purpose is fulfilled. Simplifying the background of Article B with a minimal description of research and a considerable amount of nature description makes this article more attractive and comprehensible to readers without a more profound scientific knowledge of the issues discussed.



## **8 Comparison of the Problem-Solution pattern of Articles 1-3, A and B**

This part of the text aims to find similarities or differences between Articles A and B regarding the occurrence of the Problem-Solution pattern and compare individual parts of the Problem-Solution pattern with their role in the text and language characteristics concerning evaluative words. Following, the work compares these parts of the Problem-Solution pattern with Van Dijk's semantic categories in terms of occurrence in the text. This comparison aims to examine the order of these parts and the possible relation between them.

I chose articles A and B for their different topic and structure to compare different Problem-Solution patterns or a given structure. Before analysing and comparing articles A and B, the paper analyses popular science articles 1-3 to show that the text pattern is often absent in popular science articles or that the given text pattern is in almost basic form. Another reason for choosing the given articles is to show the reader this basic pattern to understand better the complicated text pattern of the selected Article A.

### **8.1 The Problem-Solution pattern of Article 1**

The subchapter analyses a possible occurrence of the Problem-Solution pattern in Article 1. The description of the situation provides the background of the text. As mentioned in the practical part, this element is in the Problem-Solution pattern called the General Situation and is situated at the beginning of the text if the Problem-Solution pattern occurs. Section 2 provides information and represents the Particular Situation. From the first and the second sections, the lay readers generally learn about the climatic problems likely to affect coffee growing and that some *forgotten* coffee plant could solve this problem. This stage of the text pattern does not trigger any text pattern yet and only gives general information.

Article one deals with a rediscovered species of the coffee plant, namely *Stenophylla*. This plant is resistant to rising temperatures. In addition, the plant has an indistinguishable taste from real Arabic coffee. The researchers consider the rediscovery of the plant a miracle and hope that this plant will one day replace the less heat-resistant Arabic coffee.

The third and fourth sections feature negative evaluative signal words: *increasingly difficult* and *unproductive*. Signal words might seem to indicate the Problem. These sections state that growing high-quality coffee will be difficult but not impossible. The same situation occurs with the land used for high-quality coffee when it is stated that only half of it will still be productive. The solution as a coffee substitute for the more resistant variety *Coffea Stenophylla* that existed before is situated in section five. It was only necessary to rediscover this possibility. Sections three and four might seem

like the Problem. There is no real problem creating the text pattern. I count the occurrence of negative words in these two sections as journalism and its effort to attract readers.

## **8.2 The Problem-Solution pattern of Article 2**

Article two deals with human nonimmune cells that form a surprising mixture when encountering an infection: soap. The researchers tried to select these cells from others by infecting the cells with Salmonella. One gene that contained the APOL3 protein stood out from the others. This protein only attacks bacterial membranes by infection and is harmless to host membranes. Understanding how the body defends itself is essential for developing future treatments.

The General Situation occurs in the title. Even though the General Situation tends to be neutral, lexical signals indicate a future problem. Readers find general information also through sections 1, 2, and 3. In section 4, the part of the sentence *are often targeted by pathogens* triggers the Problem. The following section 4 (scientists) offers the Response to the Problem. The Response is clearly expressed by *looked for the molecular basis of that action, the team screened and looking for those that conferred some protection from infection*.

The Positive Evaluation follows the Response in section 8. Readers recognize the Positive Result of the Problem of the article thanks to the lexical signals *We were a bit surprised to find says, given such a molecule could dissolve host membranes too. But the researchers found that APOL3 specifically targets lipids found in bacteria, its activity is blocked by cholesterol, a common component of mammalian cell membranes, leaving human tissues unaffected*. Section 9 confirms the Positive Evaluation of the research with a positive comment from the scientist. The Positive Evaluation also concludes the pattern and occurs in section 10. According to scientists, evolution has found an elegant way to control this infection.

## **8.3 The Problem-Solution pattern of Article 3**

In Article 3, readers are introduced to how scientists have compiled the first map showing how proteins interact with cancer cells. This map shows previously overlooked mutations, and it is these that treatment has to focus on. Carcinogenic genes do not work alone, and scientists describe them as parts of a machine interacting with each other. Scientists suggest that finding proteins that work together for specific types of cancer should constitute an understanding of the development and growth of cancer.

The Problem-Solution pattern starts with the General Situation in the first section. The readers are given essential information about overlooked mutations of proteins in the initial research. The signal word *overlooked* marks the past problem and gives information about the contextual background. The second section constitutes the Particular Situation and introduces the research and its vital

outcome to readers. The Problem in the third section arises from the fact that cancer genes are like device components and do not act alone. Section 4 introduces the Method and how scientists find other proteins that make cancer mutate. The Method brings the Positive Evaluation in sections 9 and 10. Ideker, one of the scientists, hopes it will be possible to use this Method of mapping carcinogenic cell mutations in other types of cancer. Furthermore, the Method should help understand the growth and development of cancer. The Problem-Solution pattern is closed by Positive Result in section 11.

#### **8.4 Comparison of the Problem-Solution pattern of Articles 1-3**

According to my findings, the first article illustrates the frequent absence of the Problem-Solution pattern in popular science news. The text of the mentioned article contains evaluative words, non-evaluative words and specialised lexical items, which might indicate the Problem-Solution pattern. Thus, some parts of the text can be mistaken for the Problem-Solution stages, such as in sections 1 and 2. However, during the analysis of the texts of popular science news, it is necessary to consider that they are primarily subject to journalism. Signal words often attract the reader's attention and arouse a supposed feeling about the problem. The reason for the absence of the Problem-Solution model in some popular science articles is their purpose. These articles aim to arouse and maintain interest in the topic among readers

Articles 2 and 3 illustrate the text of the Problem-Solution pattern in the simplified form, where the individual stages follow each other chronologically. The first stage in both articles is the General Situation, which provides the readers with a background of the story. The following stage of Article 3 is the Particular Situation in section 2. In this stage, readers learn the details of the story. However, article 1 is based on general information, and it is this stage. Nevertheless, a General or Particular Situation is optional, and its absence does not affect a text pattern.

Both Articles 2 and 3 have the Problem expressed shortly. According to Hoey, the Problem requires a response/method which offers a way to solve the problem (Hoey 2001, 124). While the Response of Article 2 occurs only in section 2, the Response of Article 3 can be found in sections 4-8. Both articles are closed with the Positive Result and the Positive Evaluation combined in a single statement, as can also be seen in **Figure 2**. The text pattern of Articles 2 and 3 has the same chronological structure. They differ only in the number of occurrences of individual stages. I see this as the result of placing importance on different information.

## 8.5 Text patterns and their linguistic features

This section deals with a closer analysis of Article A concerning the Problem-Solution pattern, the real arrangement of its parts, the roles in the text and the linguistic characteristics of these parts. Furthermore, this section analyses the occurrence of the Problem-Solution pattern and compares their occurrence in the text with the division of the text to Van Dijk's semantic categories. The section draws on **Table 2**. Attention is paid to the individual stages and evaluative words, which are integral to the individual stages.

### 8.5.1 Text pattern from the perspective of viruses (pattern 1)

This subchapter deals with a closer analysis of the Problem-Solution pattern, the arrangement of its parts, the roles in the text and the linguistic characteristics from the perspective of viruses. Furthermore, the subchapter analyses the occurrence of stages in semantic categories. For the analysis, the thesis draws on **Table 2** and **Table 4**.

Viruses use caterpillars as a replication factory. However, the caterpillars are attacked by parasitic wasps, which use them as destined-to-die incubators. Viruses thus lose their living space. Therefore, they combine with the caterpillars, and the viruses produce a toxic for the parasitic wasps.

The left side of Table 4 indicates a general overview of evaluative words of the Problem-Solution pattern, and the right side marks the section of their occurrence in the text. The work draws on the stages of the pattern and the division into semantic categories from **Table 2**.

Table 4: Viruses – Signal words overview

<b>Viruses –Overview of the signal words of the Problem-Solution pattern</b>	<b>Number of the section</b>	<b>Stage</b>
<i>can kill</i>	1	The General situation
<i>The enemy of my enemy is my friend.</i>	2	The Particular Situation
<i>destined-to-die, bad news, bad, would kill, blocked</i>	5A, 5B, 12, 24	The Problem
<i>can help, killing factor, incredibly toxic, can come to fight, fights, could kill</i>	7, 8, 9, 11, 13, 20	The Method
<i>key, defences</i>	25	The Partially Positive Evaluation
<i>weren't affected, to thrive</i>	26	The Partially Negative

		Result
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The General Situation is signalled by the present simple time with the lexical signal words - *can kill*. These signal words grammatically and explicitly express the generally valid truth so that readers are acquainted with the usual behaviour of viruses. It means that viruses usually do kill... on the general condition unless the situation changes significantly.

The Particular Situation uses the explicit sentence: *The enemy of my enemy is my friend*. The division of the text into a General situation and the Particular Situation provides readers with background information and up-to-date information on the content of the article. The division of the text into stages is similar to the Headline and the Sub-headline with a similar function.

The Problem is developed using emotionally negative signal words in sections 5 A, 5 B, 12, and 24. In contrast, the Method is expressed by modal verbs that express a possibility, an ability such as *can kill, can come or could kill*. These two stages appear in the Consequences, Background, and Main Event.

The Partially Positive Solution in section 25 uses nouns such as *the sign, a key, defences* as signal words that evoke possible solutions. The signal words in section 26, Negative Result, reflect the reality of life because not everything is black and white. These two stages occur in the Main Event, and there seems to be no connection between Hoey's stages and Van Dijk's categories.

The pattern is chopped, and pieces of all stages emerge throughout the text in agreement with the article genre. The pattern is chopped, and pieces of all stages emerge throughout the text in agreement with the article genre. The table shows that lay readers are first acquainted with the basic information through the General Situation and then with the specific situation through the Particular Situation. The method does not solve the problem, so the problem returns and the text pattern offers another alternative method until the text pattern is closed. The subsequent alternation of the Problem and the Method keeps lay readers in suspense and, at the same time, immediately offers possible Solutions to the given Problem. Hoey calls this sequence text pattern recycling. The author chunks information to lay readers through this fragmentation. The text pattern from the perspective of viruses is fulfilled with crucial stages of the Problem-Solution pattern. It consists of all critical stages: the General Situation, the Problem, the Method, the Evaluation or the Solution, and the Result. Even though the Result is not bad or good, it still meets Hoey's Problem-Solution patterns condition.

## 8.5.2 Text pattern from the perspective of wasps (pattern 2)

The second main actors in Article A are wasps. This section analyses the Problem-Solution pattern from the perspective of wasps and focuses on the evaluative words and individual stages of the Problem-Solution pattern from the perspective of wasps in terms of Van Dijk's semantic categories.

Parasitic wasps use caterpillars as destined-to-die incubators. In this way, they take away the living space of viruses that use caterpillars as a replication factory. To preserve the genus, the wasps have to face viruses that help caterpillars produce a protein toxic to wasps. However, some wasps are immune to this toxic protein.

The analysis draws on **Table 2**. The first column gives the section number of the individual stages of the Problem-Solution pattern. The third column indicates the particular Problem-Solution pattern, and the last column denotes the semantic categories. **Table 5** on the left indicates the signal words overview and the number of the section where these signal words occur on the right.

Table 5: Wasps – Signal words overview

<b>Wasps –Overview of the signal words of the Problem-Solution pattern</b>	<b>Number of the section</b>	<b>Stage</b>
<i>can kill, infected</i>	1	The General Situation
<i>When, come calling, unwitting, destined-to-die</i>	3, 5A, 12	The Particular Situation
<i>(viruses) can help (caterpillars), killing, incredibly, can, to fight off, fights for, the wasp-killing, kill, can, could kill, poor, didn't survive.</i>	7, 8, 9, 11, 13, 14, 15, 16, 20, 22, 23	The Problem
<i>blocked, lived</i>	24	The Method
<i>key, defenses</i>	25	The Partially Negative Evaluation
<i>weren't affected, allowing</i>	26	The Partially Positive Result

The General stage uses present simple tense and signals words with explicit negative meaning, describes the general situation, and is universally valid under normal conditions. This stage coincides with the Headline category.

The signal words of the Particular Situation are time adverbial as *when*, present simple tense and negative adjectives as *parasitic* or *destined-to-die*. As with the previous text pattern from the perspective of the viruses, these stages appear in the Lead category and the Background category.

Here it is possible to notice that the textual analysis of the classifications of essential information classified into Hoey's stages agrees with the classification into Van Dijk's categories.

The Problem is evident from the negative signal words, mainly the verbs *kill* and the noun *fight*. The role of wasps in Article A is only negative, so the Problem occurs in many sections. Suppose the work compares the scope of the Problem with the categories according to Van Dijk. In that case, the Problem falls into many categories without a visible connection between stages and categories.

The Method, Negative Solution, and Partially Positive Result stages are minimal compared to the Problem. Each stage occurs in only one section. In terms of Van Dijk's categories, these stages are limited to the Main Event. The signal words are explicitly stated, reflecting the negative role of wasps in Article A. A large number of these signal words are in the simple past tense.

The text pattern contains stages comparable to the previous perspective of viruses. The difference between these two is only in the Solutions and Results. While the earlier text pattern of the viruses contains the Partially Positive Solution and the Partially Negative Result, the text pattern from the perspective of wasps contains the Partially Negative Solution and the Partially Positive Result. From the perspective of viruses, a Partially Positive Solution in section 25 of Article A tells readers that protein is the key to defending caterpillars against wasps. These are promising results for viruses that want caterpillars as replication factories. However, a Partial Positive Solution involves the Partially Negative Result because some wasps are unaffected by the toxic protein, which allows the offspring of the wasps to thrive within the caterpillars, and the viruses lose their living space.

For the wasps, it is the situation mirror image of the viruses. The Partially Negative Solution from the perspective of the wasps results from the fact that not all wasps can use the caterpillars as destined-to-die incubators due to the toxic protein produced by caterpillars. The Problem-Solution pattern is closed with the Partially Positive Result because some wasps are immune to the toxic killing protein. It is clear from this that the individual text patterns differ according to the actors' perspective, while the division of the text into categories, according to Van Dijk, is the same for all actors.

Although the Problem-Solution pattern with wasps as the main actors are simple, it fulfils Hoey's Problem-Solution pattern. The General Situation passes in the stage of the Particular Situation, followed by the developed Problem. The readers are offered only one Method to solve this problem, leading to the Partially Negative Solution with the following Partially Positive Result. The Problem-Solution pattern is clear and more or less consistent.

### 8.5.3 Text pattern from the perspective of caterpillars against wasps (pattern 3)

The section analyses the Problem-Solution text pattern, particular stages and linguistic characteristics from the perspective of caterpillars. When focused on caterpillars, the text features two different Problems resulting in two different text patterns. The first problem for caterpillars constitutes parasitic wasps, and the second constitutes viruses. As the wasps use the caterpillars as the *unwitting, destined-to-die incubators* while the viruses give the caterpillars a higher chance to survive, the wasps are described as the first and the prominent Problem of caterpillars. Both text patterns arise from the same General Situation. The focus is listed on parasitic wasps in relationship to caterpillars is listed in this part of the text as Problem 1. Due to attacks by deadly parasitic wasps, caterpillars conceive an alliance with less dangerous viruses. Viruses help caterpillars by producing toxic proteins against parasitic wasps, which are deadly to caterpillars.

The first column of **Table 6** indicates the number of sections of the stages, and the third column gives the particular stages of the pattern. The semantic categories are in the last column. The signal words of the particular stages are on the left in Table 6, and the number of sections of their occurrence is on the right.

Table 6: Caterpillars against Wasps/Problem 1 – Signal words overview

<b>Caterpillars against Wasps –Overview of the signal words of the Problem-Solution pattern</b>	<b>Number of the section</b>	<b>Stage</b>
<i>can kill, infected</i>	1	The General Situation
<i>when, come calling, unwitting, destined-to-die</i>	3, 5A, 5B	The Problem
<i>a surprising ally</i>	4	The Particular Situation
<i>chances of survival, higher, (viruses) can help (caterpillars), killing factor, incredibly toxic, more, possible, wasp-killing, survived</i>	6, 7, 8, 9, 14	The Method
<i>come together, fight off</i>	11	The Possible Solution
<i>ability, stronger, can, could kill, poor (hosts of the wasps), efficient killer, emerge, (larvae didn't) survive</i>	15, 16, 20, 22, 23	The Positive Evaluation
<i>key for defences</i>	25	The Solution
<i>weren't affected</i>	26	The Negative Result



The Headline of Article A provides the General Situation. The situation has no specific time reference or details and is indicated by the present simple tense and describes the general validity in time. Following the caterpillars–wasps relation, the text pattern develops in section 3. The evaluative signal *parasitic* negatively amplifies the lexical signal *come calling* and triggers the Problem-Solution pattern. Further, the Problem can be found in 5A and 5B, denoted by lexical signal words *turning into destined-to-die*. The Problem with its importance is not only situated in the Lead but also in the Background.

Section 4 represents the Particular Situation with its evaluative words *a surprising ally*, and specifies the concrete situation. The stage is included in the Lead and into semantic categories with its importance. Method 1 occurs in sections 6, 7, 8 and 9 and is marked by lexical signals *chances of survival, can help* or the evaluative signal word *higher, killing factor or incredibly toxic*. The stage appears in the Consequences and the Background. Method 1 offers the Possible Solution in section 11 and can be recognised by the words *come together, fight off*. The Possible Solution occurs in the Main Event.

Section 14 offers Method 2, recognisable by the lexical words *what's more, make themselves, possible, wasp-killing, survived viral infection*. Method 2 is situated in the Main Event. It brings the Positive Evaluation in sections 15, 16, 20, 22 and 23. The Positive Evaluation is situated in the Main Event and the Background. It informs lay readers about passing the ability to make their toxic protein to offspring. The evaluative words mark this stage with evaluative words as *stronger, unknown, infected, and efficient*. Furthermore, this stage is signalled by lexical signals as *makes you stronger, can swap, could kill, new findings, were poor hosts, died before had, efficient killer a chance and didn't survive*. The non-evaluative signals are *ability or activity*.

The Problem-Solution pattern starts to close with the Solution in section 25, denoted by the lexical signal words *key for defences*. Although there is the Positive Evaluation, the lexical signals *were not affected*, denoting the Partially Negative Result as some wasps remain immune to the toxic protein. The Result occurs in section 26 and the Main Event.

All three actors of the article are equally important when evaluating the Problem-Solution text pattern and its occurrence in semantic categories (most of the stages occur in the Main Event). However, the position of caterpillars in the foreground is visible, and all participants are equally important. This extensive range of words referring to caterpillars in the text corresponds to its fundamental role in the article when it serves as a possibility for survival for the other two actors. The author uses linguistic features such as an adverbial of time and simple tenses. Furthermore, the text pattern features evaluative or non-evaluative signal words, lexical signals, according to Hoey and inscribed or evoked signal words according to Martin's terminology. The author of the text used a recycling text pattern in order to be able to provide information to readers piece by piece.

