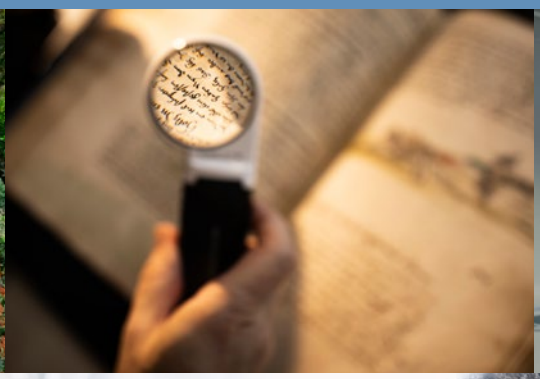
Philipps Universität Marburg

RESEARCH IN MARBURG

RESEARCH IN MARBURG

CONTENT

Photo: Rolf K. Wegst

PREFACE

Research in Marburg – networked and interdisciplinary

Photo: Rolf K. Wegst

Excellence in individual disciplines as a foundation for new knowledge. Further advances require networked thinking and interdisciplinary research. This is also highlighted by the research priorities seen at the Philipps-Universität Marburg, which we are presenting to you in this issue of *Research in Marburg*. You'll meet prominent Marburg personalities from various scientific fields at the university who bundled their innovative individual research into comprehensive collaborations.

The research collaborations we present here reflect the wide range of the academic fields at the Philipps-Universität. They also demonstrate how the continuity of working on major research questions can consistently produce successes. The collaborations in the neurosciences show how fields from the academic cultures of different disciplines can merge. The natural sciences and life sciences have long collaborated with linguistics and sports science and, beyond the limits of the university, with partners from Central Hessen and from around the world.

The Research Campus of Central Hessen, which has been in operation since 2016 together with the Justus Liebig University Giessen and the Technische Hochschule Mittelhessen, is crucially important for the Philipps-Universität Marburg. The strengths of this collaboration are joint research priorities and reciprocal supplementation of technical expertise — in, among other areas, historical security research, neuroscience, semiconductor research, microbiology, virology, and tumor research. Many of the collaborations presented here are part of the focus or profile areas of the Research Campus.

We are especially grateful to the scientists and scholars for their contributions to this publication.

I hope that you will enjoy reading the articles and gain new insights.

Sincerely,

Prof. Dr. Katharina Krause

PRESIDENT OF THE PHILIPPS-UNIVERSITÄT MARBURG

PREFACE

Digitalization – new research opportunities

The research spectrum at the Philipps-Universität Marburg ranges from amorphous, molecular materials with extreme, nonlinear optical properties to time-resolved photoelectron spectroscopy, from the "Manuscript Census" to linguistic typology and quantitative linguistics, from conflict research to synthetic microbiology. As varied as these subjects and questions may be, digital methods and tools have become indispensable when conducting modern research. Many of the collaborative research projects presented here include extensive digitization projects or stand out for producing and processing large quantities of research data. In recent years, the Philipps-Universität established numerous services related to the digitization and management of research data, thereby supporting scientists and scholars in meeting these challenges.

In some research fields, digitization has resulted in completely new qualification requirements. For example, the Academy Project "Handschriftencensus" that envisions developing an online platform of German manuscripts from the Middle Ages requires the expertise by specialists with knowledge of medieval philology and information technology. This type of skill combination barely existed until now, prompting us to ask the question of how universities can anticipate and include such requirements for the scientific training of the future already today.

Expertise in information technology plays a central role in many of the research collaborations you are about to learn about with in this brochure. Information technology provides solutions that are opening up new research opportunities in collaborative research. In addition to an improved monitoring system for climate research, as well as a biodiversity database, this includes, for example, using artificial intelligence to identify new categories of psychological and neurological disorders.

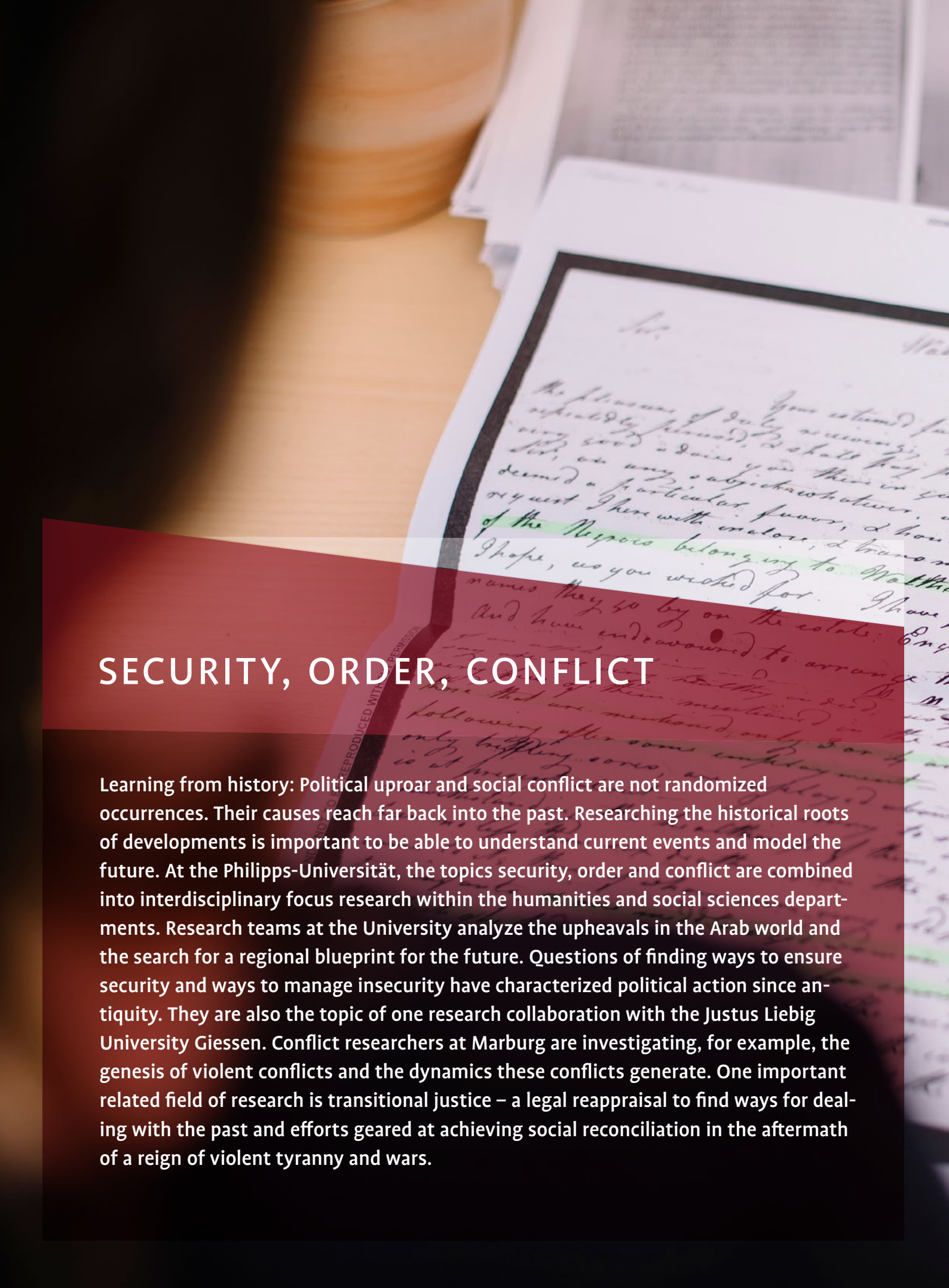
Photo: Rolf K. Wegst

The use of digital methods is also a central feature of the latest research network at the Philipps-Universität Marburg: the "Merian Centre for Advanced Studies in the Maghreb" (MECAM), and the creation of a digital infrastructure has facilitated effective collaboration among all participants. MECAM is funded by the German Federal Ministry of Education and Research. Currently it is one of the most important international collaborative projects at the Philipps-Universität. It is the result of nearly 15 years of outstanding regional research at the Center for Near and Middle Eastern Studies. The goal is to stay away from doing research about the actors in the region but to work jointly with them. True to this approach, the headquarters for the new center is located in the heart of the region it researches — in Tunis, Tunisia. Enjoy discovering the diverse research that is underway in Marburg!

Sincerely,

Prof. Dr. Michael Bölker

VICE PRESIDENT FOR RESEARCH AND INTERNATIONAL AFFAIRS AT THE PHILIPPS-UNIVERSITÄT MARBURG



SECURITY, ORDER, CONFLICT

Learning from history: Political uproar and social conflict are not randomized occurrences. Their causes reach far back into the past. Researching the historical roots of developments is important to be able to understand current events and model the future. At the Philipps-Universität, the topics security, order and conflict are combined into interdisciplinary focus research within the humanities and social sciences departments. Research teams at the University analyze the upheavals in the Arab world and the search for a regional blueprint for the future. Questions of finding ways to ensure security and ways to manage insecurity have characterized political action since antiquity. They are also the topic of one research collaboration with the Justus Liebig University Giessen. Conflict researchers at Marburg are investigating, for example, the genesis of violent conflicts and the dynamics these conflicts generate. One important related field of research is transitional justice – a legal reappraisal to find ways for dealing with the past and efforts geared at achieving social reconciliation in the aftermath of a reign of violent tyranny and wars.

Photo: Henrik Isenberg

UNDERSTANDING THE DYNAMICS OF CONFLICTS AND PEACE PROCESSES

Divided past — shared future?

The Marburg Center for Conflict Studies addresses, for example, how violent conflicts develop, how the adversaries deal with the fallout in the aftermath of conflict, and how conflicts are resolved. The questions at the forefront include: What are causes of conflict? What experiences, ways of thinking, ideologies or interests shape their dynamics? Why do humans participate in acts of violence? How do peace processes succeed without laying the groundwork for new conflicts?

When the Center for Conflict Studies was founded in 2001, the Philipps-Universität already had a track record of almost 20 years of teaching and research in this field. The departments of social sciences, education, legal studies, as well as social psychology and media sciences contribute to this interdisciplinary center. The research projects at the center are concerned with peace processes, forms of violence, coming to terms with human rights violations, international interventions, refugees and migration, critical security research, mediation, as well as the actors and the dynamics of social conflicts. Issues such as perspectives on gender and sex, changes in norms or transfer to practitioners are shared features of many projects. Many projects have an empirical orientation. They develop case studies on countries such as Iran and East Timor in Asia; Kenya, Cameroon, Togo, Senegal and Sierra Leone in Africa; Northern Ireland, Germany, Romania, Georgia, Turkey and Kosovo in Europe; Canada, Mexico and Colombia in North and South America; as well as Morocco and Tunisia in North Africa.