### 8.5.4 Text pattern from the perspective of caterpillars vs viruses (pattern 4)

This part of the text deals with the Problem-Solution pattern from the perspective of caterpillars facing the problem caused by viruses. Problem 2 arises from the same General Situation as the text pattern derived from Problem 1. Both text patterns based on Problem 1 or Problem 2 constitute one general Problem-Solution pattern.

The text pattern based on Problem 2 represents caterpillars and their problem with viruses. Although viruses help caterpillars fight off deadly parasitic wasps, they still represent a danger to caterpillars. Viruses use caterpillars as replication factories and thus can be lethal for them.

On the left, Table 7 indicates the signal words of the stages and on the right, the section numbers of their occurrence. The first column of **Table 7** indicates the section number of stages of the pattern, and in the third column, under number 2, are stages of the pattern. The last column provides semantic categories.

Table 7: Perspective of caterpillars against viruses/Problem 2 – Signal words overview

<b>Caterpillars against Viruses – Overview of the signal words of the Problem-Solution pattern</b>	<b>The number of section</b>	<b>Stage</b>
<i>can kill</i>	1	The General Situation
<i>a replication factory, can be lethal</i>	5B	The Problem
<i>chances of survival are probably higher, can help, killing factor, can come together to fight off, activity, virus-infected, an efficient killer</i>	6, 7, 8, 11, 17, 22	The Particular Situation
<i>can swap (genus)</i>	14	The Method
<i>what doesn't kill you makes you stronger</i>	15	The Particular Positive Evaluation
<i>key for the caterpillars' defenses</i>	25	The Particular Positive Result

The pattern starts in the same General Situation as the text pattern of the relation between caterpillars and wasps. Readers are introduced to the relationship between caterpillars and viruses. The General situation is denoted by the lexical signal *can kill* and appears in Headline in section 1.

The following stage triggers the Problem-Solution by lexical signals *a replication factory, can be lethal*. Even though the Problem occurs in only section 5B, the stage impacts the development of the following text pattern. The division of the text into semantic categories corresponds with the

individual stages, and the Problem occurs in the Lead. It thus confirms the importance of given information for lay readers.

The Particular Situation occurs in sections 6, 7, 8, 11, 17, and 22. The stage is denoted by lexical signals as *chances of survival are probably higher, can help, killing factor, can come together to fight off, activity, virus-infected, an efficient killer*. The occurrence of the Particular Situation is widely spread into many categories, namely Consequences, the Background, the Evaluation and the Main Event.

Section 15 evaluates the text pattern in the Partially Positive Evaluation with lexical signals *what doesn't kill you makes you stronger* occurring in the Main Event. The pattern closes in section 25 with the lexical signal *what doesn't kill you makes you stronger, and* I assign this stage to Main Event.

The pattern begins with the General Situation, similar to the caterpillar-wasp text pattern. The fact that this is the Problem-Solution pattern is clear from the occurrence of the following stage - Problem, which skipped the Particular Situation. In contrast to the Problem explicitly stated in one part of the text, the Particular Situation is extensive and intertwines a large part of the text. Lay readers are offered the Method that forms the Partially Positive Evaluation. The Particular Situation, an intermediate stage, follows between the Evaluation and the Result. The pattern is closed with the Partially Positive Result. The pattern can be summed up as fragmented as a result of how the author drops information piece by piece throughout the text. The pattern can be summed up as fragmented due to how the author drops information piece by piece throughout the text.

## **8.6 Summary of the Problem-Solution pattern in Articles A and B**

This section evaluates the Problem-Solution pattern in Articles A and B. At first, it is necessary to realise that Article B, as opposed to A, does not contain a Problem-Solution pattern. The absence of a Problem-Solution pattern does not mean there is no pattern in Article B. The text can be divided into semantic categories. Although the structure of Article B with no Problem-Solution is more often found in scientific news. Journalism aims to inform readers about research, progress, and new data information in a given scientific field. For this purpose, applying the Problem-Solution pattern in the text based on and derived from the Problem is unnecessary. If the article contains a Problem, it may be due to the genre – journalism. The Problem is thus only artificially created to attract the interests of readers.

There are several ways to read a text pattern; the first is to read the whole text as one general formula. An example is given in **Figure 2**. The pattern can be read as a matrix (Hoey 2001, 133-134), given that the text has three actors: caterpillars, wasps, and viruses. The matrix pays attention to the reaction of other actors in the text. The field in the other part of the image, as in **Figure 3**,

would be blank. Article A features more than one actor. The reactions of these actors constitute the branched text pattern, as in the case of the pattern from the perspective of caterpillars.

The work divides the organisation itself according to two criteria. The first criterion is the time range covered by the pattern. From this point of view, it is clear that the organisation of individual stages occupies three periods - the recent past (discovery itself), the time of informing about the discovery and the future (possible future profit from research). The narrowed time range divides the text pattern into individual stages. The second criterion - the order of the individual stages is subject to journalism. Stages are not arranged chronologically. This pattern of chopping is due to the biting of information for the reader. This biting of information is evident in all the samples of Article A. One stage can end in one section, and another starts in the same one.

From a linguistic point of view, the articles contain both evaluative or non-evaluative signals and lexical signals, which indicate the individual stages. The presence of these language resources in popular science articles is not limited to the presence of the Problem-Solution pattern.

## **9 Text Time vs Field Time analysis**

This part of the text seeks similarities or differences between Articles A and B using structural analysis of text and time by Martin and Rose. The difference between Text time vs Field time analysis and the overview of the analysis is significant. Martin and Rose divide the text according to the time utterance are made, while the general analysis contains patterns based on the division of the text into stages or categories by their meaning and role in the text.

According to Martin and Rose, when needed to attract readers' attention, a news story begins at any time and jumps to a different time to present different aspects of the story and the viewpoints of different actors. This specification applies to newspaper articles in general. Popular science articles are a specific genre of newspaper articles, so it is necessary to consider Haupt's definition when applying the Text time vs Field time analysis to popular scientific articles. Haupt's definition of popular scientific news states: "The verb to inform and reference to recent scientific knowledge as a content specification emphasises the transactional aspects of the genre" (Brown and Yule 1987, in Haupt 2014, 12).

The analysis will also focus on the fragmentation of the speech of individual actors. In a general analysis, this speech fragmentation presents different perspectives on the plot. In analysing popular scientific articles, this phenomenon of fragmentation of speech is used to evaluate a scientific discovery or express hope for the possible use of the discovery in the future. The commentary on the discovery and its contribution attracts the lay readers' attention. At the same time, the fragmentation of speech of the individual actors of the article represents the main component of the structural analysis by clearly demonstrating the news of article specifications and thus the emphasis on the sequence of the text before the time sequence.

### **9.1 Article A**

This subchapter deals with the Text time vs Field time of Article A analysis. The text is arranged from top to bottom and sorted by time section from left to right. The individual text is fragmented in the time section according to the time of the speech, the time to which the speech relates, or the occurrence of the event. Thus, if a scientist comments on the research, his speech is set in the time of his speech and fragmented into the period his speech belongs to.

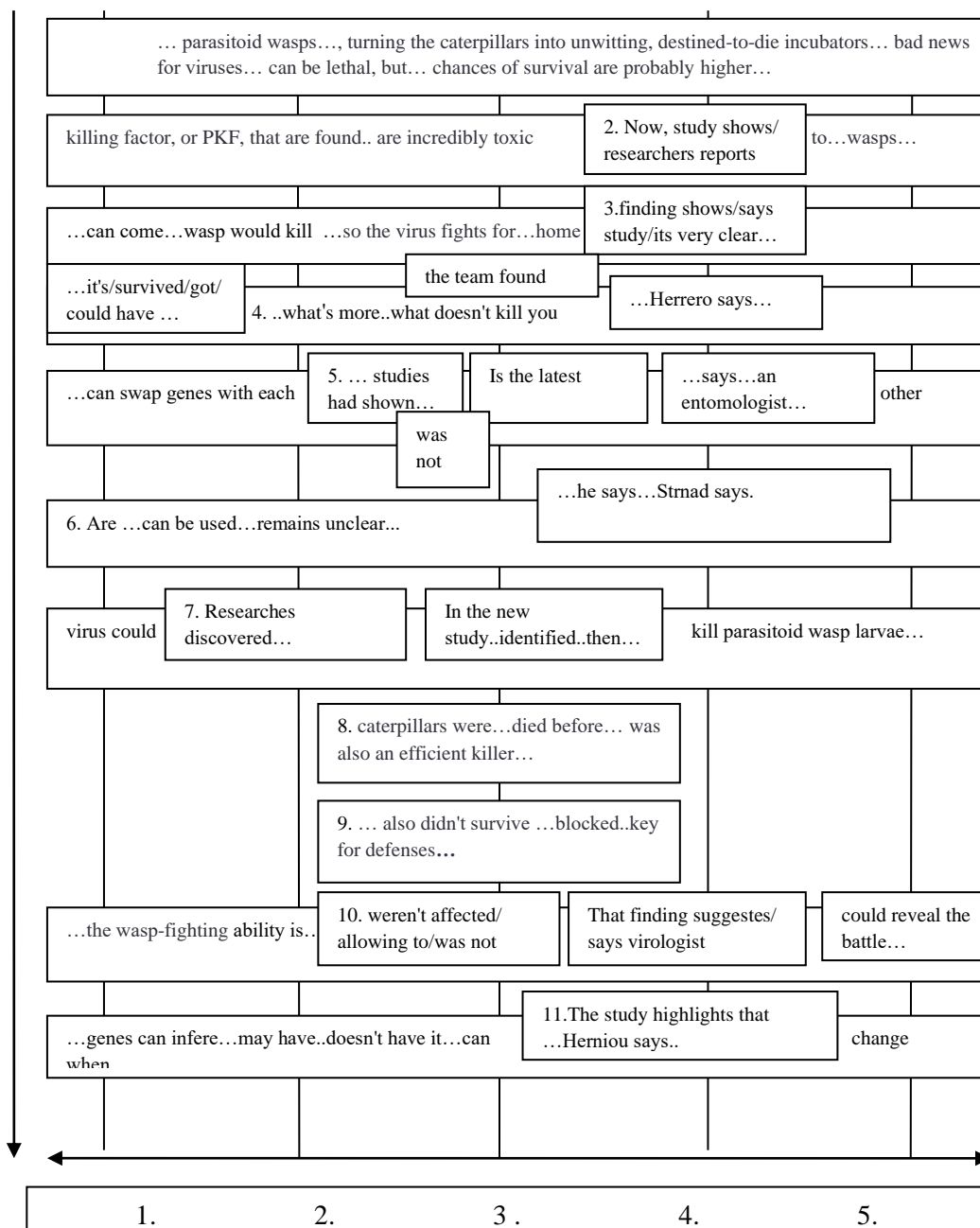


Figure 5: Text time vs Field time – Article A

**Figure 5** demonstrates that popular science articles are text structured and thus the opposite of a text with a time structure. The text structure is displayed by skipping from one-time sequence to another. The table indicates that the movement over time is more towards a recent event, i.e. the recent past. The fragmented speech of the various actors illustrates the movements. The speech is situated in the present and returns to the main event of scientific discovery. Articles with a classic text structure have this movement more or less focused over time or tend to move to the near future.

The above table by Martin and Rose shows that the nucleus of the lead section extends the Headline. Switching the speech of individual actors differs from the usual dialogues in the stories. The speeches of the individual actors are arranged with an emphasis on the text rather than on time.

These sequences of individual speeches thus bring different perspectives and evaluations of the main events. According to Martin and Rose, these are patterns of manipulation and involvement of lay readers. These manifestations are in the sections marked with numbers 3,4, 5, 6, 10 and 11. At the same time, the researchers appreciated the results of the research. In section 11, the speaker explicitly highlights the research results and, at the same time, expresses the possibility of using the research results in the future.

## 9.2 Article B

This part of the work applies the analysis of Text time vs Field time to Article B. The text from top to bottom is arranged according to the text of Article B. The parts of the text are sorted from right to left according to the time they are situated and the period covered by the content of the article.

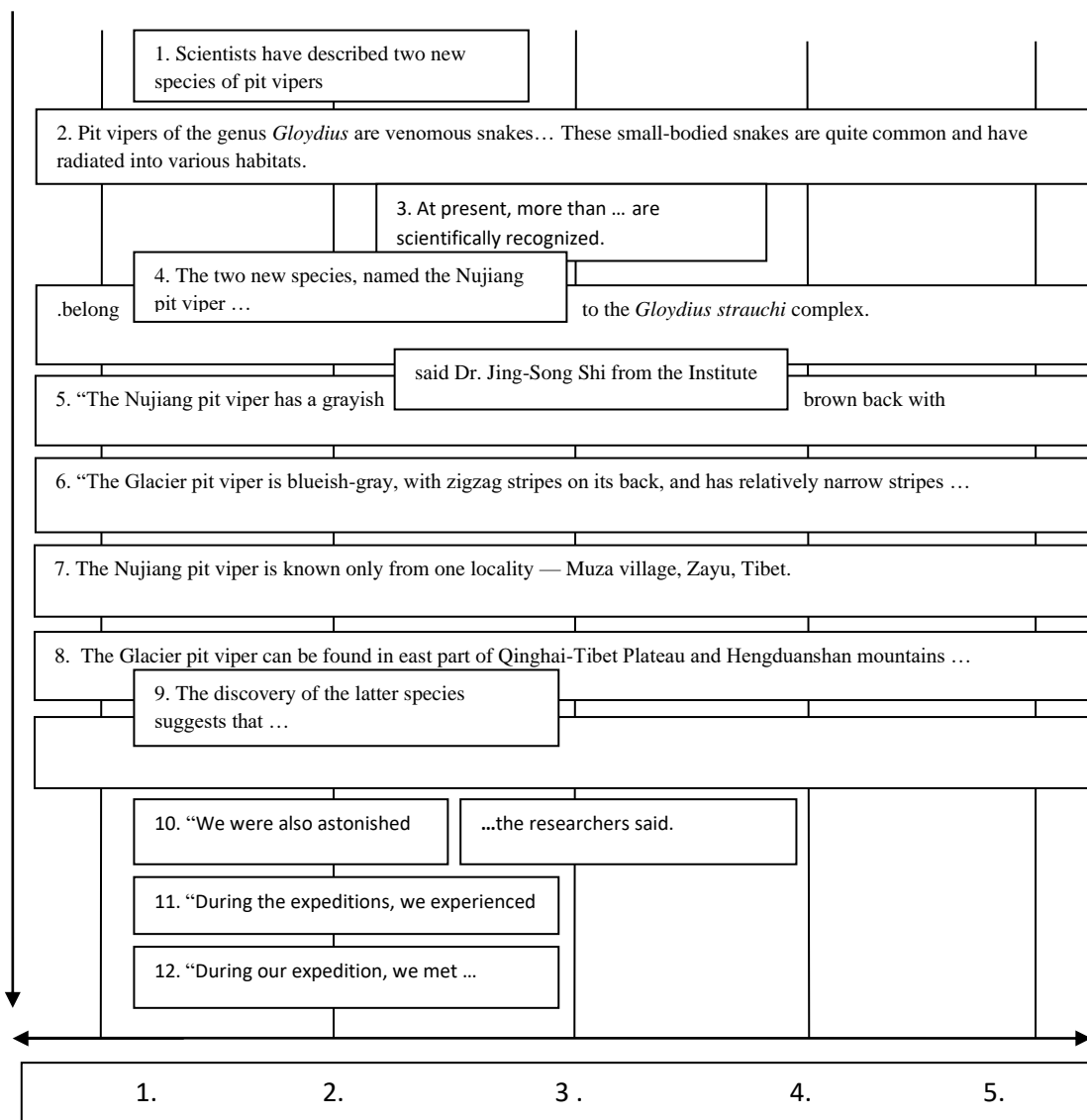


Figure 6: The Text time vs Field time – Article B

The Text time vs Field time structural analysis of Articles B and A shows the text unfolding the event it refers to rather than a more prominent movement in time. The fragmented time sequences

of the individual parts of the text illustrate the structure. Although fewer speakers praise or comment on the discovery, the speech goes back to a recent past, a scientific discovery. At the same time, this movement in time from the present to the recent past confirms Haupt's definition of informing lay readers about recent research (Haupt 2014, 12).

The purpose of Article B is to inform about the Result of the research and, above all, to arouse the lay readers' interest in the given topic. The aim to attract the lay readers to the topic shows the fragmentation of the speech, which not only returns to the recent past to the discovery of the viper but also praises the surrounding beauties of nature, i.e. the time sequence close to the discovery itself. These beauties of nature are associated with the object of research, vipers, so this praise stimulates interest in the field of research. The two articles are, therefore, similar in this respect.

Article B does not contain time sequences like Article A expressing the possible use of research results in the future. On the contrary, both articles contain time sequences intervening in the future that expresses the generally valid truth. In Article A, the following references are presented by the words as *turning the caterpillars into unwitting destinate-to-die incubators, wasps would kill, or genes can infer*. The generally valid truth in Article B is represented by the words *snakes are quite common, pit-viper is bluish-gray, has relatively narrow stripes* and another. These sequences intersect from the past to the future and apply under normal conditions.



## 10 Inverted pyramid, epideictic arguments – the comparison of Articles A and B

This bachelor thesis compares two popular scientific articles to examine the text patterns, structure of Articles A and B and linguistic characteristics. When assessing the text structure of popular scientific news, it is necessary to consider their subordination to the genre and journalistic discourse. Van Dijk's categories show a macrostructure without noticing their order, leading to more possible ways of a news organisation.

In the theoretical part, I dealt with the Inverted pyramid, the structure often used in journalism. The chapter will deal with similarities or differences between Articles A and B according to Morse's inverted pyramid rules.

### 10.1 Article A

The section aims to organise Article A to the Inverted pyramid and find possible similarities or differences with Article B

Figure 7 demonstrates the basic structure of Article A in the Inverted pyramid. The left side provides the general division of news articles, and the right side denotes the division of Article A in the Inverted pyramid.

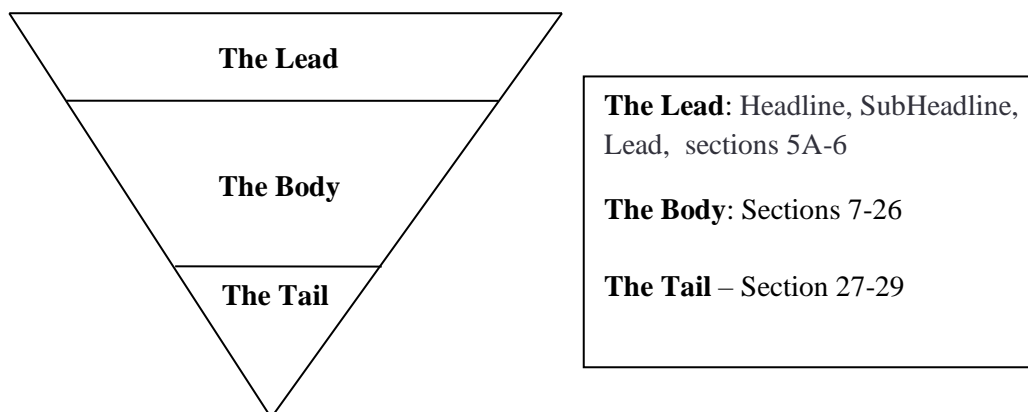


Figure 7: Inverted pyramid – Article A

The Headline, the SubHeadline and the Lead are situated up to the 6th section at the top of the pyramid. These parts of the text fulfil the criteria of providing essential information, answering the question: Who? What? Where? Why? Shortly, Readers became acquainted with the fact that parasitic wasps use caterpillars as unwitting destined-to-die incubators to preserve their insect species.

The body of the Inverted pyramid is built up from sections 7 to 26 and provides additional details, background, evidence, support or other information. Lay readers are informed about the discovered

proteins and the historical background preceding the research, or they are given detailed comments and praise from other scientists about the research.

The Tail should feature the least essential things as information to find other information about the topic or extra context. The Lead is situated within sections 27-29, and the Bottom features an assessment of scientists and highlights the research contribution. The last part of the pyramid fulfils its function even though there is no additional information from other sources.

## 10.2 Article B

The section aims to apply the Inverted pyramid to Article B compared to Article A. **Figure 8** demonstrates Article B divided into parts agreeing with the Inverted pyramid. There is the general Figure of the Inverted pyramid on the left, and the right side provides the division of the text into parts of the Inverted pyramid.

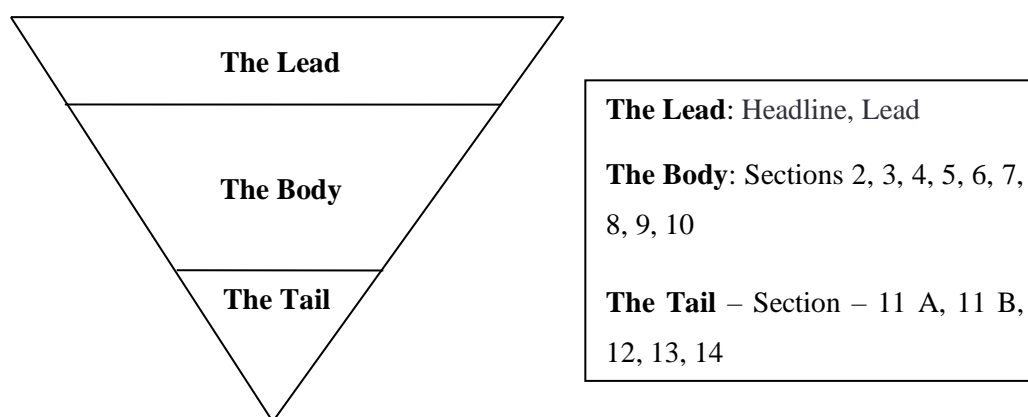


Figure 8: Inverted pyramid – Article B

The Inverted pyramid of Article B contains the Headline and the Lead. If I focus on the primary function of this section, it answers the question, Who? Where? How? Why? When? These parts with General Situation serve as much function as the top of the inverted pyramid of Article A. They occur in sections 1-3. The lay readers are informed that scientists have discovered two new species of pit vipers in China. As in Article A, the timing of the discovery is expressed only implicitly here. The only difference between the top of the Inverted pyramid of Article A and Article B can be found in the question Why? While Article A this question explicitly stated, Article B can implicitly consider the research's subject as scientists' interest.

The body of Inverted pyramid Article B consists of sections 4-10. These sections provide the reader with a more detailed description of the discovery, the background, and the commentary of a seemingly uninvolved scientist on a new viper species. The body of Article B of the Inverted pyramid provides more independent evaluations from non-participating scientists and a more

detailed discovery description. Nevertheless, the two parts of Articles A and B do not differ significantly and fulfil their function.

The Bottom or the Tail of the Inverted pyramid of Article B does not contain more information about the research itself. Readers in this section will find an evaluation of the finding of a new species of viper and again praise nature. This part of the Inverted pyramid of Article A coincides with the Bottom of Article B and is situated within sections 11-14.

Articles A and B are popular scientific articles but have different purposes. Article A informs the lay reader about the discovery, while Article B seeks to arouse readers' interest in the topic. Nevertheless, when comparing Article A and Article B according to the structure of the Inverted pyramid, both articles coincide and perform the function according to the arrangement of the Inverted pyramid.

### **10.3 Epideictic arguments – the wonder, the application**

This part of the chapter compares Articles A and B from the viewpoint of the epideictic arguments, according to Fahnestock. Fahnestock distinguishes three types of persuasive speech according to Aristotle: forensic, deliberative, and epideictic. Chosen Articles A and B fall into science journalism. The subchapter analyses Article A and Article B from the perspective of epideictic appeal because Fahnestock assigns this third type of persuasive speech to science journalism. By comparing these two articles, A and B, I want to find out whether and to what extent these two articles will be similar or different, given that the two are different in terms of the Problem-Solution pattern occurrence.

#### **10.3.1 Article A**

The subsection focuses on the epideictic arguments in Article A to find similarities or differences to Article B. Science accommodators use two appeals in the epideictic arguments: the wonder and the application, to provide readers with purely scientific facts. The deontological argument corresponds to the wonder, while the teleological appeals to the teleological argument.

I identify the deontological appeal – the wonder, in section two: *"..how certain viruses can help caterpillars stymie parasitoid wasps."* This part of the article introduces the viewer to the wonders of nature. The term "viruses" usually raises unpleasant expectations of future problems for readers. Here, science accommodators present how nature can deal with the pitfalls, and actors from whom this would not be expected will come together to preserve their continued existence. Section three explicitly states this fact: *"... viruses and caterpillars come together to fight off a common wasp enemy."* Section four develops these wonders of nature with the phrase: *"What's more..."* in section three: *"The new finding shows .."* or in section five: *"The new finding is is one of the latest..."* These deontological appeals attempt to praise the research.

The teleological appeal, the application, occurs in section ten: "*The pinpointing ..could reveal the details of a long-held evolutionary battle.*" The application adds value to research because it will lead to future benefits.

### **10.3.2 Article B**

In this section, I focus on applying epideictic arguments in Article B. I will compare the Result with Article A and determine whether these articles differ or are similar in accommodating epideictic arguments – the wonder and the application.

In Article B, the deontological argument, the wonder is found in section one: "*Scientists have described ...*" This appeal refers to the scientific breakthrough discovery of two new species of vipers. Other deontological arguments occur in sections ten, eleven and twelve. These deontological arguments inform readers about the beauties of nature that scientists were surrounded by during the research.

The second, the teleological argument appears in section nine; "*The discovery suggests that glaciers might be considered as key factors to this.*" With this teleological appeal, science accommodators seek to add future value/benefit to research. Comparing Articles A and B from the point of view of epideictic oratory accommodation, I concluded that both articles are identical. Both of them fulfil epideictic oratory accommodation with the occurrence of deontological and teleological appeal. Even though Articles A and B differ in the occurrence of the Problem-Solution pattern, both articles provide lay readers with information about scientific research in a form that is easy for lay readers to read and understand and thus make science more accessible to noninitiated audiences.

## 11 Conclusion

A detailed qualitative analysis of two articles suggested that the meaning of **the Problem-Solution pattern** is less significant than dividing the text into semantic categories. The essence of the Problem-Solution pattern is solving a problem. At the same time, it is necessary to remember the primary function of popular science articles: informing. To fulfil this primary function - to inform the reader, it is not necessary for the text of a popular science article to solve a problem. In terms of the existence of the problem in the analyzed popular scientific news, I consider the occurrence of the problem to be minor, created by authors mainly to gain the readers' interest.

In contrast to the occurrence of the Problem-Solution pattern in the texts of popular science articles, the division of texts into **semantic categories** is always present in the texts of these articles. I find the reason for this fact to be a broader/freer division of the text into semantic categories according to its purpose. These categories are more general than the individual stages of the Problem-Solution text pattern. They do not depend on the focus of the text's topic. The existence of the Problem-Solution directly depends on the existence of the Problem stage. At the same time, the semantic categories cover all types of texts. The Problem-Solution pattern and semantic categories rearranged and adapted to the structure of their genre, i.e. the structure of an Inverted pyramid.

When focusing on the occurrence of a **Text time vs Field time structure**, it is necessary to remember that its arrangement corresponds to the **Inverted pyramid**. The events are not described chronologically, and the organization of the text according to the Inverted pyramid takes precedence because the author places the most crucial information in the foreground of the text. The text time vs field time structure also illustrates the temporal ordering of events according to the actual time they happened. There is no correspondence with the Problem-Solution pattern.

Regarding **Text time vs Field time structure**, we can distinguish three time layers without unexpected jumps of the text to other periods outside the main points related to discovery/research. The first layer contains information arranged in a field extending from the past to the future. In this case, these are generally valid truths that serve as background information in the article. Another purpose of Background is to provide readers uneducated in the field with the necessary information to understand the topic under discussion. The second layer refers to the recent past. Authors situate reports on discovery in this time layer. The third time layer of the text falls into the present. These are the comments of discovery or other scientists, whether or not they participated in the given discovery. An additional division of time falls into the future. The phase is usually the end of the text, when, after evaluating the scientific fact, there is a statement about its further use in the future.

**Linguistic features** play a fundamental role in the text of popular science articles regardless of the occurrence of the Problem-Solution text pattern. They help the reader to navigate the text and predict what will follow. Thanks to the use of inscribed signal words or evoking signal words, the

author intentionally evokes in the reader the desired reaction to a scientific discovery or scientific event. If it is a Problem-Solution pattern, signal words are vital in their occurrence in the text.

**Signal words** trigger not only the most crucial stage - the Problem but also the other stages in the text. Considering the low frequency of occurrence of the Problem-Solution pattern in popular science articles, I believe that the authors of the articles often pretend the existence of a problem in a text of an article to attract the reader's attention. Evaluative words serve as an evaluation of a given scientific discovery or event.

By comparing Articles A and B, I concluded that text patterns of popular scientific news differ in the text. Sometimes text patterns are not present at all. The absence of a Problem-Solution pattern does not affect the purpose of the articles, which is to inform readers. Articles are primarily governed by genre and journalism, regardless of the text patterns or their absence. The structure of texts corresponds to the arrangement according to the Inverted pyramid. The form of the text pattern is secondary, and it is up to the author to choose which information to give greater importance.

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## 13 Appendixes

### 13.1 Appendix 1

List of Articles A and B and Articles 1-3

Table 8: Sources of Articles A and B and Articles 1-3

Source	Name in BA	The author's name	Website
Science News	Article A	Erin Garcia de Jesús	<a href="https://www.sciencenews.org/article/viruses-wasp-larvae-caterpillars">https://www.sciencenews.org/article/viruses-wasp-larvae-caterpillars</a>
Sci-News	Article B	News Staff	<a href="https://www.sci.news/biology/two-new-gloydius-species-10142.html">https://www.sci.news/biology/two-new-gloydius-species-10142.html</a>
BBC News	Article 1	Helen Briggs	<a href="https://www.bbc.com/news/science-environment-56804147">https://www.bbc.com/news/science-environment-56804147</a>
Science News	Article 2	Jonathan Lambert	<a href="https://www.sciencenews.org/article/human-cells-soap-substance-bacteria-immunity">https://www.sciencenews.org/article/human-cells-soap-substance-bacteria-immunity</a>
Scientist News	Article 3	Jason Arunn Murugesu	<a href="https://www.newscientist.com/article/2292070-first-map-of-proteins-in-tumour-cells-pinpoints-cancer-therapy-targets/">https://www.newscientist.com/article/2292070-first-map-of-proteins-in-tumour-cells-pinpoints-cancer-therapy-targets/</a>

#### Texts of Articles A and B and Articles 1-3

##### ARTICLE A

##### Viruses can kill wasp larvae that grow inside infected caterpillars

**A new study is a take on the adage, "The enemy of my enemy is my friend."**

JULY 29, 2021 AT 2:00 PM

When parasitic wasps come calling, some caterpillars have a surprising ally: a viral infection.

1. Insects called parasitoid wasps lay their eggs inside young moth larvae, turning the caterpillars into unwitting, destined-to-die incubators for possibly hundreds of wasp offspring. That's bad news for viruses trying to use the caterpillars as replication factories. For the caterpillars, viral infections can be lethal, but their chances of survival are probably higher than if wasps choose them as a living nursery.
2. Now, a study shows how certain viruses can help caterpillars stymie parasitoid wasps. A group of proteins dubbed parasitoid killing factor, or PKF, that are found in some insect viruses are incredibly toxic to young parasitoid wasps, researchers report in the July 30 Science.
3. The new finding shows that viruses and caterpillars can come together to fight off a common wasp enemy, says study coauthor Madoka Nakai, an insect virologist at Tokyo University of Agriculture and Technology. A parasitoid wasp would kill a host that the virus needs to survive, so the virus fights for its home. "It's very clever," Nakai says.
4. What's more, some moth caterpillars make the wasp-killing proteins themselves, the team found. It's possible that in the distant Past, a few moths survived a viral infection and "got some presents" in the form of genetic instructions for how to make the proteins, says study coauthor Salvador Herrero, an insect pathologist and geneticist at the University of Valencia in Spain. Those insects could have then passed the ability down to offspring. In this case, "what doesn't kill you makes you stronger," Herrero says.
5. Previous studies had shown that viruses and insects, including moths, can swap genes with each other. The new finding is one of the latest examples of this activity, says Michael Strand, an entomologist at the University of Georgia in Athens who was not involved in the work.
6. "Parasite-host relationships are very specialised," he says. "Factors like [PKF] are probably important in defining which hosts can be used by which parasites." But whether caterpillars stole the genetic instructions for the proteins from viruses or if viruses originally stole the instructions from another host remains unclear, Strand says.



7. Researchers discovered in the 1970s that virus-infected caterpillars could kill parasitoid wasp larvae using an unknown viral protein. In the new study, Herrero and colleagues identified PKF as wasp-killing proteins. The team infected moth caterpillars with one of three insect viruses that carry the genetic blueprints to make the proteins. Then the researchers either allowed wasps to lay their eggs in the caterpillars or exposed wasp larvae to hemolymph — the insect equivalent of blood — from infected caterpillars.
8. Virus-infected caterpillars were poor hosts of the parasitoid wasp *Cotesia kariyai*; most young wasps died before they had the chance to emerge from the caterpillars into the world. Hemolymph from infected caterpillars was also an efficient killer of wasp larvae, typically destroying more than 90 percent of offspring.
9. *C. kariyai* wasp larvae also didn't survive in caterpillars, including the beet armyworm (*Spodoptera exigua*), that make their own PKF. When the researchers blocked the genes for the proteins in these caterpillars, the wasps lived, a sign that the proteins are key for the caterpillars' defenses.
10. Some parasitoid wasps, including *Meteorus pulchricornis*, weren't affected by PKF from the viruses and also beet armyworms, allowing the wasp offspring to thrive inside caterpillars. That finding suggests that the wasp-fighting ability is species-specific, says Elisabeth Herniou, an insect virologist at CNRS and the University of Tours in France who was not involved in the work. Pinpointing why some wasps aren't susceptible could reveal the details of a long-held evolutionary battle between all three types of organisms.
11. The study highlights that "single genes can interfere with the outcome of [these] interactions," Herniou says. "One virus may have this gene and the other virus doesn't have it," and that can change what happens when virus, caterpillar and parasitoid all collide.

## ARTICLE B

### Two New Species of Venomous Snakes Discovered

Oct 6, 2021

1. Scientists have described two new species of pit vipers in the genus *Gloydius* from Zayu in Tibet and Heishui in Sichuan, China.
2. Pit vipers of the genus *Gloydius* are venomous snakes distributed mainly in northern Asia, but extending into southern Europe in the case of a species called the Halys pit viper (*Gloydius halys*).

These small-bodied snakes are quite common and have radiated into various habitats.

3. At present, more than 20 *Gloydius* species mainly belonging to three groups — i.e., the *Gloydius blomhoffii* complex, *Gloydius intermedius-halys* complex, and *Gloydius strauchi* complex — are scientifically recognised.
4. The two new species, named the Nujiang pit viper (*Gloydius lipipengi*) and the Glacier pit viper (*Gloydius swild*), Research belong to the *Gloydius strauchi* complex.
5. "The Nujiang pit viper has a grayish brown back with irregular black ring-shaped crossbands, wide, grayish-brown stripes behind the eyes, and relatively short fangs," said Dr. Jing-Song Shi from the Institute of Vertebrate Paleontology and Paleoanthropology at the Chinese Academy of Sciences and the Shenyang Normal University and colleagues.
6. "The Glacier pit viper is blueish-gray, with zigzag stripes on its back, and has relatively narrow stripes behind its eyes."
7. The Nujiang pit viper is known only from one locality — Muza village, Zayu, Tibet.
8. The Glacier pit viper can be found in east part of Qinghai-Tibet Plateau and Hengduanshan mountains, Heishui country, north Sichuan, about 15 km away from Dagu Holy-glacier National Geological Park.
9. The discovery of the latter species suggests that Research the glaciers might be considered as key factors to the isolation and speciation of the alpine pit vipers in the southwest China.
10. "We were also astonished by the sceneries we encountered during the field work," Research the researchers said.
11. "During the expeditions, we experienced striking views of sacred, crystal-like glacier lakes embraced by mountains, as well as colorful broadleaf-conifer forests and morning mists falling over the village."
12. "During our expedition, we met a lot of hospitable Tibetan inhabitants and enjoyed their kindness and treats, which made the expedition more unforgettable."

## **ARTICLE NO. 1**

### **Climate change: Future-proofing coffee in a warming world**

1. Scientists say a "forgotten" coffee plant that can grow in warmer conditions could help future-proof the drink against climate change.
2. They predict we could soon be sipping *Stenophylla*, a rare wild coffee from West Africa that tastes like Arabica coffee, but grows in warmer conditions.
3. As temperatures rise, good coffee will become increasingly difficult to grow.
4. Studies suggest that by 2050, about half of land used for high-quality coffee will be unproductive.
5. To find a wild coffee that tastes great and is heat and drought tolerant is "the holy grail of coffee breeding", said Dr Aaron Davis, head of coffee research at the Royal Botanic Gardens, Kew.
6. "Being somebody who's tasted a lot of wild coffees they're not great, they don't taste like Arabica so our expectations were pretty low," he told BBC News.
7. "And we were completely blown away by the fact that this coffee tasted amazing. It has these other attributes related to its climate tolerance: it will grow and crop under much warmer conditions than Arabica coffee."
8. *Coffea stenophylla* is a wild coffee species from West Africa which, until recently, was thought to be extinct outside Ivory Coast.
9. The plant was recently rediscovered growing wild in Sierra Leone, where it was historically grown as a coffee crop about a century ago.
10. A small sample of coffee beans from Sierra Leone and Ivory Coast were roasted and made into coffee, which was then tasted by a panel of coffee connoisseurs. After rediscovery/straight after that
11. Over 80% of judges could not tell the difference between *Stenophylla* and the world's most popular coffee, Arabica, in blind tastings, the researchers reported in the journal *Nature Plants*.
12. They also modelled climate data for the plant, which suggests it can potentially tolerate temperatures at least 6C higher than Arabica.
13. Seedlings will be planted this year in order to start assessing the wild coffee's potential in safeguarding the future of high-quality coffee.
14. Dr Davis hopes *Stenophylla* will one day be grown again in Sierra Leone on a major scale.
15. "It's not going to be in coffee shops in the next couple of years, but I think within five to seven years we'll see it entering the market as a niche coffee, as a high value coffee, and then after that I think it will be more common," he said.