CONFLICT TRANSFORMATION IN COLOMBIA

One hallmark of the center is that students are closely involved with research projects, e.g., the peace process in Colombia. Accordingly, the Marburg sociologist Professor Dr. Anika Oettler initiated the project Imaginando la reconciliación — Imagining Reconciliation —, wherein students from the Philipps-Universität investigated how the perception of the violent conflict in Colombia has shaped the understanding of reconciliation among Colombian students. “We link science and practice,” Oettler says, “and thereby improve the methods of qualitative social research. Anyone doing research at the center benefits from this.”

Violent conflict has a long history in Colombia. The Revolutionary Armed Forces of Colombia (FARC) guerilla movement has been fighting the government since the 1960s. A peace treaty was signed in 2016, which is regarded internationally as an exemplary achievement. FARC fighters gave up their weapons, and a Special Justice for the Peace was appointed. The treaty showed ways for overcoming fundamental causes of the conflict, especially the unequal distribution of land, the lack of political participation by large parts of the population, and the illicit drug economy. However, the ambitious goals of the treaty are being implemented at a very slow pace. “Building peace is a difficult process,” Oettler says. “The majority of the population in Colombia is hoping for an end to the violence and for reconciliation. But the exact meaning of reconciliation is disputed. Different people perceive the conflict and the peace process differently, based on how they themselves were affected.”

The students analyzed the peace agreement between the government and FARC for concepts of reconciliation. To gain insights into the public discourse at the time surrounding the peace process, they held group discussions with Colombian students from various universities in the country. The graffiti by street artists in Bogotá served as an impulse for starting a discussion on the issue of reconciliation in a decades-long conflict. The talks led to the assessment that reconciliation can succeed if the people of Colombia acknowledge the complexity of the conflict. For example, the questions “who was a perpetrator?” and “who was a victim?” are often unclear and cannot be answered with certainty. The students also argued for a culture of remembrance as an important building block for reconciliation, since remembering the past is the only way we can learn from it. The inequality in the Colombi-

Graffiti in Colombia's capital, Bogotá. Street artists deal with the peace process.

Photo: Julian Reiter

an society does not constitute a fundamental obstacle to reconciliation according to the students. Instead, they believed that the consciousness and the behavior of the individual were crucial. The willingness to see things from the perspective of the other side was important, they argued. The students ascribed a central role in the peace process to the media. The media, they believe, have the power to promote the public discourse, but it could also manipulate opinions and fuel conflicts by its reporting bias. Overall, they do not see the peace treaty as an end point but as the beginning of a path with many challenges.

The project team's self-perception also calls for reflecting on the research results with the participants in Colombia. "Our approach," Anika Oettler explains, "provides for scrutinizing our own research practice and for making sure that we're not doing research on the people of the global south but together with them." This also applies to the current research project, Diálogo y conflicto — Dialogue and Conflict — which is ongoing in the context of the Colombian peace process in collaboration with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Friedrich Ebert Foundation (FES). "Against the backdrop of current protests, the issue of dialogue-based conflict resolution is more important than ever," Oettler emphasizes. She is also in demand as a consultant in Colombia. Since 2018, she has been providing scientific and academic support to the work of the truth commission. She is mainly interested in finding ways for dealing with the violence perpetrated against women, gay men and women, and transgender people. This research interest overlaps with the field of inquiry of the political scientist Professor Dr. Susanne Buckley-Zistel, who, working at the center, investigates how the truth commissions are handling gender-specific violence.

DEALING WITH VIOLENCE PERPETRATED AGAINST WOMEN

Transitional justice is one of Buckley-Zistel's research foci. The term is understood to capture a wide range of instruments for dealing with human rights abuses. The goal is to bring perpetrators to justice and to achieve justice for victims, as well as to support the transition to peaceful coexistence. In this research field, the Center for Conflict Studies works closely with other centers at the Philipps-Universität: The International Research and Documentation Center for War Crimes Trials (ICWC) and the "Reconfigurations" research network at the Center for Near and Middle Eastern Studies (CNMS), which explored the upheavals in the Arab world. As a part of the first phase of the project, sponsored by the German Research Foundation (DFG), "Acknowledging Sexualized Violence by Truth Commissions," Buckley-Zistel and Dr. Anne Menzel examined how sexualized violence is addressed in the discourse of truth commissions and what victim roles are attributed to women.

Photo: Issouf Sanogo/AFP via Getty Images

Liberia: Former female fighters in the civil war learning to sew. Many of them had been sexually assaulted by soldiers.

Violence against women has been an integral part of all transitional justice proceedings for several years, including in cases that the research team investigated with regard to places like Sierra Leone and Kenya. These African countries published the final reports by their truth commissions over the course of the past decade. "Truth commissions search for their own way of understanding the past," Buckley-Zistel says. The reports from the countries use the same narratives to explain why women fell victim to violence. In violent conflicts, she continues, sexualized violence often serves as a mechanism to humiliate women.

"Women become the target of sexually motivated crimes mainly because of their role in a society," Buckley-Zistel explains. "Violence serves to reinforce claims of social dominance," she says. "To prevent crimes like this from happening, the understanding of the roles of men and women in society and the balance of power between men and women would have to undergo fundamental changes." In the second phase of the project, the team therefore investigates the extent to which a confrontation with the violence perpetrated against women has led to greater gender-based justice in the countries that were examined.

While it is a great achievement that violence against women is being considered by truth commissions, recognizing women as victims is a double-edged sword. "This recognition can take forms that will further weaken women's social position," Buckley-Zistel points out. Women are in fact not only passive victims but also political actors or, in some cases, even perpetrators, she continues. "The truth commission in Liberia, for example, highlighted the plight of women as victims of violent attacks and ignored the fact that up to one third of the combatant troops consisted of women," Buckley-Zistel reports.

The project team analyzed the texts authored by the truth commissions, as well as official statements by participants for predominant narratives, interpretations, and motives. Interviews and conversations in Sierra Leone and Kenya helped understand the work of the commissions against the backdrop of social trends. Exchanges with women also raised questions that were related to research ethics. "We're dealing with precarious situations. After all, in many societies — including our own — sexual violence is regarded as a stigma. This begs the question of why victims of violence would tell their stories," Buckley-Zistel says. "However, it has been our experience that women are often grateful that someone is interested in their stories at all."

Transitional justice research has a critical orientation in Marburg. "We view the processes with skepticism. The equation that dealing with the past will lead to peace, reconciliation, and a better life does not compute," Buckley-Zistel says. The norms that are behind the process of facing and accepting the past would have to be explored. But this is not always possible, she says. Dealing with the past, she explains, can also stir up conflicts and ignite new problems in the fabric of a society. The idea of justice in the sense of punishing concrete actions is a Western concept. She reminds us that punitive justice is often in conflict with restorative justice, which is more about restoring the social relationships between the parties to the conflict. Next year, further aspects of tensions in the implementation of transitional justice will be analyzed as part of a DFG research project on victims' compensation headed by the Marburg sociologist Professor Dr. Thorsten Bonacker.

Photo: akg-images / Gerard Degeorge

The Killing Fields of Choeung Ek. This place of execution 15 km (9.3 miles) southwest of Phnom Penh is today a memorial to the victims of the Khmer Rouge.

REASONS WHY PEOPLE PARTICIPATE IN GENOCIDE

Truth commissions focus on the victims of violence and on the violence that they have suffered. Genocide research increasingly also addresses the perpetrators and the question of how it is possible that human beings participate in the commission of acts of mass violence. To this end, the conflict researcher Professor Dr. Timothy Williams, who was at the Philipps-Universität until 2019 and is now an assistant professor in Munich, developed an explanatory model he called the "complexity of evil." Williams looks at perpetration from a specific perspective. He neglects the role of perpetrators as individual persons but concentrates instead on their actions: "That's the difference," he explains, "because perpetrators can take on different roles. They're also in part victims, bystanders, or rescuers."

Williams believes that three factors are crucial for determining participation in a genocide. These factors can influence and modify each other. The most important factor is the motivation as it gives the impulse to act. Depending on their situation and the environment, people expect that their needs will be met. The group that the people feel a part of also plays a major role. This may be a party, e.g., the Communist Party of Kampuchea for the Khmer Rouge in Cambodia, or an ethnic group, e.g., the Hutu in Ruanda. These groups exert pressure on the individual creating a risk of being excluded from the group; this may motivate a person to participate in acts of violence. Some individuals may also have an opportunistic motivation, e.g., material enrichment or careerism. In addition, there are factors that facilitate participation in a genocide. These include ideologies that provide a moral justification for violence or that dehumanize the victims. Another facilitative factor is the anonymity afforded to individuals as members of a

The Khmer Rouge captured this Cambodian's home region when he was just ten years old. After a few positions in civilian and military units, he was transferred to a security center at age 16. Because of his excellent performance as a guard, he was promoted to bodyguard and messenger for the prison warden and in this role conveyed orders from the warden to militias to investigate and arrest many people.

Photo: Daniel Welschenbach (from the exhibition "Entering the Tiger Zone")

Khmer Rouge: As the head of an all-female mobile unit, this Cambodian woman (class of 1953) was responsible for around a hundred workers constructing dikes. It was in part up to her judgment whether these women were working hard enough and who on her team might be among the internal enemies.

Photo: Daniel Welschenbach (from the exhibition "Entering the Tiger Zone")

group, thereby relinquishing one's personal responsibility. Social dynamics, moreover, may also lower the threshold for participating in acts of violence. For example, countries with instable political or societal conditions are more vulnerable to genocide. This is in part because some groups may view instability it as an opportunity for shifting the balance of power in their favor.