What is Arabica coffee?

16. Arabica beans are deemed to have a superior taste. The coffee is grown in the mountains and accounts for over 60% of the world's coffee production.
17. Arabica has limited resilience to climate change; farmers are already experiencing the impacts of elevated temperatures and low or erratic rainfall.
18. Other threats to coffee production include price fluctuations, pests and diseases, and extreme weather.
19. The research was carried out in collaboration with the French research institute Cirad and the University of Greenwich. Past till rediscover

Where is wild coffee found?

20. The vast majority of wild coffee grows in the remote forests of Africa and on the island of Madagascar. Beyond Africa, wild coffee is found in other tropical climates, including parts of India, Sri Lanka, and Australia.

## **ARTICLE NO. 2**

### **HEALTH & MEDICINE**

## **Human cells make a soaplike substance that busts up bacteria**

### **A surprising cellular defensive strategy could inspire new antibiotics**

JULY 15, 2021 AT 2:00 PM

When faced with bacterial invaders, some human cells dispense a surprising substance: soap.

1. These cells, which aren't part of the immune system, unleash a detergent-like protein that dissolves chunks of the inner membranes of bacteria, killing the infiltrators, researchers report in the July 16 Science.
2. The “professional” players of the immune system, like antibodies or white blood cells, get lots of attention, but “all cells are endowed with some ability to combat infection,” says immunologist John MacMicking, a Howard Hughes Medical Institute investigator at Yale University.
3. In humans, these run-of-the-mill cellular defenses have often been overlooked, MacMicking says, even though they are part of “an ancient and primordial defense system” and could inform the development of new treatments for infections.
4. Often, nonimmune cells rely on a warning from their professional counterparts to combat infections. Upon detecting outsiders, specialised immune cells release an alarm signal called interferon gamma. That signal rouses other cells, including epithelial cells that line the throat and intestines and are often targeted by pathogens, to action.
5. MacMicking and colleagues looked for the molecular basis of that action by infecting laboratory versions of human epithelial cells with Salmonella bacteria, which can exploit cells' nutrient-rich interior. Then, the team screened over 19,000 human genes, looking for those that conferred some protection from infection.
6. One gene, which contains instructions for a protein called APOL3, stood out. When this gene was disabled, the epithelial cells succumbed to a Salmonella infection, even when warned by interferon gamma. Zooming in on APOL3 molecules in action inside host cells with high-powered microscopy, the researchers found that the protein swarms invading bacteria and somehow kills them.
7. *Salmonella* are hardy microbes, protected by an outer and inner membrane, a feature shared by many different forms of bacteria. This double layer renders these bacteria hard to kill, but further investigation revealed how APOL3 and another molecule, GBP1, work together to do it. GBP1 somehow loosens the bacteria's outer membrane, opening doors for APOL3 to deliver its death-by-dissolution to the inner lipid membrane. APOL3 has both water-loving and lipid-loving parts, letting it bind to the inner membrane and dissolve it into the intracellular fluid, like soap washing away grease.
8. “We were a bit surprised to find detergent-like activity inside human cells,” MacMicking says, given such a molecule could dissolve host membranes too. But the researchers found that APOL3 specifically targets lipids found in bacteria, and its activity is blocked by cholesterol, a common component of mammalian cell membranes, leaving human tissues unaffected.
9. “Everything about these findings is supercool,” says Jessica Brinkworth, an evolutionary immunologist at the University of Illinois at Urbana-Champaign who was not involved in the study. Many infections start in these epithelial cells, and understanding how they fight back is crucial to developing future treatments, she says.
10. “The really interesting finding is how the APOL3 is able to distinguish between bacterial membranes and host membranes,” she says. That evolution found such an elegant way to control this powerful tool “is a beautiful thing.”

## **ARTICLE NO. 3**

### **First map of proteins in tumour cells pinpoints cancer therapy targets**

HEALTH 30 September 2021

1. The first ever map of how proteins interact in cancer highlights previously overlooked mutations that could be targeted for therapy.
2. Trey Ideker at University of California, San Diego, and his colleagues devised a map which looked at how several dozen common cancer proteins interact in breast cancer and in head and neck cancer.
3. “Cancer genes do not act alone,” says Ideker. “It's just like the parts of any machine – they each affect each other.”

4. Protein interaction maps involve cataloguing all the various ways proteins interact with each other in a biological system. In this case, the team picked 61 commonly mutated proteins in the two cancers and determined how they each interacted with each other and with the hundreds of other proteins in cancer tumours.
5. “We are looking for communities of proteins that are under pressure to mutate during cancer,” says Ideker.
6. For head and neck cancer, the team found 771 protein interactions involving around 650 proteins and 84 per cent of the interactions had never been reported before. If these interactions are critical for tumour growth, future oncology drugs that target and disrupt them could slow the growth of cancers.
7. Meanwhile, looking at the data overall, the team discovered a mutation to the protein collagen that had been overlooked by previous research.
8. “This is the big advance of the study,” says Ideker. “There's been anecdotes of finding cancer mutations this way before, but no one has systematically shown this.”
9. Ideker hopes the method will be used in other cancers and that others will join in the quest to map even more protein interactions in cancer. Not only will this help find new drugs, he says, but it will also help scientists find new cancer biomarkers – which will help doctors devise more personalised treatments.
10. “By identifying which proteins often work together in specific cancers and helping us understand how mutations affect such protein interactions, this research helps us achieve a better understanding of cancer development and progression,” says Chris Bakal at the Institute of Cancer Research in the UK.
11. But he notes that the researchers only looked at a small number of proteins and therefore the study's primary value is highlighting how protein interactions can be best mapped in cancer in the first place.
12. “A lot more work will be needed,” he says.

## 13.2 Appendix 2

List of articles examined for the occurrence of the Problem-Solution pattern

Table 9: Details of the articles examined for the occurrence of the Problem-Solution pattern

The Number of the article	The Name of the article	The Source	Occurrence of P-S pattern
T1	Why do not two identical twins have the same fingerprints? New study provides clue	Science	No
T2	China is flying blind as the pandemic rages	Science	Yes
T3	Glassy eyes may help young crustaceans hide from predators in plain sight	ScienceNews	No
T4	Why male giraffes drink potential mates' pee	ScienceNews	No
T5	50 years ago, scientists discovered the Great Pacific Garbage Patch	ScienceNews	No
T6	Tiger sharks helped discover the world's largest seagrass prairie	ScienceNews	No
T7	Half of All Mountain Glaciers Are Expected to Disappear by 2100	ScientificAmerican	No
T8	The pandemic prematurely aged teens' brains	Science News Explorer	No
T9	Green energy is cheaper than fossil fuels, a new study finds	Science News Explorer	Yes

T10	The Great Atlantic Sargassum Belt is carrying a massive bloom of brown seaweed toward Florida and the Caribbean	The Conversation	No
T11	Innies, outies and omphalophobia: 7 navel-gazing questions about belly buttons answered	The Conversation	No
T12	Sabertooth cat skull newly discovered in Iowa reveals details about this Ice Age predator	The Conversation	No
T13	An oracle predicts regulators of cell identity	Nature	No
T14	A deep artificial neural network powered by enzymes	Nature	Yes
T15	The brain's encoding of warm and cool	Nature	No
T16	Turkey–Syria earthquake reveals building danger	Nature	No
T17	Indoor air pollution kills and science needs to step up	Nature	No
T18	Global pandemic treaty: what we must learn from climate-change errors	Nature	Yes
T19	Even after COVID, the world's vaccine strategy is failing	Nature	Yes
T20	How quickly does COVID immunity fade? What scientists know	Nature	Yes

Table 10: Internet sources of articles examined for the occurrence of the Problem-Solution pattern

Number of the article	Source of the article	Name of the author of the article
T1	<a href="https://www.science.org/content/article/why-don-t-identical-twins-have-same-fingerprints-new-study-provides-clues">https://www.science.org/content/article/why-don-t-identical-twins-have-same-fingerprints-new-study-provides-clues</a>	Claire Usher
T2	<a href="https://www.science.org/doi/epdf/10.1126/science.adg5286">https://www.science.org/doi/epdf/10.1126/science.adg5286</a>	Dennis Normile
T3	<a href="https://www.sciencenews.org/article/glassy-eyes-young-crustaceans-predators">https://www.sciencenews.org/article/glassy-eyes-young-crustaceans-predators</a>	Erin Garcia de Jesús
T4	<a href="https://www.sciencenews.org/article/why-male-giraffes-drink-female-mate-pee">https://www.sciencenews.org/article/why-male-giraffes-drink-female-mate-pee</a>	Erin Garcia de Jesús
T5	<a href="https://www.sciencenews.org/article/50-years-ago-ocean-plastic-great-pacific-garbage-patch">https://www.sciencenews.org/article/50-years-ago-ocean-plastic-great-pacific-garbage-patch</a>	Demian Perry
T6	<a href="https://www.sciencenews.org/article/tiger-sharks-discover-worlds-largest-seagrass-prairie">https://www.sciencenews.org/article/tiger-sharks-discover-worlds-largest-seagrass-prairie</a>	Nikk Ogasa
T7	<a href="https://www.scientificamerican.com/article/half-of-all-mountain-glaciers-are-expected-to-disappear-by-2100/">https://www.scientificamerican.com/article/half-of-all-mountain-glaciers-are-expected-to-disappear-by-2100/</a>	Chelsea Harvey
T8	<a href="https://www.snexplores.org/article/covid-pandemic-premature-aging-teen-brains">https://www.snexplores.org/article/covid-pandemic-premature-aging-teen-brains</a>	Freda Kreier

T9	<a href="https://www.snexplores.org/article/green-energy-cheaper-than-fossil-fuels-climate">https://www.snexplores.org/article/green-energy-cheaper-than-fossil-fuels-climate</a>	Laura Allen
T10	<a href="https://theconversation.com/the-great-atlantic-sargassum-belt-is-carrying-a-massive-bloom-of-brown-seaweed-toward-florida-and-the-caribbean-202570">https://theconversation.com/the-great-atlantic-sargassum-belt-is-carrying-a-massive-bloom-of-brown-seaweed-toward-florida-and-the-caribbean-202570</a>	Stephen P. Leatherman
T11	<a href="https://theconversation.com/innies-outies-and-omphalophobia-7-navel-gazing-questions-about-belly-buttons-answered-195162">https://theconversation.com/innies-outies-and-omphalophobia-7-navel-gazing-questions-about-belly-buttons-answered-195162</a>	Sarah Leupen
T12	<a href="https://theconversation.com/sabertooth-cat-skull-newly-discovered-in-iowa-reveals-details-about-this-ice-age-predator-201628">https://theconversation.com/sabertooth-cat-skull-newly-discovered-in-iowa-reveals-details-about-this-ice-age-predator-201628</a>	Matthew G. Hill
T13	<a href="https://www.nature.com/articles/d41586-023-00251-6">https://www.nature.com/articles/d41586-023-00251-6</a>	Jeffrey A. Farrell
T14	<a href="https://www.nature.com/articles/d41586-022-03150-4">https://www.nature.com/articles/d41586-022-03150-4</a>	Magdalena Helmer
T15	<a href="https://www.nature.com/articles/d41586-023-00158-2">https://www.nature.com/articles/d41586-023-00158-2</a>	Unknown
T16	<a href="https://www.nature.com/articles/d41586-023-00364-y">https://www.nature.com/articles/d41586-023-00364-y</a>	Miryam Naddaf
T17	<a href="https://www.nature.com/articles/d41586-023-00338-0">https://www.nature.com/articles/d41586-023-00338-0</a>	Unknown
T18	<a href="https://www.nature.com/articles/d41586-023-00339-z">https://www.nature.com/articles/d41586-023-00339-z</a>	Unknown
T19	<a href="https://www.nature.com/articles/d41586-022-04423-8">https://www.nature.com/articles/d41586-022-04423-8</a>	Seth Berkley
T20	<a href="https://www.nature.com/articles/d41586-023-00124-y">https://www.nature.com/articles/d41586-023-00124-y</a>	Cassandra Willyard

### The Texts of Articles 1-20 examined for occurrence of Problem-Solution pattern

Text Number 1.

#### **Why do not two identical twins have the same fingerprints? New study provides clue**

#### **Ways of chemical signals spread across developing fingers, creating one-of-a-kind patterns of ridges**

9 FEB 2023

No two fingerprints are exactly the same. That's what makes them so useful for police and smartphones to positively identify people. Previous research has shown genes play a role in how the complex pattern of grooves and bumps on our fingertips form, so why don't identical twins have identical fingerprints? A new study reveals that three families of signaling molecules—along with slight differences in the shape of the finger and the timing of skin growth—all interact to create our unique variations.

“It is a great example of how minor fluctuations ... can generate endless variations in a pattern,” says Roel Nusse, a developmental biologist at Stanford Medicine who was not involved in the research.

The uneven surfaces of fingers improve grip and are found in humans and climbing species, such as koalas and chimpanzees. They also help us feel the difference between textures. Fingerprints form relatively early in fetal development, starting around the 13th week of gestation with the formation of indentations in the fingertips called primary ridges. These ridges develop into three main patterns: symmetrical, circular arrangements called “whorls”; longer, curved patterns called “loops”; and triangular ridges known as “arches.” Scientists have identified several genes that influence which patterns end up in a person's fingerprint, but the biochemical mechanisms that drive the formation of these ridges have proved elusive.

To shed light on this mystery, Denis Headon, a geneticist at the University of Edinburgh, and colleagues sequenced the RNA inside the nuclei of human embryonic fingertip cells to identify the genes being expressed during development. (The embryonic tissue came from people who terminated their pregnancies in the United Kingdom.) Those genes unearthed three different signaling pathways—families of proteins that carry instructions between cells—that each play a role in directing the growth of skin on the fingertips. Genes involved in two of these signaling pathways, known as WNT and BMP, are expressed in alternating stripes of cells in the developing fingertips, creating what will ultimately become the grooves and bumps of the fingerprint. A third factor, EDAR, is expressed alongside WNT in the developing grooves.

Mice also have simple ridge patterns on their digits. When researchers artificially suppressed the signaling pathways in mice, they found the WNT and BMP signals work in opposing ways. WNT appears to stimulate

cell growth to create raised bumps in the outer layer of the skin, whereas BMP suppresses cell growth to form grooves. EDAR signals help determine the size and spacing of the ridges. For example, when researchers knocked out the WNT pathway, their digits formed no ridges at all, whereas knocking out the BMP pathway made the ridges wider. And in mice carrying a mutation that silenced EDAR activity, a polka dot pattern of ridges grew on their digits rather than stripes.

Ultimately, these three signaling pathways work together to control the formation of primary ridges that grow into the corrugated structure of fingerprints, the team reports this week in *Cell*.

The opposing relationship between WNT and BMP in human fingertips is characteristic of Turing patterns—in which different, overlapping chemical activities give rise to complex patterns—which are widespread in nature and give rise to the stripes and spots seen in animal fur and tropical fish skin. “The individual uniqueness [of fingerprints] comes from minute elements of the pattern,” Headon says, such as long ridges that stop, ridges that split in two, or short ridges called islands. “Turing patterns readily produce this type of fine-scale pattern,” he explains.

But the overall shape of the fingerprint pattern—whether the fingerprint ends up as a whorl, a loop, or an arch—depends on the anatomy of the finger and the exact timing of ridge formation. In the human embryonic tissues, the researchers found primary ridges start to form in up to three locations: the center of the fetal finger's soft raised pad, the end of the finger under the nail, and the crease at the joint where the finger bends. From these three sites, the ridges spread out across the fingertip like “waves ... each ridge serving to define the position of the next one out,” Headon says. The finger's anatomy helps direct the pattern of finger cell growth. If the pads are large and symmetrical and ridges begin to form there early, they tend to produce a whorl. If the pads are longer and asymmetrical, they result in a loop. If ridges simply fail to form on the pad, or if they begin to form there late in development, then the ridges from the crease and the fingernail will meet in the middle, producing an arch.

The researchers also found that the same chemical signals—WNT, BMP, and EDAR—cause cells elsewhere in the body to develop into hair follicles. But our fingertips remain hair-free because the follicle formation on the palms of our hands halts early. This suggests different structures in the skin all start down the same early developmental path before diverging into specialized roles. “It may be that all of the structures formed by our largest organ, the skin—including hair, glands, fingerprints—are all fundamentally generated by the same mechanism,” Nusse says.

Text Number 2.

### **China is flying blind as pandemic rages**

#### **Official death tolls are impossibly low, and some worry new variants may escape detection**

3 JAN 2023

Most scientists believe China's decision to end its zero-COVID policy was long overdue. But now they have a new worry: that the country is collecting and sharing far too little data about the rough transition to a new coexistence with the virus.

China abruptly dropped virtually all controls a month ago, after protests, a sagging economy, and the extreme transmissibility of the virus' latest variants made clinging to zero COVID untenable. Now, “SARS-CoV-2 has an open goal in front of it: a population with very low levels of standing immunity,” says evolutionary biologist Edward Holmes of the University of Sydney. But how the epidemic is unfolding is a mystery because the country has practically stopped collecting basic epidemiological data.

Models that predicted a massive wave of infection and death if China ended zero COVID appear to have been correct. Press reports and social media posts have shown intensive care units stretched beyond capacity, with crowds of patients in wheelchairs and on gurneys in hallways. Doctors and nurses are reportedly working while sick. Crematoriums are overwhelmed. But China's official COVID-19 death toll is widely considered laughably low. And some scientists worry a genomic monitoring plan unveiled last month doesn't have the power to detect new SARS-CoV-2 variants arising as the virus works its way through one-fifth of the world population.

Earlier in the pandemic China's daily counts of COVID-19 cases and deaths, based partly on its exhaustive testing programs, were generally believed to be accurate. Now, they are anyone's guess. Patients with mild symptoms are not encouraged to get tested, let alone those who are asymptomatic. People testing positive at home are not asked to report their results.

The China Center for Disease Control and Prevention (China CDC) put the number of confirmed cases the last week of December 2022 at more than 35,000—a fraction of the official number in the United States. But leaked notes from an internal meeting suggest a very different reality: The agency was told that almost 250 million people in China—roughly 18% of the population—may have caught COVID-19 in the first 20 days of December. Some experts said the number is implausibly large, but Yanzhong Huang, a global health specialist at the Council on Foreign Relations, a U.S. think tank, says it's “not unreasonable,” given credible reports that 80% of Beijing residents have been infected by now.

As to the death toll, China's reporting had long been inconsistent, Huang says, with some regions reporting all fatalities in which SARS-CoV-2 was a factor, as most countries do, and others excluding people who died from other conditions, such as heart attacks, even if they had COVID-19. In early December, China's government decided the narrower definition should be used nationwide.

Even then, the official count is astonishingly low: just eight deaths for the entire last week of December, which is “not matching media reports and what is being seen on social media,” says Louise Blair, who tracks China's COVID-19 outbreak for Airfinity, a London-based health analytics firm that estimates about 9000 people were dying of COVID-19–related causes every day in late December. Also missing are data on case fatality rates, the average number of new infections stemming from each case, and hospital and intensive care admissions. “These are critical data” that would help health authorities get a handle on the surge and further the world's understanding of the pandemic, says Xi Chen, a public health scientist at the Yale School of Public Health.

A major worry is that the wave will breed a new and even more troublesome SARS-CoV-2 variant. “It's possible that something might be emerging, because there is such a big population in China,” says George Gao, who in July 2022 stepped down as head of China CDC but is now helping track circulating variants. But, he told *Science*, “There are no novel mutants—yet.” At a 20 December press briefing, Xu Wenbo, head of the National Institute for Viral Disease Control and Prevention, explained that the BA.5.2 and BF.7 Omicron subvariants, which are now causing most infections globally, are also dominant in China. BQ.1 and XBB, which have recently been spreading in Europe and North America, have turned up in limited numbers in several provinces.

Experts are split on whether China is looking closely enough. Three designated sentinel hospitals in different cities in each of China's 31 provinces, municipalities, and regions are supposed to sequence and analyze samples from 15 outpatients, 10 severe cases, and all deaths every week. “I'm afraid [that] sample size is too small,” Chen says. A stronger plan would consider province size and population density, instead of picking three cities in each, and adopt other sampling approaches, says Elizaveta Semenova, an epidemiologist at the University of Oxford. Semenova is a co-author of a study of how well 189 countries have detected new variants, published in November 2022. It concluded that effective surveillance requires sequencing about 0.5% of cases, with a turnaround time of less than 21 days. China's plan is unlikely to come close to that percentage.

But Gao and others say the program will pick up new variants in a timely way. If the surveillance plan gets up to speed, it will sequence 2000 to 3000 genomes per week, a level that “should be able to detect [new variants] and their transmission trends,” says Leo Poon, a virologist at the University of Hong Kong who has helped track variants there. Poon notes that China is sharing data from the outbreak on GISAID, the world's largest database of SARS-CoV-2 sequences.

In addition to China CDC, research groups at more than 30 hospitals and universities are also tracking SARS-CoV-2 variants, says a Chinese epidemiologist who asked not to be identified. These groups “will report immediately if a dangerous variant emerges,” the source says.

Still, the lack of reliable data is already undermining faith in China's handling of the outbreak. A dozen countries, including the United States and France, have announced they will require pre- or postflight tests on air travelers from China. Huang says that is unlikely to keep new variants out. The goal should be to convince the Chinese to be more forthcoming about what's happening on the ground—and for that, “quiet diplomacy may work better than travel restrictions,” he says.

Text Number 3.

### **Glassy eyes may help young crustaceans hide from predators in plain sight**

#### **Nanospheres in the organs reflect light that matches the color of surrounding water**

FEBRUARY 16, 2023 AT 2:00 PM

Fledgling crustaceans have eyes like the sea, a peculiarity that could help them hide from predators.

Young shrimp, crab or lobster larvae already rock nearly translucent bodies to stay out of view. But dark eye pigments essential for vision pose the risk of exposing the animals anyway.

Some see-through ocean animals rely on mirrored irises or minuscule eyes to avoid detection. Young shrimp and prawns, on the other hand, camouflage their dark pigments behind light-reflecting glass made of tiny, crystalline spheres, researchers report in the Feb. 17 *Science*.

Variations in the size and placement of the orbs allow the crustaceans' eyes to shine light that precisely matches the color of the surrounding water, possibly rendering them invisible to predators on the hunt for a meal.

Technologies that mimic the nanospheres' structure could one day inspire more efficient solar energy or bio-friendly paints, the scientists say.



“I’ve often wondered what’s going on with [these animals] eyeshine,” says evolutionary biologist Heather Bracken-Grissom of Florida International University in Miami, who was not involved in the study. She and colleagues often collect crustaceans from the deep sea, giving them nicknames like “blue-eyed arthropod” or “green-eyed, weird-looking shrimp” because the creatures don’t resemble their adult forms. Now, she says, that eye color makes sense.

In the study, chemist Keshet Shavit and colleagues used an electron microscope to peer into the eyes of lab-raised and wild crustaceans. Inside shrimp and prawn eyes, the team found crystalline nanospheres made of isoxanthopterin, a molecule that reflects light.

The spheres are a bit like disco balls, with highly reflective surfaces pointing outward, says study coauthor Benjamin Palmer, a chemist at Ben-Gurion University of the Negev in Beer-Sheva, Israel. Each sphere is made of thin, isoxanthopterin plates that stick together to form balls that range in size from around 250 to 400 nanometers in diameter.

These balls are arranged in clusters at the base of protein-dense cones that focus light on the animal’s light-sensing nerves, and form a protective cover over the pigmented cells. But crustacean larvae can still see because there are small holes in the glass, Palmer says. “It’s basically allowing light to go down to the retina on some specific angles, but on other angles, it’s reflecting light back.”

The size and order of the spheres seem to influence the color of the reflected light, the team’s observations and computer simulations show.

“The correlation between the particle size and the eyeshine color is beyond amazing,” says Shavit, also at Ben-Gurion University. Nanosphere size appears to help the animals’ eyes match the color of their native habitat, helping the critters blend into the background.

Blue-eyed shrimp that inhabit the Gulf of Aqaba’s clear blue waters off the coast of Israel, for instance, have spheres that are approximately 250 to 325 nanometers in diameter. The 400-nanometer-wide spheres of a freshwater prawn (*Macrobrachium rosenbergii*) glitter yellow-green, mimicking muddy waters found in the salty estuaries where they live.

The color reflected from the eyes of some crustacean larvae (top) is linked to the size of isoxanthopterin nanospheres (bottom) that make up a glass reflector in the eyes. Orbs with smaller diameters reflect blue or silvery light, while larger ones appear green or yellow. The eyes of a freshwater prawn (*Macrobrachium rosenbergii*) can even change color from green (DA) when the animal has been in the dark overnight to yellow (LA) after being in the sunlight for several hours.

The prawn’s eyes also seem to be able to reflect different colors in different environments. Individuals exposed to sunlight for four hours in the lab had silvery yellow eyes, possibly a result of nanospheres arranged in a disorganized jumble. But individuals left in the dark overnight had green eyes. Their nanospheres are arranged in layers — though the orbs within each layer are still disorganized, Palmer says.

Such adaptable eyes could help larvae move undetected through different parts of the ocean as changing light levels alter the color of the water, Bracken-Grissom says. At night, young crustaceans migrate to shallow waters to feed and dive back down when the sun rises. “If they are in fact using it as a form of camouflage, it would be an ingenious way to camouflage themselves as they move through these different light environments.”

Text Number 4.

#### **Why male giraffes drink potential mates' pee**

##### **Male giraffes stick their tongues in a female's urine stream to check for pheromones**

FEBRUARY 14, 2023 AT 10:00 AM

A female giraffe has a great Valentine's Day gift for potential mates: urine.

Distinctive anatomy helps male giraffes get a taste for whether a female is ready to mate, animal behaviorists Lynette and Benjamin Hart report January 19 in *Animals*. A pheromone-detecting organ in giraffes has a stronger connection to the mouth than the nose, the researchers found. That’s why males scope out which females to mate with by sticking their tongues in a urine stream.

Animals such as male gazelles will lick fresh urine on the ground to track if females are ready to mate. But giraffes’ long necks and heavy heads make bending over to investigate urine on the ground an unstable and vulnerable position, says Lynette Hart, of the University of California, Davis.

The researchers observed giraffes (*Giraffa giraffa angolensis*) in Etosha National Park in Namibia in 1994, 2002 and 2004. Bull giraffes nudged or kicked the female to ask her to pee. If she was a willing participant, she urinated for a few seconds, while the male took a sip. Then the male curled his lip and inhaled with his mouth, a behavior called a flehmen response, to pull the female’s scent into two openings on the roof of the mouth. From the mouth, the scent travels to the vomeronasal organ, or VNO, which detects pheromones.

The Harts say they never saw a giraffe investigate urine on the ground.

Unlike many other mammals, giraffes have a stronger oral connection — via a duct — to the VNO, than a nasal one, examinations of preserved giraffe specimens showed. One possible explanation for the difference could be that a VNO-nose link helps animals that breed at specific times of the year detect seasonal plants, says Benjamin Hart, a veterinarian also at the University of California, Davis. But giraffes can mate any time of year, so the nasal connection may not matter as much.

Text Number 5.

### **50 years ago, scientists discovered the Great Pacific Garbage Patch**

FEBRUARY 16, 2023 AT 9:00 AM

Scientists on an oceanographic voyage in the Central North Pacific last August became startled about the number of manmade objects littering the ocean surface. [Far from civilization and shipping lanes], they recorded 53 manmade objects in 8.2 hours of viewing. More than half were plastic. They go on to compute that there are between 5 million and 35 million plastic bottles adrift in the North Pacific.

The Great Pacific Garbage Patch is larger now than it was in 1973, containing an estimated 1.8 trillion pieces of plastic within an area twice the size of Texas (SN Online: 3/22/18). In recent years, marine biologists have started seeing evidence that garbage is disrupting ocean ecosystems. For instance, large pieces of trash have helped species cross into new territories (SN: 10/28/17, p. 32). But an even greater threat may lurk beneath the waves. Tiny bits of plastic concentrate hundreds of meters deep where they can be eaten by filter feeders and potentially make their way into the guts of larger predators (SN: 7/6/19 & 7/20/19, p. 5).

Text Number 6.

### **Tiger sharks helped discover the world's largest seagrass prairie**

#### **Scientists equipped sharks with cameras to map a carbon reservoir half the size of Florida**

NOVEMBER 16, 2022 AT 9:00 AM

Scientists have teamed up with tiger sharks to uncover the largest expanse of seagrasses on Earth.

A massive survey of the Bahamas Banks — a cluster of underwater plateaus surrounding the Bahama archipelago — reveals 92,000 square kilometers of seagrasses, marine biologist Oliver Shipley and colleagues report November 1 in *Nature Communications*. That area is roughly equivalent to half the size of Florida.

The finding expands the estimated global area covered by seagrasses by 41 percent — a potential boon for Earth's climate, says Shipley, of the Herndon, Va.-based ocean conservation nonprofit Beneath The Waves.

Seagrasses can sequester carbon for millennia at rates 35 times faster than tropical rainforests. The newly mapped sea prairie may store 630 million metric tons of carbon, or about a quarter of the carbon trapped by seagrasses worldwide, the team estimates.

Mapping that much seagrass was a colossal task, Shipley says. Guided by previous satellite observations, he and colleagues dove into the sparkling blue waters 2,542 times to survey the meadows up close. The team also recruited eight tiger sharks to aid their efforts. Similar to lions that stalk zebra through tall grasses on the African savanna, the sharks patrol fields of wavy seagrasses for grazing animals to eat (SN: 1/29/18; SN: 5/21/19, SN: 2/16/17).

Text Number 7.

### **Half of All Mountain Glaciers Are Expected to Disappear by 2100**

#### **Even if the world meets its most ambitious climate targets, about half of all mountain glaciers will melt away by the end of the century**

January 9, 2023

Nearly half the world's mountain glaciers are expected to disappear by the end of this century, even if the world meets its most ambitious climate goals.

A new study found that 1.5 degrees Celsius of global warming would wipe out around 104,000 glaciers and raise global sea levels by about 3.5 inches in the process.

And that's a best-case scenario.

Keeping global temperatures within 1.5 C of their preindustrial levels is the most aggressive target under the Paris climate agreement. Yet that threshold is swiftly approaching, and the world could overshoot it within a decade or so. Climate pledges currently in place would result in global warming of more than 2 C.

That could be devastating for mountain glaciers. The new study, published Thursday in the journal *Science*, finds that every fraction of a degree would cause a little more ice to melt.

At 1.5 C, the world would lose half its mountain glaciers. That includes many smaller glaciers, containing about a quarter of the planet's mountain ice.

At 2 C, close to 60 percent of all glaciers would disappear. At 3 C, more than 70 percent of them would vanish, and sea levels would rise by nearly 5 inches.

It's a dire warning about the precarious future of the world's frozen places. But it's also a cautious message of hope. Every little bit of future warming that the world can prevent will save a little bit of ice.

The new study examines all of Earth's glaciers outside of the Greenland and Antarctic ice sheets. That includes mainly mountain ice stretching across Alaska and Canada, the European Alps, High Mountain Asia, South America, and New Zealand.

The research incorporates many of the latest advancements in glacier modeling, allowing it to make some of the most accurate estimates yet about the ways the world's ice could respond to future warming. It accounts for complex factors, like the way the oceans can speed up the melting of seaside glaciers.

These frozen places are smaller, and often receive less attention, than the vast Greenland and Antarctic ice sheets. Yet they have enormous cultural, environmental, economic and hydrological importance.

Mountain glaciers are often vital sources of fresh water for downstream communities. They attract tourists and winter sports enthusiasts. Some have immense cultural or religious significance for Indigenous communities.

Melting glaciers also make significant contributions to the rising oceans, which affect islands and coastal communities all over the world. Scientists estimate that glaciers outside of Greenland and Antarctica are currently responsible for about 21 percent of global sea-level rise.

The new study finds that some regions of the world are more sensitive than others—particularly mountain regions with smaller glaciers in subtropical parts of the world.

At 3 C of warming, the research finds, much of the icy parts of Europe, northern Asia, New Zealand, western Canada and the U.S. would lose nearly all of their glaciers. Even at 2 C, much of the ice in these places would disappear.

Still, the study stresses that preventing as much future warming as possible makes a big difference.

In a [comment](#) on the new research, also published Thursday in *Science*, scientists Guðfinna Aðalgeirsdóttir and Timothy James note that the study achieves both a stark warning and an optimistic message at once.

“Although it is too late to avoid losing many glaciers, any effort to limit global mean temperature rise will have a direct effect on reducing how many glaciers will be lost,” they wrote.

These findings, they added, “can provide a key motivational message that is needed in this critical decade for climate action.”

Text Number 8.

### **The pandemic prematurely aged teens' brains**

#### **A small study showed certain structural changes that appeared three to four years early**

February 10, 2023 at 6:30 am

The COVID-19 pandemic may have aged teens' brains beyond their years.

The past few years have been rough on students. They've endured online schooling, social isolation, family hardships and news of a mounting global death toll. For teens, the virus and its many social side effects arrived during a crucial window in their brain's maturation.

Now, a small study finds that the brains of teens who have been living through all this look about three years older than expected. This research is the first to look for impacts of the pandemic on brain aging. The new findings emerged by comparing brain scans taken from kids before the pandemic to those taken from different teens after 2020.

The new data show that for teens, “the pandemic hasn't been bad just in terms of mental health,” says Ian Gotlib. “It seems to have altered their brains as well.” Gotlib is a neuroscientist who led the study. He works at Stanford University in California. His team shared its findings December 1 in *Biological Psychiatry: Global Open Science*.

Beatriz Luna did not take part in the new study. But as a developmental neuroscientist, she's familiar with this period of brain changes. Luna works at the University of Pittsburgh in Pennsylvania. She says the new study did not link the brain changes it found to poor mental health during the pandemic. (In fact, it didn't explore those questions.) But, she adds, “we know there is a relationship between adversity and the brain.” Our mind will try “to adapt to what it's been given,” she notes. To her, the new work “is a very important study that sets the ball rolling for us to look at this.”

Ongoing study was poised to see 'striking' changes

The roots of this study date back nearly a decade. Back then, Gotlib helped launch a project in California's Bay Area. Its focus was depression in adolescents. As part of that study, the researchers did MRI scans of kids' brains.

Lockdown orders in the spring of 2020 forced the researchers to halt this work. When they restarted a year later, Gotlib worried that stress from the pandemic threatened to alter his group's results.

Kids making their way back to the study were now reporting higher rates of anxiety and depression than their peers had before 2020. So, the team decided to compare brain scans captured before the start of the pandemic to scans taken between October 2020 and March 2022.

The researchers looked at differences in 64 scans from each group. Those groups had about the same mix of boys and girls. The average age was around 16.

And the results were “striking,” Gotlib now reports.

Adolescent brains undergo a remodeling process as kids mature into adults. Part of this remodeling thickens two brain regions. One is the hippocampus. It's involved in memory and concentration. The other, the amygdala (Uh-MIG-duh-luh), regulates how we process emotions. At the same time, the outer layer of the brain gets thinner. Known as the cortex, it's involved in many cognitive functions. Those include attention, memory, problem solving and emotional regulation.

The brain scans revealed that during the pandemic, this structural maturation had sped up in the brains of teens. Their brains appeared three to four years older than did same-age teens scanned before the start of the pandemic.

Exactly what about the pandemic caused this is not clear. But “this study shows that the pandemic has had a material impact” on how the brains of teens mature, says Joan Luby in St. Louis, Mo. A child psychiatrist, she wasn't involved in the research. She works at the Washington University School of Medicine.

A response to stress?

Gotlib suspects stress is to blame. Mental health plummeted among teens during the pandemic. Previous studies have shown that violence or negligence can speed up a child's brain maturation. So, Gotlib thinks, “it's not a big leap” to think that stress during the pandemic could also have shaped brain development in the kids studied here.

But what caused the brain changes and what those changes mean are still not known.

Rudolf Uher is a neuroscientist at Dalhousie University. It's in Halifax, Canada. More screen time due to online schooling could be at play here, he says. And, he cautions, future research may not confirm this study's findings.

For now, it's unclear whether faster brain aging affects teen health now — or perhaps even later in life. While no one can know the impacts for sure, Luby notes that “if your brain is prematurely aging, that's generally not a good thing.”

What is clear, Gotlib says, is that access to mental health services will be crucial to helping children who have lived through the pandemic. “These kids are hurting,” he says. “We need to take that seriously and make sure we're offering them treatment.”

times, these feelings seem to be triggered by nothing; they can appear out of nowhere.

Text Number 9.

### **Green energy is cheaper than fossil fuels, a new study finds**

#### **Making a fast switch to cleaner renewable power could save trillions of dollars by 2050**

January 20, 2023 at 6:30 am

On September 15, there was a giant *ka-BOOM!* And with that, Portland General Electric dynamited Oregon's last coal-fired power plant into rubble. The company also opened a new power plant on September 28 — what it's calling the nation's first large-scale wind and solar generating facility. (Batteries nearby will store the electricity until it's needed).

Both the old plant and the new one were tasked with generating electricity. But the coal-powered one relied on burning fossil fuels. That spewed carbon dioxide, or CO<sub>2</sub>, into the atmosphere, which contributes to climate change. For years, economists have said that a switch to cleaner power — such as wind or solar — would be very costly. Such a switch is referred to as “decarbonization.”

Explainer: What is decarbonization?

But making that switch globally should actually save money, researchers now report. Decarbonizing our energy use could save trillions of dollars over the next 20 years or so. That's the conclusion of a September 13 paper in *Joule*.

Doyme Farmer is a scientist in England who studies complex systems. He works at the University of Oxford. “We can do a green-energy transition that replaces fossil fuels with renewables like solar and wind,” he says of his team's findings. “It's not just cheap, it will make money.” That, he says, should bring energy prices down.