"Going beyond individual cases, the model enables us to understand the interests and psychological processes at work that lead to participation in genocide and compare the underlying dynamics," Williams explains. He uses the model, for example, in his research in Cambodia. There, he interviewed low-ranking members of the Khmer Rouge who had been involved in the mass murder of their own people between 1975 and 1979. These Khmer Rouge told their life stories and gave a picture of their everyday lives during the Pol Pot regime. "The stories suggest that the interviewees were in fact involved in acts of violence, but they don't see themselves as perpetrators," Williams reports. They largely rejected any personal responsibility while stressing that they were victims themselves. "This perspective is important to protect their self-perception," Williams says. From the point of view of the former Khmer Rouge, the elite cadres within the Communist Party were responsible for the violence in Cambodia. They themselves had no choice but strict obedience. Any indication of protest could have cost them their lives. The interviewees therefore thought of themselves as mere puppets of the regime, without the possibility of engaging in independent action. However, they also reported how they could leverage small windows of opportunity to exert agency in their own lives in order to help people, for example, by shielding them from being arrested.

The perception that almost the entire population — including low- and mid-level Khmer Rouge cadres — fell victim to the regime is a widely accepted reality in Cambodian society. Only a few high-ranking Khmer Rouge leaders were indicted before the tribunal. Williams reflects critically on this: "Although the narrative of universal victimhood facilitates the reconciliation process," he says, "it carries risks for the future. In the event that violence recurs, the people are unlikely to protest and take responsibility for their actions."

The enmeshment of the roles of perpetrator and victim is particularly pronounced in Cambodia. But this issue is also addressed by other projects at the center. For example, the center illustrates the complexity of dealing with a past that is marred by violent conflict. The Center for Conflict Studies offers good prerequisites for managing this complexity — through collaborations among disciplines but also through combining methodologies by linking field research, comparative analysis, and theoretical reflection on these observations. ■

PROFILE

Projects:
Imaginando la Reconciliación (2017 – 2018)
Diálogo y Conflicto (2019 – 2020)
Prof. Dr. Anika Oettler

Redressing Sexual Violence in Truth Commissions (2015 – 2020)
Prof. Dr. Susanne Buckley-Zistel

The Complexity of Evil – Modelling Perpetration in Genocide (2012 – 2017)
Prof. Dr. Timothy Williams

Center for Conflict Studies
Management: Prof. Dr. Susanne Buckley-Zistel, Prof. Dr. Thorsten Bonacker

Founded: 2001

FOR MORE INFORMATION

www.uni-marburg.de/en/conflict-studies

UPHEAVAL IN THE ARAB WORLD

Gardening as political commentary

Little remains of the hopes for democracy and a better life once awakened by the Arab Spring. But the political and social changes in the Near and Middle East reverberate — e.g., in everyday culture, in the relationships between members of different generations, and in dealing with the past. One Marburg research network analyzed the historical roots of the upheavals and the search for an outlook for the future in the region.

Although the upheavals of the Arab Spring exposed the crisis of Arab nation states, they failed to produce speedy solutions. This was a predictable outcome, as Professor Dr. Rachid Ouaissa explains: "Even at the beginning of the upheavals, our researchers at the Marburg Center for Near and Middle Eastern Studies took the position that a transition to democratic systems cannot be expected immediately." The Algerian-born Ouaissa heads the "Reconfigurations" research network at the Philipps-Universität Marburg. The network's work is focused on the structural and historical developments that have transformed the Middle East and North Africa (MENA). From 2013 to 2019, the network received funding from the German Federal Ministry of Education and Research. It pooled regional expertise in Marburg with experts from political science, Arab culture and literature, Islamic studies, peace and conflict research, sociology, history, comparative cultural research, legal studies, media studies, and religious studies.

Starting in Tunisia, in 2011, protests began spreading to Egypt, Libya, Jordan, Morocco, Syria, Yemen, and the Gulf states. Dictatorships were toppled within a short period of time. "These upheavals are the open-ended start to a new phase in the history of the region," stresses Ouaissa. The research network accordingly oriented its work on a concept by the sociologist Norbert Elias: reconfigurations. This concept articulates that changes are underway the outcome of which is uncertain and that they may actually lead to a restoration.

Focus on the changemakers

The reasons for the events in the MENA region reach far back into the past. The research network thus took on the historical roots of the most recent developments. The members of the group — in the sense of a "grassroots history" — looked in particular at the social actors who were instrumental in the uprisings of 2011. "Even under authoritarian conditions," says Ouaissa, "there existed a diverse social trend below the government level; for example, labor struggles, youth protests, resistance in everyday life, or the emergence of autonomous social and cultural spaces."

The Arab Spring made it clear that narratives and ideologies such as pan-Arabism, socialism, or Islamism — and the anticolonial habitus that is common to these currents — were no longer functioning as a legitimation of power. They lost their strength as a unifying bond of the linguistically, ethnically, and culturally diverse population of the MENA region. The research team observed how civil society actors were questioning the official cultures of remembrance and how they injected their own perspectives. As means of expression, they utilized, for example, the visual arts, theater, literature, film, and caricatures.

The new beginning also includes dealing with the past, making sense of the past. Important steps in this direction are the transitional justice processes — as they provide a legal reckoning and social reconciliation following the end of dictatorship and civil war. In the MENA region, Tunisia, Egypt, and Libya, as well as Morocco and Iraq, have gained experience in this area. "In view of the mixed experiences with transitional justice," says Ouaissa, "we wanted to critically reappraise the values underlying this concept and the effectiveness of the processes for dealing with the past in order to secure a lasting peace. In Marburg, we are working on these topics in conjunction with the Center for Conflict Studies and the International Research and Documentation Center for War Crimes Trials."

The countries in the MENA region influence each other, which is illustrated, for example, by the domino effect the Tunisian protests triggered in the neighboring

Photo: Friederike Pannewick

Graffiti reflecting social changes in the Arab world.

countries. But cross-border interdependencies also shape the region. Among other projects, researchers examined the role of the Moroccan port of Tangier as an economic hub between Europe and Africa. The network also looked at migrants and refugees living in Europe who, having crossed borders, contribute to shaping the development of the region.

To understand the changes, the research team has been using the categories of space, generation, and representation. “We don’t consider the countries of the MENA region as spaces in the sense of a defined territory,” Ouaissa explains. “Instead, we are more interested in the actors’ struggles for political, economic, and cultural spaces.” Because the Arab Spring is considered to be a result of protests by young people, the researchers also investigated what shared experiences were the basis for this generation’s commitment to change and how this generation differentiates its political future from the projects of the past by older generations. Further analytical work focuses on how actors create meaning through words, symbols, images, narratives, or art. The researchers describe this as representations of what they observed in everyday routines. “Norms, values, and rules are renegotiated — and reconfigurations are continually annotated — in the way people dress, eat, live, and consume music and film,” Ouaissa explains.

Iraq: In Erbil, the capital of the autonomous Kurdistan Region, high-rises and office buildings are popping up like mushrooms.

Photo: Ryan Koopmans www.ryankoopmans.com / Getty Images

COUNTERMOVEMENT TO THE DUBAI MODEL

One of the research projects of the Reconfigurations network looked at Kurdistan in northern Iraq. Since 2003, this region has evolved into an international capital investment center. Shopping centers, residential areas, amusement parks, and office and hotel towers were erected. The Kurdish government markets its quasi state as "the other Iraq" or "the Kurdish Dubai" claiming its outstanding qualities are a readiness for democracy and economic effectiveness. This picture supplements previous narratives that focus on heroism and genocide. Dr. Andrea Fischer-Tahir investigated how these reconfigurations are interpreted and designed in everyday life. She noted that, in addition to the ambitious construction projects, alternative projects, like district museums, cafés, and art and cultural institutions, also find their spaces. "Projects like these are counter-movements to urban development planning that is often perceived as a delusion of grandeur," Fischer-Tahir explains. "However, I was surprised to discover a wave of small-scale gardening enterprises outside the big cities, and even a revival of small-scale husbandry in the urban context."

People from different professions and of all generations engaged in gardening as a form of cultural representation. "As diverse as these actors are, it became clear that they interpreted the social conditions and their own actions in a similar way," Fischer-Tahir says. Growing fruits and vegetables and keeping chickens is consistent with the desire for healthy food items. "At the same time, it is a critique of Kurdistan's and the region's dependence on food imports, and of the social development that is perceived as alienating Kurdish traditions," she continues. Gardening is understood as a form of re-appropriating nature and a commentary on the identity of the Kurds. These activities are also an attempt to escape a continuous political crisis and a permanent state of war at least in one aspect of one's daily life. "The discourse on health and organic food is integrated with the discourse on Kurdish identity, cultural heritage, and the future of the nation," says Fischer-Tahir.

Young teachers demonstrating in Rabat for fixed employment contracts in the public school system.

Photo: AFP via Getty Images

PRECARIOUS GENERATION IN TURMOIL

Another project by Dr. Christoph Schwarz compared protest movements in Morocco and Spain — two countries that have long been viewed as regional models for the peaceful transition from dictatorship to democracy through the implementation of reforms. Schwarz looked at the generation of young people who suffer, in both countries, from a lack of opportunity and who protested in 2011 for the right to work and the right to make a living. Based on biographical interviews, Schwarz examined how these activists came to be politically engaged and how they viewed the experiences of the older generations.

"Many young activists of the Moroccan Spring had to overcome conflict with their parents," Schwarz reports. "The parent generation feared that the demonstrations would lead to uprisings, which in turn would trigger violent repression that would be reminiscent of the times under King Hassan II during whose reign they had come of age." Despite a certain loosening of the tight political reigns under King Mohamed VI, it is still forbidden to criticize the king, even today. But the young people were not intimidated by the warnings of their parents, nor by threats of repression. They managed to unite the Moroccan opposition across different ideologies and age groups and mobilize the largest demonstrations since independence. "Structurally, these protests — which were mainly started by the younger generation — have done little to effect change," Schwarz notes. "But these experiences have expanded the limits of what can be said publicly." This achievement is at risk now, once again. Protests by the people of Morocco's Rif, a rural region neglected by the government, are again being suppressed by force.

Also in Spain, a surprising alliance came about between the generations in the wake of the 2011 protests. Many young people from the movement of the *Indignados* ("outraged") told Schwarz they could barely discuss politics with their parents – who had grown up during the transition to democracy and whom they frequently described as politically unengaged — whereas they could talk with their grandparents, who had grown up under the Franco dictatorship. "This is how a grandparent movement — the *Yayoflautas* — developed in Spain, a movement protesting the prevarication of the young generation during the period of austerity, set against the backdrop of the grandparents' own experiences with an authoritarian regime," Schwarz reports.