This might sound surprising. “People think it will cost a lot of money to throw away our whole energy system and replace it,” he says. “But we’re always doing this.” For example, gas stations are replaced about every 25 years. If between now and 2050 we replace each gas station with an electric-vehicle charging station, we’ll reach the climate goal set by many governments.

The Wheatridge Renewable Energy Facilities in eastern Oregon include 300 megawatts of wind energy production, 50 megawatts of solar energy and 30 megawatts of battery storage.

NEXTERA ENERGY  
RESOURCES  
The role of modeling

Those estimates don’t come from crystal-ball gazing. Farmer’s team has been using big energy simulations known as computer models. No one can know with certainty how much we will pay for energy in the future. That’s why scientists turn to models that can predict this. Their calculations help communities decide what types of energy they should invest in.

Economists have long used such models to predict future energy costs from fossil fuels. Doing this for renewables has proven more challenging. “Fossil fuels cost about the same as they did 100 years ago” once we adjust for inflation, Farmer says. That’s because they’re an old, established technology. In contrast, “the price of solar has dropped by a factor of 5,000 since it was first used in 1958.” In fact, he says, the cost of all renewables, including wind energy and battery storage, has been coming down every year. So, predictions of their future costs can be much trickier.

Explainer: CO<sub>2</sub> and other greenhouse gases

Farmer was part of a team that in 2010 predicted solar energy would be cheaper than coal-fired electricity by 2020. At the time they wrote this in the journal *Nature*, people didn’t believe them. They called it “crazy,” he recalls. His group had observed the trends in solar energy costs and assumed they would keep going for the next decade or longer.

And this proved true.

Many economists wrongly predicted the cost of renewables. Why? Farmer says they put assumptions into their computer models that limited how cheap and plentiful clean power could become. But they did not have evidence to support those limits. Data from the past 20 years, he says, now suggest that solar and wind will soon take over in generating electricity. Today, harnessing those renewables is typically cheaper than building new fossil-fueled plants.

Farmer’s team spent a lot of time gathering data on how the cost of renewable energy has dropped as its use has increased. With these data, they created a model to predict future costs. Their model put no limits on how much or little energy could cost.

The model is based on probability — the likelihood that something will happen. To test if this model was accurate, the researchers applied it to past conditions. For example, they set it up as if it were the year 2000 and had it predict what solar power would cost in 2010. They already had data for that year, so they could compare the prediction to what actually happened. They did this many times using different years to see if the model worked. And it did.

Predictions, of course, offer no guarantees. Farmer’s team based its predictions on the assumption that people will continue to install solar, wind and battery storage at the same pace they’ve been doing for the past 20 years. If that occurs, we’ll have a fast transition to clean power. And over that time, they estimate it should save between \$5 trillion and \$15 trillion dollars.

The switch to electric

Another aspect of this clean-energy transition will happen inside buildings. Many homes and businesses burn natural gas — a fossil fuel — for heating and cooking. Natural gas emits greenhouse gases, as well as other pollutants that can harm health. Gas appliances can be swapped out for electric versions and tap into clean electricity.

Panama Bartholomy is the director of the Building Decarbonization Coalition. His group, based in Petaluma, Calif., focuses on limiting gas emissions indoors. “We assume the [electric] grid is getting cleaner over time, which it is. So, we want more and more of our heating to come from electricity.”

It’s much easier to make these types of changes when governments recommend them, says Beth Miller. She is an ecologist and consultant with Good Company. Based in Eugene, Ore., it helps companies and communities reduce their carbon footprint. Some states are already taking steps to make these changes. On September 22, for instance, California decided it would ban the sale of gas-fired space heaters and water heaters by 2030.

Modern electric induction cooktops, like the one shown here, are more efficient than conventional electric burners and avoid the greenhouse gases that natural-gas burners emit.

After homes and businesses make the switch to electric alternatives, they will be more comfortable, says Bartholomy. They will be safer and cleaner, too, he adds. Instead of a gas furnace, an electric heat pump could both heat and cool a home. Gas heaters and stoves won’t be pumping pollution into a home’s air. And cooks will have even more control on a modern electric induction cooktop than on a gas stove, says Bartholomy.

Getting fossil fuels out of your home is probably the largest positive impact you can have for the planet, Bartholomy says. “We all need to fight for a livable climate. There is no way to meet our climate goals while still burning gas in buildings. For a livable future, we must stop burning fossil fuels.” And the bonus: It now looks like doing that should also save people a lot of money.

Text Number 10.

### **The Great Atlantic Sargassum Belt is carrying a massive bloom of brown seaweed toward Florida and the Caribbean**

Published: April 7, 2023 8.20am

An unwelcome visitor is headed for Florida and the Caribbean: huge floating mats of sargassum, or free-floating brown seaweed. Nearly every year since 2011, sargassum has inundated Caribbean, Gulf of Mexico and Florida coastlines in warm months, peaking in June and July. This brown tide rots on the beach, driving away tourists, harming local fishing industries and requiring costly cleanups.

According to scientists who monitor the formation of sargassum in the Atlantic Ocean, 2023 could produce the largest bloom ever recorded. That's bad news for destinations like Miami and Fort Lauderdale that will struggle to clean their shorelines. In 2022, Miami-Dade County spent US\$6 million to clear sargassum from just four popular beaches.

Sargassum isn't new on South Florida beaches, but its rapid increase over the past decade indicates that some new factor – likely related to human actions – is affecting when and how it forms.

In my work as a coastal scientist, I've watched these invasions become the new normal, choking beaches and turning clear blue waters golden brown. Along with other researchers, I'm trying to understand why sargassum has proliferated into this new sprawling bloom, how to deal with such massive amounts of it, and how affected countries can predict the severity of the next influx.

A biological hot spot at sea

Sargassum grows in the calm, clear waters of the Sargasso Sea – a 2 million-square-nautical-mile (5.2 million-square-kilometer) haven of biodiversity that lies east of Bermuda in the Atlantic Ocean. Rather than beaches, it's bounded by rotating ocean currents that form the North Atlantic Subtropical Gyre.

In the open ocean, islands of sargassum create a rich ecosystem that ocean explorer Sylvia Earle calls “a golden floating rainforest.” Suspended by round “berries” filled with gas, the seaweed offers food, sanctuary and breeding grounds for crabs, shrimp, whales, migratory birds and some 120 species of fish. Mats of it form the sole spawning grounds for European and American eels and habitat for some 43 other threatened or endangered species.

Sargassum also shelters sea turtle hatchlings and juvenile fish during their early life in the open ocean. Ten endemic species live nowhere else on Earth. The Sargasso is a valuable commercial fishery worth about \$100 million per year.

But in recent years, large quantities of sargassum have drifted west, forming what researchers call the Great Atlantic Sargassum Belt. As of late March 2023, the sargassum belt was about 5,000 miles (8,000 kilometers) long and 300 miles (500 miles) wide

The belt is actually a collection of island-like masses that can stretch for miles. It doesn't uniformly cover beaches when it washes up: Some areas can be relatively clear or only mildly affected. But the overall mass this year is overwhelming.

What's fertilizing huge blooms?

What can plausibly explain the sudden increase in this floating seaweed since 2011 – the first time that large aggregations of sargassum were detected from space? While climate change is warming ocean waters, and sargassum grows faster in warmer water, I believe it's more plausible that the cause is a drastic increase in agricultural activity in the Brazilian Amazon.

Scientists have shown that huge brown tides that were observed in the Gulf of Mexico in 2005 and 2011 were linked to nutrients carried down the Mississippi River. Now, intensive cattle ranching and soybean farming in the Amazon basin are sending rising levels of nitrogen and phosphorus into the Atlantic Ocean via the Amazon and Orinoco rivers. These nutrients are key ingredients in fertilizer, and also are present in animal manure.

Another major source of nutrients is dust clouds from the Sahara, which can stretch for thousands of miles across the Atlantic Ocean, carried by trade winds. These clouds contain iron, nitrogen and phosphorus from dust storms in Saharan Africa and biomass burning in central and southern Africa. As they blow across the Atlantic, they help fertilize seaweed.

A threat to sea life

Along with its devastating effects on recreational beaches in the Caribbean and South Florida, sargassum has important but less visible ecological impacts near the coast. Large floating mats of sargassum block sunlight,

which is essential for the survival of underwater grasses. These grasses stabilize the seafloor and provide food and shelter for many species of fish and invertebrates and for Florida's endangered manatees.

Coral reefs also require sunlight and clean water to survive. Reefs in Florida and the Caribbean are under many other stresses, including ocean warming and coral bleaching, so they are already highly vulnerable.

Thick masses of sargassum on beaches can make it difficult or impossible for endangered sea turtles to dig nests and lay eggs on beaches. Spring and summer, when sargassum accumulates, are prime sea turtle nesting seasons.

Taming the sargassum monster

Researchers across the Caribbean are working to find productive uses for these enormous quantities of organic material that float ashore. In South Florida, communities mainly use the seaweed as mulch, but this requires thoroughly washing it to remove the salt, either naturally via rainfall or by spraying it with fresh water. Recycling sargassum into fertilizer for use on crops is problematic because it often contains toxic heavy metals such as arsenic and cadmium.

Sargassum has become a recurring seaweed monster, but humanity is the real villain. Until nations find ways to reduce large-scale nutrient pollution, I expect that huge sargassum blooms will be a recurring presence in Florida and the Caribbean.

*This is an update of an article published Aug. 2, 2021.*

Text Number 11.

### **Innies, outies and omphalophobia: 7 navel-gazing questions about belly buttons answered**

Published: April 5, 2023 8.23am EDT

*Everyone has one, but you might not know much about it. Here biologist Sarah Leupen, who teaches human and comparative animal physiology, explains the ins and outs of belly buttons.*

1. Why do I even have a belly button?

Your belly button, or navel – clinically, your umbilicus – is the permanent scar left from where your umbilical cord connected your circulatory system, when you were a fetus, to the placenta. Fetuses don't breathe, eat or eliminate waste, so the placenta provides an exchange site for the mother to deliver oxygen and nutrients from her bloodstream to the fetus, as well as collecting its wastes to eliminate from her body.

After the baby is born, the physician or other attendant cuts the cord and clamps off the stub, which then dries and falls off after about a week, leaving the point of connection – your belly button – remaining.

If the cord is not cut, as has been the practice in some times and places and as is becoming trendy again in others, it will close off after an hour or so, then naturally detach a few days after birth. Some health care practitioners are concerned that this “lotus birth” could be an infection risk, since the umbilical cord remains attached to the placenta, which is dead tissue once out of the mother's body.

2. If it's a scar, why doesn't it disappear over time?

If you injure just the outer layers of your skin, as in a cut or burn, the scar will soon completely disappear, especially in young people. And newborns are very young people. But unlike in those situations, the umbilicus involves more tissue layers — not just the skin but the connective tissue underneath – so it makes sense it doesn't just blend in with the rest of your abdominal wall once it's healed.

What about some pretty complicated surgeries that don't leave scars? Doctors perform many operations in ways that deliberately avoid scarring, which is not nature's way. In fact, one way to minimize scarring for surgeries uses this existing scar – surgeons can take advantage of the navel as an incision site for removing your appendix or gall bladder or for weight-loss surgery.

But if you don't like the way your umbilical scar looks, plastic surgery to change its appearance, called umbilicoplasty, is possible. People sometimes take this cosmetic option after pregnancy or the removal of a piercing, or just to make an “outie” into an “innie.”

3. But why do some people have outies, anyway?

The look of your belly button is not related to the location of the clamp or where your doctor cut the cord.

Outies are simply an example of normal human variation, like the way some people have curly hair or dimples. When the tip of the umbilical cord's remnant pokes out past the skin around it, you have an outie; about 10% of people have these. Any concave navel is called an “innie” and a convex one an “outie.”

Sometimes outies can be caused by an umbilical hernia in the baby or another medical problem, but most of it is just due to what your genes encoded. You might also temporarily have an outie during late pregnancy, when the abdominal pressure from the growing fetus stretches your navel and may push it out.

4. How deep does it go?

You can probably easily probe the depth of your own navel – there are no hidden recesses there. What's under it is the same as what's under the skin of the rest of your abdomen: your abdominal muscles, to which the navel is attached by a short umbilical stalk, and the peritoneum, the membrane that lines the abdominal cavity. Under that lie your guts – that is, your intestines and other abdominal organs. If you keep following this imaginary journey back, you'll get to your spine – the belly button is usually lined up between the third and fourth lumbar vertebrae (L3 and L4).

Learn how to find your pet's belly button.

5. Do other animals have belly buttons?

Because the navel is a scar from where the umbilical cord connected the fetus to the placenta, all placental mammals have them. That includes all mammals except marsupials (like kangaroos and possums) and monotremes (like platypuses and echidnas).

Your cat or dog or guinea pig does have a belly button, but because it's a flatter scar than a person's rather than a concave one, and is covered in fur, you might have missed it.

6. Is there anything besides lint in there?

Like any concave surface, if you have aninnie, it probably gathers bits of debris occasionally. Your navel also has microbiota, just like the rest of your skin. Because it's pretty protected from soap and abrasion, a more stable and diverse bacterial community lives in your navel than elsewhere on your skin's surface.

The innovative Belly Button Biodiversity project at North Carolina State University has revealed a lot about these little friends. The researchers found over 2,000 species of bacteria in the first 60 belly buttons they investigated.

It looks like most people have a set of eight common belly button bacteria, but the project is discovering new ones all the time.

7 Why do belly buttons gross out some people?

There hasn't really been much research into why some people find belly buttons to be repulsive.

It may overlap with omphalophobia, the fear of belly buttons and touching them. There's no specific treatment beyond the therapy or anti-anxiety medications a doctor might prescribe for any other phobia.

Whatever your feelings about belly buttons, they're harmless. What's more, they're part of your evolutionary legacy as a mammal, the group of animals so invested in their offspring that they invented a way to deliver nutrients and oxygen, the mother's bread and breath, straight into their developing young. Your navel can be a reminder of that first life-sustaining care you received from another person before you were even born.

Text Number 12.

### **Sabertooth cat skull newly discovered in Iowa reveals details about this Ice Age predator**

Published: April 3, 2023 8.28am EDT

The sabertooth cat is an Ice Age icon and emblem of strength, tenacity and intelligence. These animals shared the North American landscape with other large carnivores, including short-faced bears, dire wolves and the American lion, as well as megaherbivores including mammoths, mastodons, muskoxen and long-horned bison. Then at the end of the Pleistocene, between 50,000 and 10,000 years ago, they all vanished. The only place to see them now is in the fossil record.

Carnivore fossils are extremely rare, though, in comparison to those of their prey. Prey are always more abundant than predators in a healthy ecosystem. So the probability of burial, storage and discovery of carnivore bones and teeth is therefore slim compared to those belonging to herbivores.

Scientists have a relatively small and scattered inventory of sabertooth fossils. The exception comes from Rancho La Brea in downtown Los Angeles, where over 1,000 individual sabertooths were mired in tar-seep death traps.

That's why the recent discovery of an exquisite sabertooth cat skull in southwestern Iowa is so exciting. The *Smilodon fatalis* skull was collected from late Pleistocene sand and gravel exposed along the East Nishnabotna River. My colleague, biologist David A. Easterla, and I are studying this specimen to learn more about the life history, prey selection and eventual extinction of this ancient predator.

Analysis of the world, from experts

Clues from a cranium

The animal's common name – sabertooth cat – comes from its highly distinctive, saberlike canine teeth that poke out of the mouth as much as 5 or 6 inches (13 to 15 centimeters).

Sabertooths are sexually dimorphic, with males generally larger than females. The Iowa skull is larger than those of many adult males from Rancho La Brea. Several bones of the skull have not sealed together and the



teeth are basically unworn, leading us to believe this individual was almost certainly a young male between 2 and 3 years old that was still growing.

We estimate he weighed 550 pounds (250 kilograms). That's upwards of 110 pounds (50 kilograms) greater than the average adult male African lion. Given a few years to mature and fill up loose skin, he might have tipped the scale at 650 pounds (300 kilograms).

Observations of the life cycles of modern lions and tigers suggest this sabertooth was newly independent or on the cusp of independent living.

However, whether sabertooths stuck together in groups or were loners is hotly debated. Disagreement revolves around just how much of a size difference there is between males and females. In many living animals, males are typically larger than females in male-dominated harems, as in modern lions. In the case of sabertooths, some scholars identify this pronounced sexual dimorphism between the sexes and contend these ancient cats lived in groups, akin to today's lions. Other researchers see only minimal size differences and view sabertooth cats generally as solitary predators, perhaps more like tigers and all other felines.

Whatever the case, at 2 or 3 years old the cat obviously possessed the weaponry – jaws and paws – and heft to take down large prey alone. He likely garnered experience hunting by first watching his mother locate, stalk, ambush and kill prey and defend the carcasses, then perhaps with her help, and finally, alone. His learning curve was probably a lot like lions and tigers as they mature physically and behaviorally.

Hunting for survival is high stakes. Repeated failure means death from starvation. And attacking large prey equipped with defensive gear like horns, antlers, hooves and trunks is always dangerous and sometimes lethal. For instance, a recent study of 166 modern lion skulls from Zambia revealed that 68 had healed or partially healed injuries associated with taking down prey. Put another way, 40% had survived major head trauma to hunt another day.

One saber in the Iowa skull is broken off where the canine tooth emerges from the roof of the mouth. Morphological details of the fracture edges indicate the damage happened around this animal's time of death. It's possible the break may relate to a defense wound thanks to a prey animal's well-placed hoof, antler, horn or swat. Since the stub is not worn, the encounter may have even caused the cat's death.

Additional technical analysis yields more info

A technique called stable isotope analysis allows researchers to figure out what an animal ate and even where it lived based on ratios of isotopes in its teeth or bones.

Andrew Somerville, a specialist in isotopic biogeochemistry, is leading this effort with the Iowa sabertooth. Our team suspects that sabertooth cats in this area would have focused their hunting on the Jefferson's ground sloth, a massive, lumbering and solitary browser. With adults weighing around a ton, its size was probably a major deterrent to other predators – but not necessarily to sabertooths. Sharp sabers to the neck could have killed the sloth, size be damned.

My colleagues and I are also developing what natural science researchers call diet-breadth mixing models. Using stable isotopes of carbon and nitrogen preserved in Ice Age carnivore, herbivore and omnivore bones from southwest Iowa, our models should tell us if sabertooths, short-faced bears and dire wolves competed for the same prey, the habitats they searched for prey and, possibly, how these food-web connections collapsed at the end of the Ice Age.

Radiocarbon dating indicates this Iowa sabertooth lived between 13,605 and 13,455 years ago, making it among the last of its kind to walk the Western Hemisphere. Slightly younger dates – but not by much – come from Rancho La Brea, eastern Brazil and far southern Chile.

These dates mean sabertooths and the first people to infiltrate these places – Clovis foragers in North America and Fishtail foragers in South America – shared the landscape for a short period of time. People probably chanced upon sabertooth tracks, scat and kills now and again. Maybe a few lucky people observed the magnificent animal going about its life. But neither knew what the future had in store.