Photo: Yassine Gaidi/Anadolu Agency/Getty Images

STRUGGLE FOR DEMOCRACY

Dr. Mariam Salehi from the Center for Conflict Studies looked at mechanisms for dealing with and making sense of the past in Tunisia within the framework of the Reconfigurations network. After the fall of the Ben Ali regime in 2011, a transitional justice process began, also planned with international support, whose central institution was the Truth and Dignity Commission. Its mandate included dealing with the rule of Ben Ali but also that of his predecessor, Bourguiba, who had led Tunisia to independence in 1956. The ambitious undertaking was coupled with the promise to uncover the truth about atrocities perpetrated by an authoritarian regime, hold the perpetrators accountable, compensate the victims, and ensure that the crimes would not recur.

"Working through and dealing with the past is always shaped by political interests and conflicts over value," Salehi says. "As a result, the carefully planned process couldn't be easily implemented in a step by step fashion." Transitional justice was considered an important project for the moderate Islamist Ennahda Party that won the first free elections in 2011. Many of its constituents are victims of human rights violations, as well as socially and economically marginalized. But the Nidaa Tounes Party emerged victorious from the 2014 elections. It has many members from the old regime in its ranks. "With the change in government, the process of finding ways for dealing with the past lost political priority," says Salehi. "The truth commission was a thorn in the side of those now in power who tried to actively interfere with the truth commission's work."

Salehi's overall conclusion contains mixed results for the Tunisian transitional justice process so far. "The truth commission has significantly advanced the cause of finding the truth and exposing the crimes of the former regime for the eyes of a public-at-large to see. For some victims, acknowledgment of their injuries will be symbolically important, and, for others, compensation might help a little," Salehi believes. In terms of the outlook for the future, however, the commission has hardly fulfilled its mandate. "While the structures of violence have been exposed, they must also be dismantled to prevent actors from the old regime to regain power and repeat these atrocities." Salehi believes it is important to follow up on the recommendations outlined in the truth commission's report that was presented in late 2018. This way, she says, learning to deal with the past could contribute to achieving a sustainable structural change in Tunisia.

Tunisia: People celebrating the eighth anniversary of the Arab Spring on Avenue Habib Bourguiba in downtown Tunis.

Promoting local initiatives

In the final phase of the project, the Reconfigurations network forwarded its findings to changemakers in the MENA region, thereby promoting their commitment. For example, the network supported the Cultural Heritage Research Center at La Manouba University in conceiving a Jewish museum with an affiliated study center in Tunis. The opening is planned for 2020. "The initiative will increase our awareness of the diversity and the minorities in Tunisian society, and it will thus strengthen the democratization process," explains network spokesperson Ouaissa. The network also supported the ongoing educational reform program. Among other contributions, the scientists and scholars organized a conference in Tunisia for discussions on the career opportunities for young people and the development of a vocational training system. ▪

PROFILE

Project:
Reconfigurations Research Network (supported by the German Federal Ministry of Education and Research)

Spokesperson:
Prof. Dr. Rachid Ouaissa

Participants:
Center for Near and Middle Eastern Studies, Center for Conflict Studies, International Research and Documentation Center for War Crimes Trials, Institute for Modern History, Institute for Media Studies, Institute for Modern German Literature, Institute for Social Anthropology and Religious Studies, Institute for Political Science, Institute for Sociology, Center for Gender Studies and Feminist Futurology, Institute for Romance Philology, Institute for English and American Studies, Center for Interdisciplinary Religious Studies, and 13 partner institutions in Germany and abroad

Term: 2013 – 2019

FOR MORE INFORMATION

www.uni-marburg.de/en/cnms/research/re-configurations

HISTORICAL SECURITY RESEARCH

Searching for security in uncertain times

News about terrorist attacks, civil wars, or epidemics intensify the impression that the world is becoming an increasingly insecure place. But is this even true? Especially in comparison with other periods in history? The historical perspective mitigates this perception when it comes to assessing current events, according to research teams in Marburg and Giessen. They investigate what people from antiquity until today have understood security to mean and what consequences this knowledge has had for political action.

In 2015, the former Minister for Foreign Affairs Frank-Walter Steinmeier and the Körber Foundation invited Marburg historian Prof. Dr. Christoph Kampmann, along with other representatives from the science and diplomatic communities, to peace talks in Syria. The motto was: "Westphalia for the Middle East," aimed at the issue of whether we can learn anything for the benefit of the present from the Peace of Westphalia, which ended the Thirty Years' War in 1648. Kampmann is an expert in the Early Modern period and one of the spokespersons for the Collaborative Research Center (SFB) "Dynamics of Security" that is funded by the German Research Foundation (DFG). Since 2014, scientists and scholars from Marburg and Giessen have been researching what contemporaries of different eras understood security to mean and what political dynamics resulted based on these views. "We're essentially doing basic research," Kampmann says. "But as historians, we also appreciate being asked about current events."

In Kampmann's view, the Peace of Westphalia is a good example of how historical experiences can be utilized for the present. Some of the characteristics of the Thirty Years' War — such as the entanglement of various conflicts, the involvement of numerous actors, the interference by major outside powers — we also encounter in the context of the hostilities in Syria. "Obviously, it is understood that the answers that were found the treaty of the Peace of Westphalia can't be transferred verbatim to modern conflicts," Kampmann emphasizes. "It's about incorporating the techniques and tools of diplomacy from that time into today's peace talks." For example, the peace negotiations from 1645 to 1648 teach us that, especially when dealing with difficult conflicts, it is important to demonstrate a willingness to explore new paths, and how important it is to start talking in the first place.

Security in lieu of peace?

Security is a key concept in politics today and in almost all other areas of life — on the internet, in business, the environment, transportation, architecture, health, or migration. Security has in fact replaced the concept of "peace" as a guiding principle. "Peace has a utopian character," says Eckart Conze, professor of modern history in Marburg. "Security seems to be a more concrete, more limited concept that can be applied to many areas." Conze also serves as deputy spokesperson for the research group and is one of the founders of historical security research in Germany. What is security? "Security is generally understood to mean the absence of fear, danger, and threat. But security is perceived differently depending on the context," says Dr. Angela Marciniak, the scientific coordinator of the research group. "In the eighteenth century, the dominant view was that security can be achieved in full," explains the expert in political theory and history of ideas. "It's different today. Uncertainty has become normal. In particular, it's about how or if we can control uncertainty."

The understanding of security is changing

"We operate on the premise that security is a social construct that has developed dynamically throughout the historical process and that is, time and again, the subject of political disputes and rival interests," Kampmann says. The research teams from the fields of history, social sciences, legal studies, and art history capture this dynamic under the concepts of "securitization" and "desecuritization" — drawing from the work by the Copenhagen School that is prominent in political science. Accordingly, it's not about the real existence of threats but about how to communicate about a given topic, and to decide whether or not the firm belief that something is relevant for security concerns gains traction. To understand the dimensions of security and security policy throughout history, the collaboration investigates the period from antiquity until the present in 19 subprojects.

DYNASTIC SUCCESSION AS INSECURITY

One project examines dynastic marriage contracts that were important agreements in the early modern period to safeguard the ruling dynasties. One research team wants to explore how these marriage contracts affected war and peace in Europe. Were marriage contracts — with their provisions on elevating some princes in rank or on territorial expansion — the cause of wars? Or did they promote a stable peace because marriages strengthened the networking fabric among the dynasties? "Both could be true," says project leader Christoph Kampmann. "Dynastic marriage contracts did not serve any long-term strategy but rather short- and medium-term interests," says the historian.

As a basis for its research, the team is compiling a database documenting about 700 marriage contracts by European dynasties from 1500 to 1815. "We're making the contracts accessible by means of analytical categories," explains postdoctoral researcher Dr. Julian Katz, who heads the database project. These categories include references to estate-based information, details on dowries and inheritances, clauses on religious denominations, as well as links to other agreements, such as peace treaties.

In his own research, Katz focuses on dynastic marriage politics in an intercultural context. He takes a closer look at securitization, alliance and marriage politics between the conquistadores and the indigenous nobility during the Spanish colonialization of America.

Postdoctoral researcher Dr. Christian Wenzel investigates the connection between guarantees of succession and ideas of the state's security in the early modern period. "Matters of succession were considered a recurring factor of uncertainty for the stability of dynastic polities," he explains. One illustrative example is the situation in England at the end of the seventeenth century. During the so called "Glorious Revolution", parliament deposed the Catholic Stuart King James II and conferred the crown to his Protestant daughter and her Dutch husband, then attempting to have this arrangement guaranteed by the States General, the parliamentary body of what we call the Netherlands today. "Thus, through a combination of circumstances, the dynastic succession in England was temporarily protected by another republican polity," Wenzel reports. He also studies peace treaties where guarantees of succession play a major role. As an

Photo: © Sotheby's/akg-images

Example of dynastic marriage policy: *The Wedding of the Prince of Wales to Princess Caroline of Brunswick* (April 8, 1795). Painting by John Graham (1755–1817)

example, he cites the Peace of Utrecht, which ended the War of the Spanish Succession in 1713. “The documents relating to the negotiations have received almost no analytical attention to date, especially with respect to the security concerns of the actors, the roles of estate-based players, and the public.”

If queens ruled in their own right in early modern times, this was considered a threat to the security of the dynastic polity. Doctoral student Anja Krause investigates, on the one hand, the reasons for this perception. On the other hand, she examines the nature of the political responses that were available to mitigate the risk. This includes, for example, a marriage contract between the queen and a suitable husband. Krause examines the marriage contracts of the queens of England between the sixteenth and nineteenth centuries. While the husband of Mary I of England, also known as Mary Tudor, (1553-1558), was granted few rights, the Dutch husband of Mary II of England, also known as Mary Stuart, (1689-1694), had extensive powers and inheritance rights. The position of the husband to the successor Anne, Queen of Great Britain (1702-1714), was again greatly diminished. “Among other things, I’m studying why there was no stringent handling of a queen’s rule,” Krause says. “In addition, the fact that the marriage contracts of the queens were approved by parliament provides important clues for analyzing the given contemporary relationship between the dynasty and the polity.”

Photo: Ness Kelton/AFP via Getty Images

In November 2019, the citizens of Bougainville held a vote on their independence from Papua New Guinea.