The big cat vanished from both continents shortly after people arrived. The ultimate cause of the die-off is difficult to pinpoint, and multiple factors were certainly at play. However, at least with sabertooths, we can say extinction was a hemisphere-wide synchronous event that transpired in a geological instant, perhaps over just 1,000 or 2,000 years, which makes it difficult to directly or indirectly tie people to the die-off.

The Iowa skull, combined with other fossil evidence from the region and observations of modern large carnivores, has cast new light on the life history and behavior of sabertooth cats. Ongoing research promises to provide additional clues about the diet and ecology of this iconic predator."

Text Number 13.

#### **An oracle predicts regulators of cell identity**

**A computational tool called CellOracle can predict how networks of genes interact to program cell identity during embryonic development. The tool should help to hone efforts to understand how development is regulated.**

08 February 2023

As an animal develops, each of its thousands or even trillions of cells must be programmed to adopt one of many possible cell identities. This programming is controlled by a group of proteins and the genes that encode them, which are collectively known as developmental regulators. Writing in *Nature*, Kamimoto *et al.*<sup>1</sup> present a computational approach to predict the shifts in cell identity that will occur if levels of individual developmental regulators are altered. Their systematic approach promises to help researchers determine the regulators most worthy of further study, saving valuable resources and suggesting biological phenomena that might previously have been missed.

The key process underlying development is differential expression of the genome. Although present in all cells, many genes are expressed in only one or a few cell types, where they confer identity or specific functionality. This differential expression is driven mostly by transcription factors, which bind to specific DNA sequences to promote or suppress expression of target genes. Many of these target genes themselves encode transcription factors, forming a complex, interacting regulatory network.

Decades of work have provided insights into the gene regulatory networks that control development, mainly through painstaking experimental alteration of the expression of single genes<sup>2,3</sup>. Identifying new facets of this network would improve our ability to understand disease-causing mutations and to develop approaches to regenerative medicine involving cells of particular identities. With this aim in mind, Kamimoto and colleagues developed a computational tool called CellOracle that predicts potential regulatory interactions and the effects of disrupting regulators.

The authors' approach requires wild-type gene-expression data from thousands of single cells. These data can be optionally supplemented with information about the 'accessibility' of genomic regions, which can indicate whether a region is available for transcription factors to bind to it. CellOracle first uses these data to determine which transcription factors might regulate each gene's expression, by looking for transcription factors' preferred binding sequences in accessible DNA associated with a gene. The tool then prunes these sets of potential regulatory relationships to select ones that are active in each cell type, on the basis of the correlated expression of transcription factors and the genes that they might regulate.

A user of CellOracle can then investigate the effects of perturbations in the gene regulatory network, by shifting expression of a chosen transcription factor in the model. The expression of that factor's identified target genes shifts accordingly, and the process is then repeated (because target genes often encode transcription factors that target other genes). CellOracle compares the gene-regulatory network in its final, shifted state to states that are present in the original data, to predict the consequences of the change. For example, progress through a developmental transition might be abnormally fast, slow, or blocked, or an unusual change in cell identity might occur.

#### **AI predicts the effectiveness and evolution of gene promoter sequences**

CellOracle joins a cast of computational tools for regulatory network inference<sup>4</sup>. Some of these require gene-expression data from cells carrying genetic mutations, but CellOracle needs only wild-type data, reducing the experimental effort required to get started. Furthermore, the purpose of many of these tools is mainly to identify a gene regulatory network, but CellOracle focuses on predicting the outcome of disrupting regulators in that network.

The authors first confirmed that CellOracle works by using published single-cell genomic data sets that describe the formation of blood and immune cells in mice and humans (a developmental setting in which many key regulators are already known). Most of the genes that CellOracle predicted as potential regulators of blood or immune identity have functions that have been reported previously, and that align with the tool's predictions.

The authors next applied CellOracle systematically to all embryonic transcription factors in zebrafish (*Danio rerio*), again using published data. The aim was to predict regulators of all cell-identity decisions in this species' development. The team then focused on the role of genetic regulators in forming a tissue called the axial mesoderm, which runs along the trunk of the embryo. In this tissue, an axial mesoderm progenitor cell type gives rise to a pair of descendant cell types — notochord and prechordal plate cells (Fig. 1a). These two cell types together send signals that pattern other tissues (such as the spinal cord and the brain) and provide a signalling barrier that divides the embryo into left and right halves.

Genetic screens have identified several regulators that confer notochord identity, including the gene *noto*, deletion of which transforms notochord progenitors into muscle progenitors<sup>5</sup>. CellOracle predicted that loss of *noto* would also shift axial mesoderm progenitors towards a prechordal plate identity (Fig. 1b), and Kamimoto *et al.* confirmed this experimentally. The tool also predicted that loss of the gene *lhx1a* would inhibit early axial mesoderm differentiation (Fig. 1c). And indeed, the researchers found that zebrafish embryos lacking *lhx1a* had fewer mature derivatives of axial mesoderm, and expressed genes that were associated more strongly with early, immature states.

CellOracle is not without limitations. For instance, it did not predict some known effects of regulator disruption (such as that loss of the gene *pu.1* leads to depletion of red blood cell progenitors<sup>6,7</sup>), and did not

identify some known regulators (such as the gene *foxa3* in the axial mesoderm<sup>8,9</sup>). Moreover, the tool predicts only shifts to a different 'normal' cell identity; it cannot predict whether perturbations would create a scrambled or non-normal cell state. Lastly, it cannot currently model more-complex outcomes, as might occur from mutations that do not solely increase or decrease the expression of transcription factors (such alterations include 'missense' mutations, which substitute one amino acid of a protein for another).

#### **A deep artificial neural network powered by enzymes**

However, it would be unhelpful to demand perfect accuracy from an approach such as this. As stressed by Kamimoto and colleagues, the value of this method is to sharpen hypotheses and prioritize or direct future experiments. Screens in which random mutations are introduced to the genome have identified many developmental regulators (and have taught us fundamentally how developmental regulators work), but some regulators are hidden from those approaches — such as when two regulators must both be lost before observable changes can occur in development.

Furthermore, observing these changes requires looking in the right way, in the right place, at the right time. CellOracle and related computational approaches (including SCENIC+)<sup>10</sup> can suggest regulators and trait changes of interest that might have been missed, from data that are often available already. Moreover, testing the tool's predictions is easier than ever, thanks to gene-editing tools such as CRISPR–Cas9 and ever-cheaper single-cell genomic assays.

Even in the well-studied axial mesoderm, CellOracle identified previously unknown regulators and predicted new roles for previously identified regulators. The authors' predictions can be browsed online, and their tool is freely available ([www.celloracle.org](http://www.celloracle.org)). It has already been used by the authors to identify regulators of cell reprogramming in a tissue called the endoderm<sup>11</sup>. Other groups have used it to predict regulators of immune-cell identity<sup>12</sup>; to further explore known regulators of the formation of cell types in the thymus<sup>13</sup>, immune system<sup>14</sup>, cartilage and bone<sup>15</sup>; and to study progenitors of an embryonic tissue called the neuromesoderm<sup>16</sup>. My own prediction is that approaches such as CellOracle will hasten our understanding of the regulatory networks that determine cell identity. Let us hope that, in doing so, they will accelerate development of medical interventions that manipulate these networks. But future users beware: just as, in Greek mythology, Apollo had to slay Python to establish his oracle at Delphi, you, too, will have to conquer Python (in this case, the scripting language) before you can use CellOracle.

Text Number 14.

#### **A deep artificial neural network powered by enzymes**

**Molecular networks have been developed that can classify complex mixtures of DNA sequences that cannot be categorized by a single linear classifier. To do this, artificial 'neurons' powered by enzymes are wired together to form an architecture that mimics the structure of a neural network.**

19 October 2022

The problem

The world is facing a shortage of memory capacity. The amount of data being generated is growing more quickly than is the ability to store the information. Thanks to the amazing endurance and capacity of DNA to store high-density genomic information, it could be used to store data with unrivalled durability (over centuries) and density; all the data in the world could be stored in less than one kilogram of DNA. However, we currently do not understand how to procure and process information in DNA with the same ease, elegance and efficiency as occurs in nature.

One aim is the ability to locate a single piece of information in a mass of DNA encoding data that are mostly unstructured — that is, lacking clear labels or organization. Most data generated by humans and machines are unstructured. It is only in the past decade, with the maturation of artificial neural networks (ANNs), that electronic computers have become able to parse unstructured data similarly to — or better than — humans. Several groups have theorized<sup>1,2</sup> or built<sup>3,4</sup> DNA-based networks that can process information similarly to ANNs, providing seminal proofs of concept. However, these networks have had limited capacity to discriminate patterns that differ only slightly.

The solution

Previous examples of DNA-based networks used nucleic acids to both store and process information<sup>3,4</sup>. However, in nature, enzymes have evolved to process information in DNA. Genetic programs are orchestrated by myriad DNA-processing enzymes, including polymerases, which replicate DNA or transcribe it into RNA. Inspired by gene-regulatory networks and aided by a microfluidics platform to manipulate small amounts of fluid<sup>5</sup>, we designed, debugged and deployed ANNs that rely on DNA-encoded enzymes. The networks store their inputs and instructions in DNA and are operated by three enzymes: a polymerase, which creates DNA; a nickase, which cuts DNA; and an exonuclease, which degrades DNA.

We built these ANNs using 'enzymatic neuron' building blocks: one neuron is made up of DNA-encoded instructions to link a set of up to 12 input DNA strands to a single chemical or optical signal. If the weighted

sum concentration of the input exceeds a given, tunable threshold, the enzymatic machinery amplifies the output strand, which can then be used as an input for a downstream, connected neuron. Our enzymatic neuron could discriminate between inputs for which concentrations differed by only about 10–20% and detect them at low (sub-nanomolar) concentrations. The neuron was also robust and reliable — behaving mostly as intended with little chemical 'noise'.

The strength of ANNs is in the numbers of neurons they contain. A single neuron is of limited use, because it can recognize only simple patterns, but a network of neurons can, in principle, recognize any pattern if the network is suitably trained and large enough. So, we connected three enzymatic neurons together. The resulting multilayered enzymatic neural network could recognize more-elaborate mixtures of DNA at different concentrations than a single neuron could (Fig. 1). This represents nonlinear decision-making: classification of inputs that cannot be separated by a single line.

Future directions

Our networks could relieve a current pain point of DNA storage: the handling and searching of massive DNA databases. These networks could also find application in diagnosing diseases on the basis of sampled DNA or RNA, by finding a specific sequence in a sea of seemingly similar sequences. The computational power of enzymatic networks could boost sensitivity and improve accuracy compared with conventional tests that look only for the presence of a single sequence — with few costs.

Although our networks improve substantially on those in the literature, with two layers and three neurons, they are still unable to process data from real-world databases such as image libraries. The obvious next step is to expand and deepen the enzymatic networks to make them 'smarter'. The machine-learning community has shown that deeper is usually better, and a network with dozens of layers should be able to recognize objects in DNA-encoded images. This will require methodological development to synthesize and sequence large amounts of information into DNA. — **Anthony J. Genot is at the Laboratory for Integrated Micro-Mechanics Systems (LIMMS), CNRS-Institute of Industrial Science (IIS), University of Tokyo, Tokyo, Japan, and Guillaume Gines is at the Gulliver Laboratory, ESPCI, CNRS, Paris, France.**

Expert opinion

Okumura and colleagues have developed enzymatic networks that can perform nonlinear decision-making, with higher sensitivity than DNA-only networks. As such, they demonstrate, for the first time, a molecular decision-making network that contains a hidden layer and an output layer. The design enables massively parallel DNA-based computing using small reagent volumes, an attractive approach for preparing DNA circuits. — Chunhai Fan is at Shanghai Jiao Tong University, Shanghai, China.

Behind the paper

We are members of the Laboratory for Integrated Micro-Mechanics Systems (LIMMS), which is a joint laboratory of the University of Tokyo and the French national research agency CNRS. A theoretical paper<sup>1</sup> in 2013 — written by three of us while in Tokyo — laid the groundwork for computing with DNA and enzymes. Years of meticulous, painstaking experimental work made it a reality, occupying much of the master's and PhD degrees of S. Okumura, the first author. We overcame limitations in experimental equipment by building a microfluidics platform to debug and 'see' the molecular programs at play (Fig. 1). This was possible thanks to the unique confluence of expertise of LIMMS. After several authors relocated to Paris, experiments continued in Japan and France with frequent in-person and remote exchanges. The results proved surprisingly robust to variations in enzyme batches and experimentalists. — **A.J.G.**

From the editor

Although artificial intelligence has revolutionized conventional computing, implementing it in molecular systems is challenging. An important step forwards is provided by the DNA-encoded enzymatic networks built by Okumura *et al.*, which offer a simple yet highly sensitive and modular design that can be visualized and tested in parallel using tens of thousands of droplets. With this, effective use of artificial intelligence by molecular computing systems seems finally within reach. — **Magdalena Helmer, Senior Editor, Nature**

Text Number 15.

### **The brain's encoding of warm and cool**

**The cerebral cortex is the outer folded layer of the brain. It contains a population of neuronal cells that is dedicated to the representation of temperature. The activity of neurons in this 'thermal cortex' is different for warming compared with cooling, and is required for the perception of temperature.**

08 February 2023

The question

The brain's cortex contains a separate region for each of the major sensory systems. These 'sensory cortices' are composed of neuronal cells whose activity is tuned to specific sensory features (such as stimulus speed or amplitude) and that act together to generate a perception of sensory information. Mammals are highly sensitive to tiny changes in temperature, and can often distinguish between temperatures that are less than 0.5 °C apart; however, the cortical neurons that respond to temperature have remained elusive. Previous work in humans and other mammals has suggested that various cortical regions are involved in thermal processing<sup>1</sup>, but it used techniques that cannot monitor single cells. Our aim was to identify the cortical region that is required for temperature perception and to pinpoint how cortical neurons represent skin warming and cooling.

#### The discovery

We used a broad-scale imaging approach to search the cortex for regions that are responsive to changes in skin temperature (Fig. 1a). A good candidate was the primary somatosensory cortex, which we knew responds to touch and cool<sup>2</sup>. Surprisingly, however, although it was responsive to cool, it was not responsive to warm — not an ideal characteristic for a dedicated 'thermal cortex'. We next examined a region on the side of the mouse brain called the posterior insular cortex (pIC). Here, we identified thermally responsive areas organized into a 'somatotopic' map, in which neighbouring neurons encode information from neighbouring points of the body (Fig. 1b). We used a technique called two-photon imaging to examine the pIC region linked to the forepaw to show that neurons there were responsive to only warm, only cool or both warm and cool (Fig. 1c).

Moreover, as expected from a dedicated sensory cortical region, pIC neurons showed dynamic responses to different aspects of thermal stimuli. Intriguingly, many features of warm and cool encoding were distinct; for example, warm evoked longer-latency and more-prolonged responses than cool. Using a technique called optogenetics, we showed that rapid, reversible inactivation of the pIC diminished the ability of the mice to sense temperature, confirming a profound role for this region in temperature perception.

#### Future directions

Our work demonstrates an intricate cellular representation of skin temperature in the cortex. The differences in cortical responses to warm compared with the responses to cool imply that cool and warm are more than just two ends of the same sensory scale, but instead resemble sensory submodalities that are sensed by separate neural pathways.

The cortex contains several layers and cell types and, so far, thermal encoding by pIC excitatory neurons has been investigated only in cortical layers 2 and 3. We therefore do not yet have a complete picture of thermal representation in the pIC. Intriguingly, some of the cortical cellular responses seem remarkably similar to those observed in sensory neurons innervating the skin, whereas others, such as the thermometer-like responses of cells encoding absolute temperature, do not. The cortex can transform and amplify specific aspects of sensory input; whether the pIC does this is not yet clear.

This work provides a platform to understand the cortical processing of thermal information. Future experiments might be able to investigate cortical-cell activity to answer long-standing puzzles about thermal perception, such as the role of temperature adaptation in perception<sup>3</sup>, the cellular mechanisms for discriminating between warm and cool and whether warm and cool perception are driven by mixed or separate neuronal pathways. Addressing these questions will require examination of the encoding properties of different types of cortical neuron, and the identification of inputs from other parts of the brain that drive cortical thermal responses. Thermal and tactile information is combined when handling objects, and we hope to address this integration process using more-complex behavioural tasks. More broadly, we were intrigued after observing similar thermal-encoding features in our experiment to those previously seen in flies<sup>4</sup>. Future cross-species comparative work could help to pinpoint key computations in thermal processing. — **Mikkel Vestergaard and James Poulet are at the Max Delbrück Center, Berlin, Germany.**

#### Expert opinion

This interesting and timely study investigates how temperature is encoded in the mammalian cortex. The authors show that the pIC responds to both warming and cooling, whereas the somatosensory cortex responds only to cooling. These results represent fundamental information about how temperature perception is encoded in the insular cortex. The finding that distinct pIC neurons encode warm and cold with response properties that match the specificity of their corresponding peripheral neurons is exciting. — **Zachary Knight is at the University of California, San Francisco, San Francisco, California, USA.**

#### Behind the paper

Because we had observed cooling responses in the somatosensory cortex in a previous study<sup>2</sup>, our first guess was that it would also encode warm, but we found almost no evidence supporting this. In fact, there are hardly any published reports of cortical cells responding to skin warming. A role for the insular cortex in thermal processing had been suggested by human brain imaging<sup>5</sup>, but previous work has not investigated individual

cells. Soon after developing a new experimental setup that can image individual cells in the pIC, we observed cortical responses to warm stimuli. At that moment, we knew we were onto something exciting. — **M.V. and J.P.**

From the editor

Temperature sensing is an essential perceptual function. Although we have beautiful work showing how hot and cold are detected at the periphery, we know little about how they are represented in the cortex. This paper gets us closer to understanding it. — **Editorial team, *Nature***

Text Number 16.

### **Turkey–Syria earthquake reveals building danger**

**Turkey and Syria's buildings have always been vulnerable to earthquakes, but war has made things worse.**

06 February 2023

Update 07 February 2023

Update 09 February 2023

A magnitude-7.8 earthquake hit southeastern Turkey and parts of Syria in the early hours of the morning of 6 February. At least 17,000 people are known to have lost their lives, with thousands more injured. The quake was followed by a magnitude-7.5 event some 9 hours later, as well as more than 200 aftershocks.

The earthquake and its aftershocks have flattened buildings and sent rescuers digging through concrete debris to find survivors, with the death toll expected to increase further. *Nature* spoke to four researchers about the seismic activity in the region and what the next few days will bring.

Turkey is in an active earthquake zone

Most of Turkey sits on the Anatolian plate between two major faults: the North Anatolian Fault and the East Anatolian Fault. The tectonic plate that carries Arabia, including Syria, is moving northwards and colliding with the southern rim of Eurasia, which is squeezing Turkey out towards the west, says David Rothery, a geoscientist at the Open University in Milton Keynes, UK. “Turkey is moving west about 2 centimetres per year along the East Anatolian Fault,” he adds. “Half the length of this fault is lit up now with earthquakes.”

Seyhun Puskulcu, a seismologist and coordinator of the Turkish Earthquake Foundation, based in Istanbul, says people in Turkey are well aware of their vulnerability to earthquakes. “This wasn't a surprise,” says Puskulcu, who last week was touring the cities of Adana, Tarsus and Mersin, and areas of western Turkey, delivering workshops on earthquake awareness.