SECURITY ON THE ROAD TO INDEPENDENCE

The focus of the subproject "International and Trusteeship Administrations" deals with the question of how security issues influence the international construction and reconstruction of states. "Ruling by trusts is not purely an administrative but also a political process with many conflicts," emphasizes Dr. Thorsten Bonacker, professor at the Center for Conflict Studies. The researchers compare the United Nations' (UN) decolonization trusteeship system from the 1950s through the 1970s with the direct administrations on the authority of the UN after the end of the Cold War. "We investigate whose security was negotiated, how domestic and international conditions have shaped the way security claims could be raised, and how this has influenced the statebuilding process," Bonacker says.

The project team is looking at decolonization processes in modern Cameroon, Togo, and Papua New Guinea. These former German colonies were initially administered on behalf of the League of Nations, then merged with the UN trusteeship system after 1945. The administering powers of the trust territories, such as France, Great Britain, and Australia, were supposed to strengthen the economic and social developments in the countries, leading them to independence. The interests in the trustee territories were negotiated by the UN Trusteeship Council. "Because of the Trusteeship Council, an international audience for political issues relating to independence was created for the first time ever," Bonacker explains.

In Cameroon, the French trust administration saw its rule threatened by the anticolonial party, the Union of the Peoples of Cameroon (UPC), and finally banned the party. Dr. Maria Ketzmerick examined the violence-laden decolonization of Cameroon and documented how the UPC appealed to the UN in numerous petitions to help shape the independence of the country. But the UPC was ultimately excluded from the political decision-making process because of its use of violence. The political decolonization process took very different routes in Cameroon and Togo, although, in both countries, the administrations faced similar challenges. Whereas the 1960s in Cameroon were characterized by massive violence, the road to independence in Togo was far less violent. Togo's move to independence was marked predominantly by a conflict between the UN and the power of the French mandate. In his dissertation, Julius Heise focuses on Togo's largest ethnic group, the Ewe. The Ewe felt threatened by the division of the mandate territory into a French section and a British section and repeatedly demanded a reunification.

As in Cameroon and Togo, the conflicts during the decolonization period also have left clear traces in the relationship between state and society in the case of Papua New Guinea, according to Dr. Werner Distler. Subjected to increasingly harsh criticism internationally, the Australian trust administration per se was almost not controversial at all in Papua New Guinea. "There was violence among different indigenous communities, but Australia did not consider this a threat to its own rule," Distler explains. Political groups on the island of Bougainville, which is rich in raw materials, were quick to seek self-determination. An initial declaration of independence occurred in 1975. But Australia and the elites in Port Moresby considered secession a threat to state building. The conflict escalated in the late 1980s into civil war, which ended with a peace accord in 1997. This agreement stipulates that the population can decide their independence. In the referendum in December 2019, almost all eligible votes decided in favor of full independence from Papua New Guinea. It remains uncertain how the central government in Port Moresby will deal with this result.

Photo: Thorsten Bonacker

Poster of the festivities for the twentieth anniversary of the UN's INTERFET mission in Dili (Timor Leste)

As a part of the project, Distler also investigates the two cases of trust mandates after the end of the Cold War, i.e., Kosovo and East Timor. These were multilateral nation-building processes with many participants from international organizations and regional powers. During the UN trust administration in Kosovo between 1999 and 2008, NATO, the OSCE, and the IMF — working

Photo: Julius Heise

Togo: Numerous files are available in the National Archives in Lomé from the colonial and decolonization periods.

alongside the UN and its suborganizations — helped organize the reconstruction with personnel from around the world. The UN exercised extensive powers in Kosovo, which contributed to them, over time, increasingly being viewed as a foreign ruler. The UN's attempts to end nationalist policy and discrimination in Kosovo were unsuccessful. For example, members of minorities, especially Serbs, felt threatened by the Kosovo-Albanian majority and left the country. Or they often live in enclaves now.

In East Timor, since 1999, following a successful referendum on independence, the UN administration has been supporting the transition from the Indonesian occupation of the former Portuguese colony to an independent state. "The former independence fighters constituted the political elite during the UN mandate. They confidently demanded to participate in the transition process," Bonacker explains. But after gaining independence in 2002, they failed to establish a stable democratic system, making it necessary for the UN to assume responsibility once again, as evidenced in a security and stabilization mission from 2006 to 2012 to safeguard, for example, the conduct of safe elections. "The relationship with the former occupying power of Indonesia has improved and no longer poses any security concerns for East Timor," Bonacker notes.

NEW UNCERTAINTIES ARE CHANGING GOVERNMENT ACTION

The subproject "Extended Security" focuses on the issues that have emerged since the end of the postwar boom in the 1970s. These topics have posed new challenges for governments in meeting their responsibility to guarantee security. Initially, the team under project leader Eckart Conze worked on topics related to environment, AIDS, and computers. "We were especially interested to see how these new security issues have changed government actions," Conze says. "We found that states no longer govern only from the top down by passing laws, but also by measures that promote individual prevention, for example." This development has been aided by the involvement of non-governmental actors, such as associations and experts, that are increasingly contributing their knowledge to the debates, thereby influencing policy and, in part, taking over government roles.

The project focuses on nuclear energy and demographic change. "After the serious reactor accidents in Harrisburg, Chernobyl, and Fukushima, nuclear energy is no longer regarded as safe by Western societies and has turned into the subject of contentious debates on the manageability of the risk of nuclear power," says Sascha Brünig, a doctoral student and researcher on the subproject. The Chernobyl accident in particular — which was perceived as a global environmental disaster and the result of outdated technology — contributed to elevating nuclear power from a national to an international safety issue. For example, transnational efforts to ensure process safety in the use of nuclear energy emerged. In addition to the states, institutions, such as the International Atomic Energy Agency, interest groups in the nuclear industry, and associations of nuclear experts use their knowledge and political influence to establish agreements on safety standards.

The "aging population" has been considered a security risk for prosperity, social peace, and sustainability for decades in the advanced industrial countries. Along those lines, doctoral student Tobias Bruns investigates how aging is represented as a threat, e.g., linguistically with words like "senilisation" or the image of the age pyramid. He further analyzes which government and non-government actors have the power to turn aging into a security issue and what effects this has on a society's image of what aging means and, not least of all, the effects on the old and the aging individual. In Germany, the Agenda policies have reportedly inaugurated, since the turn of the millennium, a new form of governance that calls for pursuing and shoring up the objectives of economic competitiveness and of secure social systems equally. To this end, the welfare state has been scaled back in favor of a model that places greater responsibility on the individual, e.g., in the form of private old-age

Photo: Colourbox.de

Ukraine: Radioactively contaminated area around Chernobyl

retirement plans. Bruns intends to compare the development of "aging" as a security issue in Germany and in the United States. "This is particularly interesting because there is no tradition of a social safety net in the United States of the kind as we have in Germany," Conze says.

Furthering a better understanding of development

The examples show how certainty and uncertainty were discussed in a variety of ways in different periods throughout history and variable subject-matter contexts and then translated into policy. With the subprojects serving as a basis, the collaborative research network seeks to establish typologies of the dynamics of security. "These typologies should contribute to furthering a better understanding of current developments and facilitate more accurate problem analysis in a globalized world," Kampmann says. ■

PROFILE

Project:
Dynamics of Security: Forms of Securitization from a Historical Perspective (DFG SFB-TRR 138)

Spokesperson:
Prof. Dr. Horst Carl (Giessen)

Deputy Spokespersons:
Prof. Dr. Eckart Conze,
Prof. Dr. Christoph Kampmann (Marburg),
Prof. Dr. Regina Kreide (Giessen)

Participants:
Justus Liebig University Giessen, Herder Institute for Historical Research on East Central Europe

Disciplines:
History, Economic and Social History, Art History, Political Science, Sociology, Law, Peace and Conflict Studies

Term:
since 2014

FOR MORE INFORMATION

About the project: *www.sfb138.de/en*

Research Campus of Central Hessen
www.fcmh.de/Research/Campus%20Focus/History%20and%20Area%20Studies

INTEGRATED GRADUATE SCHOOL WITHIN THE COLLABORATIVE RESEARCH CENTER "DYNAMICS OF SECURITY"

"Colonial medicine" and the fight against the slave trade

Karina Turmann is one of 24 doctoral students in the German Research Foundation (DFG) Integrated Graduate School (IGS) at the Collaborative Research Center "Dynamics of Security." She is a researcher within the subproject "Security and Empire," where, among other topics, she investigates the kinds of securities and insecurities that the British imperial rule produced during the late eighteenth and nineteenth centuries. Turmann writes her dissertation on "Generation, Transformation, and Instrumentalization of Colonial Medical Knowledge in the British Caribbean." Here, she reports on her experiences with the IGS and on her research.

"After earning my master's degree in history, I started working toward my doctorate in 2017 under the supervision of Prof. Dr. Benedikt Stuchtey at the Institute for Modern History at the Philipps-Universität. I'm doing research on the British colonies in the Antilles. When the abolitionist movement against the slave trade started to take hold at the end of the eighteenth century, several of the British saw it as a threat to the plantation economy, which depended on the labor of enslaved people. I'm particularly interested in medical knowledge which was acquired on the plantations and played a role in the anti-slavery movement. "Tropical" illnesses, such as malaria and yellow fever, were a particular threat on plantations. In contrast to the European settlers, many slaves were immune because they had been in contact with the pathogens from an early age. For the British doctors, it thus wasn't only about understanding and healing. Rather, they were using medicine to justify the slave trade arguing that people from Africa were physically better suited for plantation work than those from temperate climate zones."

Exhibition in Grenada

"During an archival research trip to the Caribbean, I had the opportunity to do research at the National Museum in Grenada. The local curator devised the idea of designing an exhibition on my research topic. Back in Marburg, I therefore developed a series of posters. We supplemented my posters on site with exhibits from the museum. The exhibition is called "Slavery, Science, Security: Plantation Medicine in Grenada during the Age of Abolition." In addition to planning and setting up the project, we had a workshop with students from St. George's that resulted in fascinating conversations and discussions. It means a lot to the museum's staff that the exhibition, which opened in April 2019, will supplement the historical aspects that are on record. This will hopefully help to support their mission of promoting public interest in history and coming to terms with the past while making different facets of the small island more accessible, especially for tourists."

Contributing to basic research

"As a doctoral student at the IGS, I'm also involved in one of the concept groups who perform the basic research for the entire Collaborative Research Center. I'm working with a group called "Difference and Intersectionality." My topic is relevant for the discussions within the group insofar as categories of 'being different' during colonial times or within colonial spaces emerged on several levels, or existing ones changed and intensified."