The epicentre of the main earthquake was 26 kilometres east of the city of Nurdağı in Turkey's Gaziantep province, at a depth of 17.9 kilometres. The magnitude-7.5 event occurred around 4 kilometres southeast of Ekinözü in the Kahramanmaraş province (see 'Earthquakes and aftershocks').

War has destabilized already-vulnerable buildings

Deaths in earthquakes are often caused by falling bricks and masonry. According to the US Geological Survey, many people in Turkey who were affected by the earthquake live in structures that are extremely likely to be damaged by shaking, with unreinforced brick masonry and low-rise concrete frames.

In a study<sup>1</sup> published last March in *Soil Dynamics and Earthquake Engineering*, Arzu Arslan Kelam at the Middle East Technical University, Ankara, and her colleagues suggested that the centre of the city of Gaziantep would experience medium-to-severe damage from a magnitude-6.5 earthquake. This is because most existing buildings are low-rise brick structures that are constructed very close to each other.

In 1999, a magnitude-7.4 earthquake hit 11 kilometres southeast of Izmit, Turkey, killing more than 17,000 people and leaving more than 250,000 homeless. After this tragedy, the Turkish government introduced new building codes and a compulsory earthquake insurance system. However, many of the buildings affected by this week's quake were built before 2000, says Mustafa Erdik, a civil engineer at Boğaziçi University, Turkey. Things are worse in Syria, where more than 11 years of conflict have made building standards impossible to enforce. The earthquake struck Syria's northwestern regions, with buildings collapsing in Aleppo and Idlib. Some war-damaged buildings in Syria have been rebuilt using low-quality materials or “whatever materials are available”, says Rothery. “They might have fallen down more readily than things that were built at somewhat greater expense. We've yet to find out,” he adds.

What's next?

Researchers say people need to brace themselves for yet more quakes and aftershocks, as well as deteriorating weather. “The possibility for major aftershocks causing even more damage will continue for weeks and months,” says Ilan Kelman, who studies disasters and health at University College London.

“The weather forecast for the region for tonight is dropping below freezing. That means that people who are trapped in the rubble, who might be rescued, could well freeze to death. So these hazards continue,” he adds.

Text Number 17.

**Indoor air pollution kills and science needs to step up**

**Researchers and policymakers are only now waking up to the effects of dirty indoor air. As ever, low-income and marginalized communities are most exposed.**

08 February 2023

The image of air pollution is often one of chimney stacks and smoggy cities. But this can be a misleading picture. Indoor air pollution killed more than 3 million people in 2020, almost as many as did its outdoor counterpart. And yet it has been mostly invisible to science, and to policy.

In a Comment article in *Nature* this week, three researchers describe how that needs to change. Christopher Whitty, the UK government's chief medical adviser, and colleagues Deborah Jenkins and Alastair Lewis, show what researchers and policymakers must do to improve our understanding of, and ultimately to reduce, indoor air pollution. Most people spend 80–90% of their time indoors, in homes, schools and places of work, the authors observe. But, in contrast to detailed and legally enforceable national standards for outdoor pollution that exist in many parts of the world, indoor spaces are mostly not subject to similar air-quality controls.

Hidden harms of indoor air pollution — five steps to expose them

The authors are right to draw attention to something that has been neglected for too long. Progress is hampered by our ignorance of basic facts, such as what indoor air pollution actually consists of. It includes familiar compounds such as carbon monoxide and carbon dioxide from coal burning, and nitrogen oxides from natural-gas boilers. But there is also a multiplicity of other sources, for example chemicals from synthetic compounds in paints and fabrics, mould from damp buildings and viruses and bacteria from human breath. Researchers need to be doing more to understand how all of these circulate, how they interact with each other, their impact on human health and how they will be affected by climate change.

Although indoor air pollution is a global problem, the right strategies for combating it will vary between regions, countries and even localities. “Construction styles and materials, climate and energy sources, as well as behaviours and cultural practices, all affect indoor air”, the authors point out.

What's clear, however, is that, just as poorer and marginalized people are disproportionately affected by bad outdoor air quality (A. Jbaily et al. *Nature* 601, 228–233; 2022), indoor air pollution is a source of inequality, too. In sub-Saharan Africa, for example, 700,000 people are estimated to have died from indoor air pollution in 2019, many of them from the effects of particles from indoor biomass stoves (B. Khavari et al. *Nature Sustain.* <https://doi.org/grqrbg>; 2023). Cleaner alternatives do exist, but their large-scale use needs a panoply of research-based interventions — from engineering and design to behavioural sciences.

In richer or colder countries, people on lower incomes tend to rely on gas or solid fuels for heating, or live in homes affected by damp and mould. Targeted interventions to improve air quality by, for example, incentivizing the switch to cleaner fuels, can be a win–win situation, with the happy complementary effect of assisting decarbonization, too. (The reverse is, perhaps, less true: interventions to improve energy efficiency by better insulating indoor environments might have a negative effect on air quality, a relationship that must be carefully examined.) But, as the authors write, “it is essential that decarbonization, building improvement and gains in indoor air quality are, as much as possible, delivered equitably across society.”

Indoor air pollution clearly needs to attract urgent attention from policymakers — the most recent guidelines from the World Health Organization on damp and mould were published in 2009. That's where Whitty and colleagues' article, coming from researchers who advise governments, will undoubtedly help. Ultimately, science must be better prepared for when it is called on to advise about the various strategies. Indoor air pollution should become as mainstream a public-health concern as its outdoor sibling, with all the requisite funding that flows towards it. This is one good intention that shouldn't go up in a puff of smoke.

Text Number 18.

**Global pandemic treaty: what we must learn from climate-change errors**

**The WHO's draft agreement proposes a COP-like process. That's unlikely to improve on the world's disastrous COVID response.**

07 February 2023

The global response to COVID-19 represented a “catastrophic failure of the international community in showing solidarity and equity”. This frank assessment comes in the opening line of the first, or 'zero', draft of a new international pandemic agreement, published by the World Health Organization (WHO) last week. The agreement is intended to help the world to better prepare for future pandemics. Negotiations over the details are due to start later this month and are likely to last at least a year.

Although it doesn't say so explicitly, the WHO's statement can be read as a rebuke to the leaders of high-income nations, highlighting the fact that their response to the ongoing pandemic has not been a model of

cooperation or compassion. A promise to properly support a vaccine-distribution scheme called COVAX went unfulfilled, undermining its potential. Rich countries over-ordered and hoarded vaccines, stopping them from reaching people in other countries who needed them. Some of the world's best-known and well-respected pharmaceutical companies fought to stop intellectual property (IP) being shared. Had they not done so, more manufacturers could have produced vaccines and treatments, and more lives could have been saved. The treaty drafted by the WHO is intended to ensure that this behaviour is never repeated. But as Nature has argued before, a treaty on its own offers no guarantee that promises will be kept.

Share and share alike

The draft text encourages the waiving of applicable IP rights for a defined period during a pandemic. In addition, at least one-fifth of relevant vaccines must be deposited with the WHO, to ensure that sufficient numbers reach the world's poorest and most vulnerable people at the same time as they reach people in richer countries. Prices and contracts should be made public — something that didn't happen during the COVID-19 pandemic, allowing countries to outbid each other for vaccines by offering higher prices that only pharmaceutical companies were a party to.

What the WHO's new treaty could mean for the next pandemic

The current wording also recognizes the importance of open science and the sharing of data such as viral genome sequences. Last month, the WHO urged China's authorities to share sequence data, as well as information on cases, hospitalizations and vaccination rates. Another point emphasized in the zero draft is that countries that share their scientific knowledge — as many low-income countries did during the pandemic — should also share in the benefits.

All of this is necessary and overdue, and has the backing of scientists and campaigning organizations. But researchers are rightly concerned about the lack of clarity on how the treaty will work in practice, and how signatories will be held to their promises. The WHO recommends that countries make decisions through a conference of the parties (COP), a democratic forum in which all countries have an equal voice in decision-making.

But COPs are expensive to run, and the creation of such a framework would mean that the WHO — which faces a constant struggle to get countries to fund it properly — would struggle even more. COPs also take their time to reach decisions, as we know all too well from those governing international action on concerns such as climate change and biodiversity loss.

Perhaps most important of all, a forum of 200-odd countries, plus tens of thousands of observers and lobbyists, is, arguably, not the best way to ensure that an agreement is adhered to, especially when the onus for action lies with a relatively small number of high-income nations. There's good evidence from the climate-change COP process that even legally binding agreements cannot compel nations to meet their commitments.

Even after COVID, the world's vaccine strategy is failing

Sensibly, the WHO wants countries to agree on some kind of monitoring system — a way to get them to report back on whether promises on funding, IP or vaccines are being kept. But negotiators and their teams would also be well advised to explore alternative ways of achieving the agreement's aims. Researchers who study the impact of international treaties could advise on other potential models.

It's clear from the WHO's zero draft text that the agency is determined to avoid a repeat of some of the worst of the behaviours seen during the pandemic. And it is reassuring to see, throughout the text, encouragement for governments and companies to be transparent and willing to share, particularly when it comes to know-how and products that are based on publicly funded research. Had this happened previously, the coronavirus pandemic might well have been behind us by now.

The world has little more than a year to convert the draft into finished text. The commitments in the current version will probably be watered down before an agreement is reached. But as researchers prepare to publish their studies, and campaigners rush to accelerate campaigning, it is easy to forget the need to determine the kinds of institution and structure that are essential to ensuring an agreement is delivered on. Institutional structures are as important as the content of treaties. The WHO and national negotiators need to ask themselves what value an agreement has if it includes everything in the WHO's zero draft, but proves unworkable in practice.

Text Number 19.

**Even after COVID, the world's vaccine strategy is failing**

**Without a global, publicly funded strategy, the market will fail to deliver vaccines to stop pandemics before they surge.**

13 December 2022

Four weeks ago, I visited Mulago National Referral Hospital, in Kampala, where I used to work. Today, it is home to one of Uganda's Ebola isolation wings. During my visit, I witnessed some of the challenges that the government and health-care workers were facing to contain this terrible outbreak without the most effective



tool there is: vaccines. The Sudan strain of ebolavirus has killed 56 people and spread to 9 districts in Uganda, including the capital city of 2 million people and regions that border other nations. If it spills into neighbouring countries, it could trigger a regional crisis.

All of this could have been avoided. No effective vaccines or treatments have been approved against Sudan ebolavirus. If the world had learnt its lesson from previous Ebola outbreaks and COVID-19, vaccines could have been ready for clinical testing at the outbreak's start. The fact that they aren't is a global failure.

Despite rallying to produce billions of doses of vaccines in the face of COVID-19, when it comes to developing vaccines to prevent a disease in the first place, the world is still asleep at the wheel. There is still no incentive for markets to deliver vaccines that can prevent outbreaks, even when the technology is available. If we can't even have vaccines ready for known severe threats such as Ebola, then what hope is there for future unknown pandemic threats?

#### **To beat Ebola in Uganda, fund what worked in Liberia**

I warned about this problem seven years ago in a column in *Nature* (*S. Berkley Nature* **519**, 263; 2015). Yet despite the COVID-19 wake-up call, this remains one of the biggest chinks in our pandemic-preparedness armour.

With effective, available vaccines against devastating diseases, governments could prevent escalation through contact tracing and ring vaccination: in the case of Ebola, perhaps a few dozen contacts of each infected person could be vaccinated. But producing the small number of doses needed to prevent spread is not profitable for drug companies, and donor governments are reluctant to waste money on preventive vaccines that might never get used.

'Short-sighted' hardly describes the situation. Preparing preventive vaccines for a few million dollars per batch should be seen as a small insurance policy to avoid a repeat of the US\$12 trillion the world just spent on COVID-19.

The market's failure to support vaccines should worry everyone, because the risk of future pandemics is growing. Even as COVID-19 continues to spread, in a given year there is a 2% chance of a new pandemic outbreak. Climate change, population growth, urbanization and human migration all help outbreaks to spread and escalate more rapidly.

Our best defence is having vaccines ready to use the moment disaster strikes. The World Health Organization keeps a list of nine priority pathogens with pandemic potential, including severe acute respiratory syndrome (SARS) and Ebola, as well as 'disease X', which represents a possible, as-yet-undiscovered pathogen. All nine deserve a full effort: development of several candidate vaccines through the animal-model and early clinical testing stages; viable and quality-tested vaccines that are ready for immediate testing in an outbreak; and stockpiling of enough doses to control the disease if the vaccine is shown to be efficacious. For disease X, a set of viral vectors and messenger RNA delivery systems should be ready to carry the sequences of whichever antigens prove effective against the disease, and the manufacturing and clinical trials should be worked through as far as possible. By doing much of the preclinical and clinical work in advance, we can have doses as close to ready as possible when we need them.

#### **Can mRNA vaccines transform the fight against Ebola?**

What will it take to finally catalyse change, so that I'm not writing this again seven years from now? To be clear, we have come far, from hardly talking about this issue to living through a pandemic that daily highlights its relevance. I am optimistic that a change in mindset is in view.

A key first step is the establishment of an adequate, publicly subsidized market. This will enable a coordinated global strategy with the support of G20 governments to drive the research, development and flexible small-scale manufacturing needed to produce vaccines to prevent epidemics, even if, as we hope, they will not be needed.

Wealthy countries should take the lead. They should ensure that agencies such as the Coalition for Epidemic Preparedness Innovations (CEPI), based in Oslo, and the International AIDS Vaccine Initiative (IAVI), based in New York City, are fully funded to do this work, which will involve close collaboration with government research agencies as well as Gavi, the Vaccine Alliance, and the WHO.

For Sudan ebolavirus, three candidate vaccines have been identified in early testing, following research and development driven by CEPI, IAVI, the US National Institutes of Health, the US Biomedical Advanced Research and Development Authority and others. Last week, Uganda received the first vaccine shipment for scheduled trials. But for the 56 people who have died and the 142 who have been infected, trials will come too late — and, as there are currently no new cases, they might be too late to determine vaccine efficacy.

COVID-19 has brought a renaissance in vaccine development. New vaccines are in the pipeline for many diseases. We have an opportunity to capitalize on the latest methods and a sense of urgency. We can't continue closing the stable door after the horse has bolted. If we keep relying on a market-based model that churns out millions of doses only after an epidemic is under way, then we have already failed.

Text Number 20.

#### **How quickly does COVID immunity fade? What scientists know**

## **Vaccination, infection with SARS-CoV-2 and a combination of both provide varying degrees of protection.**

02 February 2023

Three years into the pandemic, the immune systems of the vast majority of humans have learnt to recognize SARS-CoV-2 through vaccination, infection or, in many cases, both. But just how quickly do these types of immunity fade?

New evidence suggests that 'hybrid' immunity, the result of both vaccination and a bout of COVID-19, can provide partial protection against reinfection for at least eight months<sup>1</sup>. It also offers greater than 95% protection against severe disease and hospitalization for between six months and a year after an infection or vaccination, according to estimates from a meta-analysis<sup>2</sup>. Immunity acquired by booster vaccination alone seems to fade faster.

But the durability of immunity is much more complex than the numbers suggest. How long the immune system can fend off SARS-CoV-2 infection depends not only on how quickly immunity wanes, but also on how well immune cells recognize their target. "And that has more to do with the virus and how much it mutates," says Deepta Bhattacharya, an immunologist at the University of Arizona College of Medicine in Tucson. If a new variant escapes the existing immune response, then even a recent infection might not guarantee protection.

Omicron has presented just such a scenario. In late 2021 and early 2022, the main Omicron subvariants that were causing infections were BA.1 and BA.2. By mid-2022, the BA.5 wave was gathering strength in some countries. Data are now hinting at the risk of reinfection during a series of waves.

In one study<sup>1</sup>, researchers looking at Portugal's national database of infections studied vaccinated people who became infected during the BA.1/BA.2 wave. Analysis showed that 90 days after an infection, this population had high immune protection — their risk of becoming infected with BA.5 was just one-sixteenth that of people who had been vaccinated but never infected. After that, hybrid immunity against infection declined steeply for a few months and then stabilized, ultimately providing protection for eight months after infection — the duration of the study.

Another study<sup>3</sup> looked at 338 vaccinated health-care workers in Sweden, some of whom had had a previous SARS-CoV-2 infection. The authors found that workers with hybrid immunity had some level of protection against infection with BA.1, BA.2 and BA.5 for at least eight months. The workers' noses contained high levels of 'mucosal' antibodies, which are thought to shield against infection.

A study in Qatar compared the infection risks of people who had never caught SARS-CoV-2 with those of people who'd had a previous infection. Both groups included vaccinated and unvaccinated individuals. The results show that more-recent infections provide greater protection than do older ones in all cases. The authors couldn't untangle whether those differences were because of waning immunity, the virus's growing ability to evade the immune response or, more likely, a combination of the two.

### **Infection reprieve**

Taken together, the studies suggest that hybrid immunity provides some protection against infection for at least seven months, and probably longer. "That's pretty good," says Charlotte Thålin, an immunologist at the Karolinska Institute in Stockholm and an author of the Swedish study.

Other data suggest that in people whose immunity arises only from vaccination, a booster dose provides relatively short-lived protection against infection. Researchers in Israel studied more than 10,000 health-care workers who had not previously been infected; all received either three or four doses of the vaccine made by Pfizer and BioNTech<sup>5</sup>. The authors found that the fourth dose's efficacy against infection fell rapidly. In fact, after four months, the fourth dose was no better than three doses at preventing infection.

However, "we are talking just about what we call relatively mild disease", says study co-author Gili Regev-Yochay, an epidemiologist at Sheba Medical Center Tel Hashomer in Ramat Gan, Israel. None of the people in the study developed severe COVID-19.

What about those who haven't been vaccinated? Another study<sup>6</sup> in Qatar suggests that if the virus doesn't change, infection-based immunity against reinfection can last up to three years. The authors studied data from unvaccinated people who were infected with a pre-Omicron variant. But 15 months later, those infections were less than 10% effective at protecting against Omicron infection. And relying on immunity from infection is riskier than getting immunized.

But it's nearly impossible to apply the study results to predict an individual's risk of becoming infected in future. Immunity depends on a variety of factors, including genetics, age and sex. And past risk of infection isn't necessarily a good predictor of the risk of future infection, because new variants are continually arising.

### **Booster break**

How growing global hybrid immunity will affect the timing and frequency of infection surges isn't yet clear. Neither is it clear how this will influence health officials' decisions about when to offer future booster doses.

For people who are at high risk of developing severe COVID-19, it might make sense to get boosters frequently. Younger individuals without any risk factors who live in regions where the virus has been

circulating freely “may already have very significant protection that may not require as frequent boosters”, says Luís Graça, an immunologist in the Faculty of Medicine at the University of Lisbon and a co-author of the Portuguese study. Another option might be to give a booster when anti- body levels fall below a certain threshold, says Regev-Yochay.

Thâlin understands how frustrating the caveats and uncertainty can be, but says that researchers aren't likely to pin down an answer any time soon. “The virus is evolving so fast,” she says. “What's true today might not be true tomorrow.”