Exchanging ideas and looking beyond the familiar

"What I appreciate most about the IGS is the intensive exchange of ideas. In the colloquia sessions, I get valuable comments on my own research and an opportunity to familiarize myself with the working methods of other disciplines, such as legal studies or sociology. These new perspectives have been very fruitful for my own work. In addition to content-related aspects, it's great that the German Research Foundation facilitates many other activities, such as attending international conferences, writing workshops, or going on archival research trips. The IGS prepares participants both for careers in academia and outside of scientific research. I haven't decided yet which path I'll follow." ■

FOR MORE INFORMATION

Integrated Graduate School (IGS) at the Collaborative Research Center "Dynamics of Security":
www.sfb138.de/en/graduate-school

Photo: Henrik Isenberg

Rethinking the Maghreb

Promoting the internationalization of the humanities, cultural studies, and social sciences — that's the goal of the "Maria Sibylla Merian Centres for Advanced Studies". The German Federal Ministry of Education and Research has already approved Merian Centers in India, Mexico, Brazil, and Ghana. Based on an initiative at the Philipps-Universität Marburg, another center was opened in Tunisia in April 2020. The research topic is the development of the Maghreb in the aftermath of the Arab Spring.

The future of the Maghreb — which includes Tunisia, Algeria, Libya, Morocco, and Mauritania — is important, not only for the region itself. Scholars from around the world look to the Maghreb as they conduct research on some of the most crucial issues of our time: migration, distribution of resources, religious and identity conflicts. The "Merian Centre for Advanced Studies in the Maghreb" (MECAM) now offers an international platform for research on the Maghreb. The guiding theme is "Imagining Futures — Dealing with Disparity."

The center is coordinated by Professor Dr. Rachid Ouaissa from the Marburg Center for Near and Middle Eastern Studies (CNMS). The main partner in Tunisia is the University of Tunis, which provides a second coordinator. Also participating are the University of Sfax, the Tunisian Institute of Strategic Studies in Tunis, as well as the University of Leipzig, the German Institute of Global Area Studies (GIGA) in Hamburg, and the Forum Transregional Studies in Berlin.

Tunisia is an ideal location in Ouaissa's view. This is not only because of the country's geographical location, in the heart of the Maghreb. It also offers good conditions for researchers from Germany, Tunisia, and many other countries. "Tunisia is the birthplace of the Arab Spring," says Ouaissa, "and the only country in the region with a successful transition to democracy. Academic freedom, freedom of speech and freedom of the press, and a civil society with lively debates in the fields of culture and politics provide fertile ground for our work."

A region that is ready to take off — but where to?

"So far, Near and Middle Eastern studies focused primarily on the eastern part of the Arab world," says Marburg Arabic studies professor Dr. Friederike Pannewick. "With the Merian Center, we are expanding our perspective toward the western part." Ouaissa adds: "To date, the social sciences in Germany have barely been concerned with the Maghreb. We want to change that." The partners at the Merian Center explore how societies in the Maghreb envision their future and renegotiate models for the future of their region. Hence, one aspect of the Merian Center's research is called: "Imagining Futures."

Deeply rooted inequality that developed throughout the history of western North Africa is shaping this renegotiation process. Islamization and colonial rule turned the Maghreb into a region of intense exchange for Africa, the Middle East, and Europe. Many ethnic groups, cultures, languages, and religions meet here. The social differences in the countries are enormous. There are prosperous regions along the coastlines, inside the capitals, and in some economic centers. On the other hand, especially in rural areas, a lack of jobs, of educational opportunities, of health care, and of security dominates the landscape. The consequences are flight, social unrest, and extremism. How do societies deal with inequality? This question is the second aspect of the Center's research: "Dealing with Disparity."

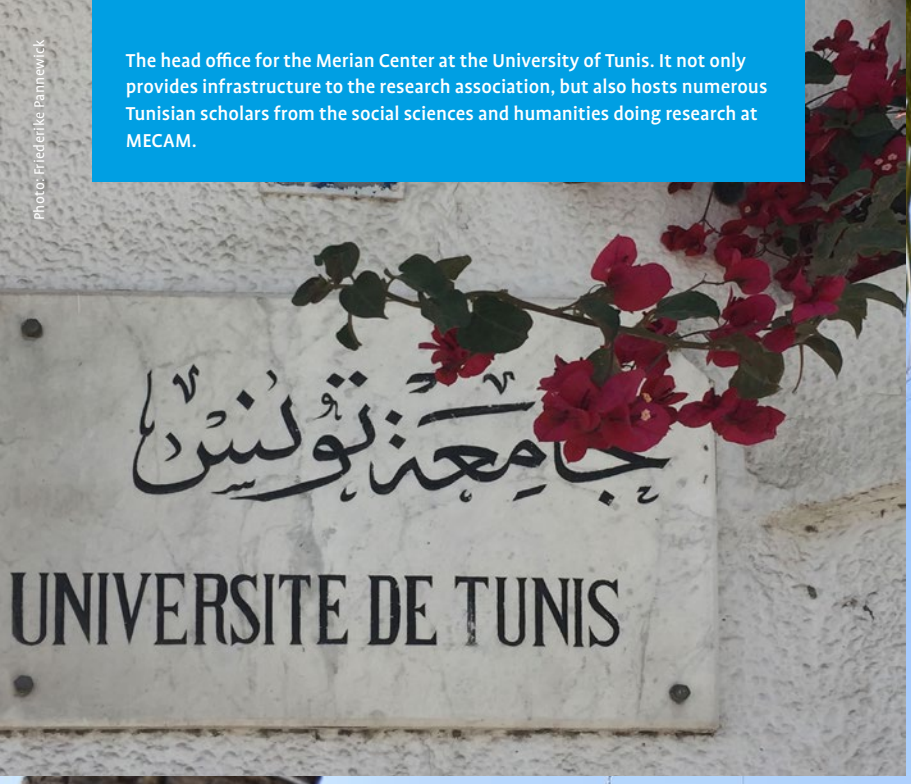
In the footsteps of Ibn Khaldun

The Merian Center is integrated with the University of Tunis, the oldest university in the country. Further Center locations are planned in Casablanca and in Beirut. MECAM will also maintain close relations with the branch office of the Marburg CNMS in Cairo. However, the hub of the project will be in Tunis. Tunis will be the meeting plane for researchers from Germany and the Arab countries, for doctoral candidates, postdoctoral scholars, and young professors from all over the world who will congregate here for joint projects.

Tunis was also the home of fourteenth-century philosopher and politician Ibn Khaldun. With his rational and empirical analyses of the causes of historical developments, he is considered the inventor of the modern social sciences. At MECAM, he is the eponym for an event series, the "Rencontres Ibn Khaldoun;" English: encounters with Ibn Khaldun. "The Rencontres are one of the ways we chose to familiarize the society with our research and discuss it on site with representatives from politics, culture, business, and civil society," Ouaissa says.

Analytical tools accelerate research

IT specialists from the Universities of Marburg and Sfax create a data infrastructure that will facilitate the exchanges of information among the researchers at the MECAM. They also support the digital analysis of content from various media formats, such as text, images, videos, or social media. They developed software to this end that will allow searching documents written in the Arabic script. The department of media studies at Marburg plays an important role in this analysis. It contributes its expertise in performing systemic investigations of the role of the audiovisual media in the social and cultural spaces.



The head office for the Merian Center at the University of Tunis. It not only provides infrastructure to the research association, but also hosts numerous Tunisian scholars from the social sciences and humanities doing research at MECAM.

Photo: Friederike Pannewick

Photo: Andrea Ruppel

Statue of Ibn Khaldun in Place de l'Indépendance in Tunis. The philosopher and politician was born in 1332 and is considered the father of the modern social sciences.

IN FOCUS: PLURALITY AND FRAGMENTATION

The Maghreb is on course to reinventing itself. Societies are facing the challenge of finding options for dealing with their own plurality and fragmentation. MECAM wants to contribute to the current discourse within the region. The many questions about the future of the Maghreb are reflected in the following fields of inquiry being pursued at the Center.

Inequality and mobility

Demonstrators marching during the Arab Spring chanted "Bread, freedom, social justice." In doing so, they denounced decades of indifference by those in power for the basic needs of the population. Since then, social inequality has further intensified. The young generation has responded by emigrating, hoping to find a better life in Europe. MECAM engages in research to assess what this development means for the future of the Maghreb.

Remembrance and justice

The Arab Spring has intensified the debate on remembrance and on how to make sense of past acts of violence and repression. To this end, truth commissions were set up for Morocco and Tunisia, for example. Memories of past injustices and the search for justice continue to shape the future of these countries. The research teams at MECAM are interested in finding out how the legacy of dictatorships influences the expectations, ideas, and models for the future of the Maghreb today.

Aesthetics and cultural practice

The images of graffiti and banners expressing the people's protest went around the world. They exemplify that experiences of violence, humiliation, or trauma are dealt with artistic means in the Maghreb. The MECAM investigates how art, literature, theater, or music influence the ideas about the future of the Maghreb within the respective societies.

Resources and sustainability

The countries of the Maghreb struggle with high unemployment, corruption, nepotism, and large income disparities. In addition, they struggle with problems such as environmental pollution, desertification, and water shortages. This leads to conflicts concerning how resources should be distributed. The MECAM is dedicated to address these questions: How do societies deal with these problems? And what economic model promises to be suitable for a sustainable development?

Identity and religions

The plurality of identities — characterized by belonging to a family, a place, an ideology, an ethnicity, or a religion — has been leveled in the Maghreb over decades. The ideologies created by the postcolonial elites and intended to convey a sense of unity have collapsed. But so far, nothing new has taken their place. The MECAM analyzes how the plurality of identities influences the debates on models for shaping the future.

PARTICIPANTS AT MECAM

Philipps-Universität Marburg (coordination)

Center for Near and Middle Eastern Studies (CNMS): Prof. Dr Rachid Ouaissa (Politics of the Near and Middle East), Prof. Dr Friederike Pannewick (Arabic Studies)

Peace and Conflict Studies: Prof. Dr. Susanne Buckley-Zistel, Prof. Dr. Thorsten Bonacker

Modern History: Prof. Dr. Eckart Conze, Prof. Dr. Benedikt Stuchtey

Sociology: Prof. Dr. Anika Oettler

Romance Studies: Prof. Dr. Olaf Müller

Media Studies: Prof. Dr. Malte Hagener

Information Technology: Prof. Dr. Bernd Freisleben

University of Tunis (coordination)
Departments: Geography, Maghreb Studies, French Literature, Arab-Islamic World in the Middle Ages

University of Sfax:
Departments: Geography, Information Technology and Applied Mathematics, Sociology

Tunisian Institute of Strategic Studies (ITES)

Leipzig University:
Institute of Geography, Institute for Oriental Studies, Small Enterprise Promotion and Training (SEPT)

German Institute of Global and Area Studies (GIGA), Hamburg: Institute of Middle Eastern Studies (IMES)

Forum Transregional Studies, Berlin

FOR MORE INFORMATION

www.uni-marburg.de/en/cnms/research/mecam

Graffiti in downtown Tunis: Street art is a part of the current political discourse.

Photo: Friederike Pannewick

THE WORLD OF LANGUAGE

Language as a cultural asset: Whether spoken or written — language shapes our communal life. Language is enormously diverse and constantly changing. The scientific understanding of language has long been a major field of research at the University of Marburg. Accordingly, the Philipps-Universität is home to one of the oldest known linguistic research centers — the Research Center Deutscher Sprachatlas. Its special features include maps of the linguistic geography and sound recordings of German dialects over the course of time. Using neurolinguistic methods, the scientists also demonstrate how the brain processes language. They established why we trust those people who speak our own dialect more than others, and what grammar has to do with spatial perception. One long-term project that is ongoing at the Institute for Medieval German Philology at the Philipps-Universität is dedicated to collecting all German-language manuscripts from the Middle Ages and make them available to the public. The documents are scattered all over the world and often preserved only in fragments. But they are important witnesses that attest to the rise of modernity.

Photo: David Maurer

Photo: Rolf K. Wegst

Voice recordings at the Research Center Deutscher Sprachatlas

EXPLORING LANGUAGE CHANGE

Speaking dialect creates trust

Dialects are dying out — this was predicted already 300 years ago. They still exist, but they are changing. At the Research Center Deutscher Sprachatlas, the changes of regional speech are analyzed and documented in the form of interactive maps and sound recordings. Using neurolinguistic methods, research teams demonstrate how mechanisms inside the brain operate during the processing of speech and how they contribute, for example, to changing dialects.

"Där goud ahl Mann es met em Gull dorchs Is gebrache on ens kall Wasser gefalle." That's what the following High German phrase sounds like in the dialect of the small town of Schlitz in the Vogelsberg district of Central Hessen: "Der gute alte Mann ist mit dem Pferd in das Eis eingebrochen und in das kalte Wasser gefallen" [English: The good old man broke through the ice and fell into the water with his horse]. This example is one of the 40 sentences that the linguist Georg Wenker used for collecting written data of German dialects at the end of the nineteenth century. Linguists from the Philipps-Universität Marburg recorded present-day dialect speakers reading these sentences aloud. The speaker from Schlitz in eastern Hessen was given the High German version of the sentence above and asked to render it into his own dialect. Further tests with speakers from this region showed that both older people as well as young people alike speak the dialect. But in Oldenburg, which is located in Lower Saxony, a different picture emerges. While the older generation still speaks the local dialect, it has been lost in the young generation.

The current sound recordings of the dialects, as well as language maps reaching from Wenker's time until today, are accessible via the online platform at www.regionalsprache.de. The platform was developed within the framework of the REDE Project of the Academy of Sciences. Newly available are recordings by speakers of different generations. "You can listen to what their best High German and to what their dialect sound like, and how they speak with strangers versus the way they speak with people they know well," Prof. Dr. Jürgen Erich Schmidt explains, who is the director of the Research Center Deutscher Sprachatlas. "The speech recordings let you experience what regionally distinct language sounds like today." For example, even when trying to speak their

best High German, older dialect speakers from Schlitz cannot hide where they originate from. By contrast, young people from Oldenburg speak what is today considered "High German".

Saxon was once High German

People associate "High German" nowadays first and foremost with speakers from northern Germany. But that was not always the case. Until the late eighteenth century, East Central German — for example, Upper Saxon — was considered the most sophisticated form of the German language. The beginnings of what we call High German today go way back. "Luther's translation of the Bible played a crucial role in the spread of written High German," Schmidt says. "Starting from 1720, there is evidence showing that people were speaking the language in the way it was written." Especially with the introduction of compulsory school education around 1800, a supra-regional written German became widespread that, however, followed the rules of pronunciation of the dialects.

"Until about 1900, only regional forms of High German existed," Schmidt explains. "We call this precursor of today's ubiquitous Standard German a 'regiolect.'" The perceived level of sophistication of the spoken language depended on how closely the spoken language approximated the written language. Low German, a dialect which is spoken in northern Germany, was the furthest removed from the High German written language. When learning High German, the speakers in this dialect region began pronouncing the language letter by letter, exactly as it was written. Later, when a standard was established for the "language of the stage" toward the end of the nineteenth century, that language was oriented on the North German pronunciation. The same decision was made in the case of "broadcast German," the standardized language for radio broadcasts in the 1930s. The Saxon dialect has been increasingly devalued ever since.

Even the pronunciation by speakers from, for example, the Rhineland and the Palatinate is no longer considered High German. Instead, they are regionally flavored colloquial speech. "A profound linguistic change and revaluation process has taken place over the past hundred years," Schmidt says. The standard pronunciation popularized by media broadcasts has shaped the idea of what constitutes good supra-regional German. It is also a vehicle for evaluating one's own speech. This explains why regiolects, especially among younger people, have increasingly become more congruent with the standard language.

North-south divide

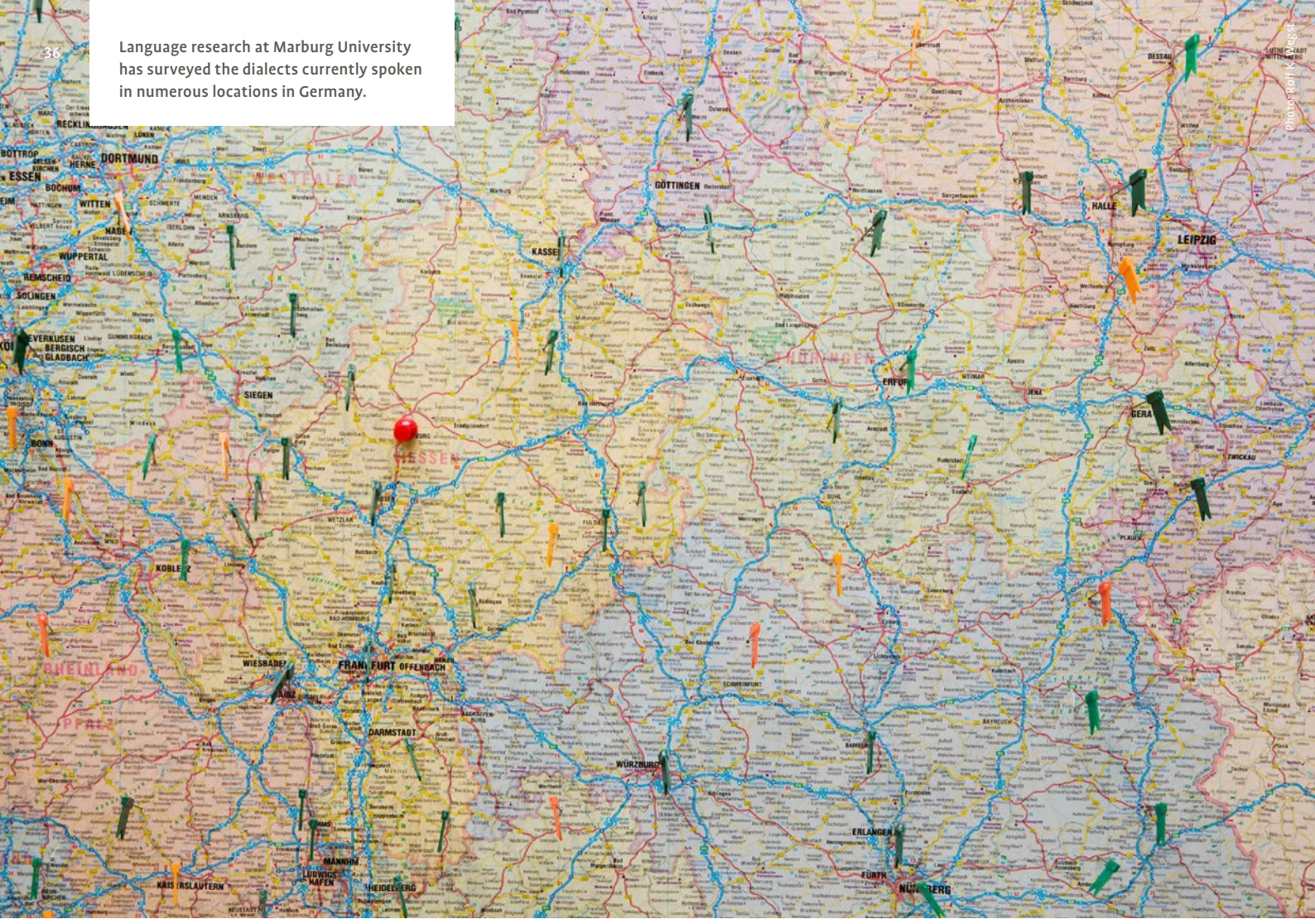
Radical linguistic changes took place to varying degrees along the axis from the north to the south. For example, dialects and regiolects in central and northern Germany, as well as in eastern Germany are retreating more forcefully than in Bavaria and the Alemannic regions. "In the far south of Germany, we still find speakers whose regional language is similar to that spoken in the late nineteenth century," Schmidt reports. An example is the region northeast of Lake Chiemsee. Speakers in this region have command of the regiolect, which they acquired as the reading language in school, as well as of the Central Bavarian dialect. "What is special about this example," says Schmidt, "is that older people always prefer the dialect if they are free to choose from a speech variety. They speak the regiolect only when explicitly asked to speak their best High German. The situation is similar in the German-speaking part of Switzerland."

Photo: Rolf K. Wegst

The nineteenth-century Wenker language maps are among the most valuable documents at the Research Center Deutscher Sprachatlas.

However, he continues, the standard situation for Southern German and West Central German is that the regiolect has become the language of choice in everyday life. Depending on the social situation and level of familiarity with the interlocutor, the pronunciation of the speech will at times trend more toward Standard German, at times more toward the dialect. In the eastern part of the Central Hessen language area, all generations still speak their local dialect. However, when their best High German is required, young people can switch to the Standard German pronunciation, the older generation cannot. Meanwhile, all the linguistic regions within Germany show the observable trend whereby speakers of the younger generation can often only speak a form of their region's regiolect close to the standard language, but they neither speak nor understand their regional dialect.

"East Central German is a special case," Schmidt explains. "A regiolect without variations that is remarkably far removed from the standard regiolect dominates regional speech in Dresden or Erfurt. Whether speakers are asked to speak High German or dialect, it always sounds the same." Schmidt attributes this to the history of German. For a long time, East Central German was considered model High German, which is why there was no need for speakers to adapt their speech to linguistic norms. "Today, this is slowly changing as a result of the devaluation process that this regiolect is undergoing," Schmidt says.



Photothek / Engels

Language research at Marburg University has surveyed the dialects currently spoken in numerous locations in Germany.

SIMPLE PAST TENSE GIVES WAY TO PERFECT TENSE

In their research on language change, linguists combine long-term observations over several centuries with short-term tracking over the past 100 to 150 years. A long-term development is the decline of the preterit, i.e., the simple past tense. This tense still appears in narratives. Hence, the typical formulaic first line of a German fairy tale is “Es war einmal” [English: “once upon a time”]. But there are indicators that the simple past tense might disappear from the German language. Linguist Dr. Hanna Fischer found that this change has been in progress for about 1,000 years — since the emergence of the perfect tense in the eighth century. “Speakers of German don’t draw a strict distinction between the two tenses,” Fischer says. “Throughout the centuries, the perfect tense increasingly penetrated the semantic and functional domains of the simple past tense — and has also been incorporated into the written language.”

One of the reasons for this change is that the simple past is relatively difficult to learn, at least for the irregular verbs such as backen [English: “to bake”]. The simple past tense has only survived for verbs that are used frequently, such as kommen [English: “to come”] or wollen [English; “to want”]. But the breakthrough of the perfect tense is not uniform: “From southern German,” Fischer reports, “the simple past had largely disappeared by the late nineteenth/early twentieth centuries. But this is different for Low German. Therein between lies a transition zone that uses variable numbers of verbs in the simple past tense.”

Photo: Rolf K. Wegst

Project Regionalsprache.de [Project Regional Language]: A team working on transcriptions

WHOM WE ARE MORE LIKELY TO TRUST

Are dialects or regiolects superfluous relics that complicate communication? Are they perhaps even educational obstacles? "No" say the linguists from the Philipps-Universität Marburg. The neurophonetics researcher Prof. Dr. Matthias Scharinger proved that speakers who are proficient in a dialect and in standard High German have more speech-processing neurons, which is advantageous for foreign language acquisition. The familiarity with a language also plays a role in economic behavior and other actions. For example, Prof. Dr. Alfred Lameli, a researcher in Marburg until 2018, and a team from the Department of Economics, found that people who speak similar dialects or regiolects are more likely to cooperate. The participants in an experiment were given a number of tasks. For every correct answer, they received a small amount of money. They could decide whether they would play alone and in competition with all the other participants or join forces with other players and share their gains. It became clear that, in most instances, the test subjects chose to cooperate if they could play with someone who spoke their own regiolect. They otherwise preferred to play alone.

The experiment confirmed another one of the scientists' investigations. They wanted to know why people would move to another region within Germany. And they queried what role dialects and regiolects play in the decision in favor of such a move. To filter out the language factor, mathematical simulations with large amounts of data were used to extract "hard" economic factors as reasons for mobility — for example, job offers, housing prices, or wage levels — and it was found that most people prefer to stay in their familiar language region, provided they have a choice. But why is this the case? "Speakers from the same language region share a common cultural identity and a similar range of experiences," Schmidt says. In addition, Schmidt continues, the differences in the use of articles, case endings, or tonal accents in dialect speech sometimes means that speakers from different regions misunderstand one another, which causes irritation. In this respect, linguists consider it rational behavior when the speakers of a given language prefer the proximity to speakers of the same language.

Photo: Hessen schafft Wissen/Anna Schroll

Experimental linguistics: Brain wave readings of a volunteer

In the neurolinguistic test lab

People assimilate their speech over the long term, when they do not understand each other. They often approximate the construct of the standard language. Or one dialect becomes dominant. The field of linguistic dynamics utilizes brain wave measurements (electroencephalography, or EEG) to document linguistic collisions. Here is an example from the Marburg Language Laboratory: When speakers of the Swabian dialect say "Broat" (High German Brot [English: bread]) in a sentence, a speaker from the Bavarian dialect region will hear this as "breit" [English: wide] because the High German diphthong "ei" is pronounced "oa" in the Bavarian dialect. This sentence then makes no sense to them. The irritation that Bavarian listeners experience are visible on the EEG in the form of voltage changes. "When a person understands the sound combinations from a different dialect correctly, the EEG does not show any differences in cerebrophysiological processing," Schmidt says.

Linguist researchers use neurolinguistic methods, such as EEG measurements, also in the exploration of many other research questions. These include the issue of how the order of subjects and objects in one sentence is processed in different languages. For highly inflected languages with many case endings, the predominant word order within a sentence is subject-before-object, but the object-before-subject word order also frequently occurs. It is understood because the case endings identify clearly which is the agent subject. "EEG measurements showed that test volunteers expected the subject to come first, despite correctly interpreting sentences where the object came first," Schmidt reports. "This discrepancy between the auditory evaluation and the EEG measurements took us by surprise." The researchers found that the object-before-subject word order is processed in two phases. First, the brain signals that the expected sentence structure has been violated, and only then follows a positive evaluation.

GRAMMAR AND SPATIAL PERCEPTION

In Dr. Simon Kasper's view, the expectation that the subject should precede the object in a sentence has to do with our perception. "Language reflects structures of perception," the linguist from the Philipps-Universität says. In his dissertation, he investigated why grammatical structures are the way they are. "Researchers worked for a long time on the assumption that we have an innate sense for correct grammar that we are born with," Kasper says. "Since the 1980s, the presumption has been that more general cognitive skills are relevant." Kasper's research has investigated how spatial perception and linguistic structure correspond. "In space, we focus on figures. The background becomes blurred. Linguistically speaking, figures correspond to subjects, the background to objects. Again, linguistically speaking, agent subjects are always in the foreground for us," Kasper explains. "If a sentence is structured according to our spatial perception, we understand it most effectively. That's why we process structures faster when the agent subject precedes the patient object, as opposed to the other way around."

BABIES CAN DISTINGUISH BETWEEN DIFFERENT LANGUAGES

Ulrike Domahs, professor of neurolinguistics, investigates the neuronal basis of different linguistic processes. Among others, she explores the roles of speech rhythm and intonation when the brain processes speech. "Stress patterns help us finding words in our brain's lexicon," Domahs explains. "Even unborn children are able to process rhythmic speech structures, and newborns can distinguish between rhythmically different languages, such as between German and French," Domahs says. When children learn to speak, they often shorten words to the stressed syllable. They produce, for example, "nana" for "banana."

Domahs and her team found that children transfer the prosodic patterns of the spoken language, which we find in shortened words like "nana," also to the written language. In tests, second graders often separate stressed and non-stressed syllables when they are writing, for example "croco dile." The notion of rhythmic (prosodic) structures in writing is a relatively new research area for Domahs. "Current models of reading and writing still assume that written language is merely organized as a linear sequence of letters," she says. "According to our new findings, we view writing as a hierarchical system with prosodic units." These findings should influence the principles of language teaching, whether in the context of early writing acquisition in elementary schools, of speech therapy or of foreign language learning. "If children recognize the basic rhythmic-prosodic patterns, it helps them selecting the correct grammatical forms and learning the basics of spelling and orthography," Domahs adds.

LINGUISTIC RESEARCH UNDER ONE ROOF

Since 2016, linguists at the Philipps-Universität Marburg have been working in a research building that provides a common infrastructure for the various linguistic disciplines. "This facilitates scientific exchange and networked collaborations on projects for our work groups," emphasizes Schmidt, the director of the research center. The focus areas at the Marburg Research Center Deutscher Sprachatlas include research on language variation and language change, as well as research on the foundations of language and language processing.

PROFILE

Institution:
Research Center Deutscher Sprachatlas

Director:
Prof. Dr. Jürgen Schmidt

Deputy Director:
Prof. Dr. Jürg Fleischer

Department:
Germanistik und Kunstwissenschaften,
Institut für Germanistische Sprachwissenschaft

Founded:
1920

FOR MORE INFORMATION

www.uni-marburg.de/de/fb09/dsa (German)

Academy Project "Regionalsprache.de" (REDE):
www.regionalsprache.de/en

PRESERVING THE GERMAN LANGUAGE MANUSCRIPT HERITAGE

The Middle Ages Meet the Digital Age

The written heritage traditions of the Middle Ages provide important documentation relevant to the cultural, religious, political, and scientific developments of the modern age. Over the 20-year course of the Handschriftencensus project (HSC) of the Mainz Academy of Sciences and Literature, medieval German language philologists at the Philipps-Universität Marburg have collected, described and made this cultural heritage available to the research community and the public in the form of an online database.

Discovering, documenting and expertly evaluating the entirety of medieval German language manuscripts, as well as extending the results to the academic research community has corresponded to a long journey. Marburg philologist Prof. Dr. Jürgen Wolf is already thinking well beyond the present scope of the project: "Our long-term objective is to establish a digitally networked portal of all literary works of the Middle Ages written in all vernacular languages." Similar projects are ongoing in France, Austria, the Netherlands, Switzerland and in Poland. A project in Romania (Transylvania Database) is in the preliminary stages and receiving support from the Philipps-Universität, among other Universities.

Handschriftencensus (HSC) has been in existence since 2006. Since then, more than 500 academic researchers from Europe, the United States and many other countries have contributed their efforts. "The Academy Project emerged out of this group," relates Wolf, who heads the HSC together with Prof. Dr. Nathanael Busch, formerly at the University of Siegen and recently appointed Assistant Chair to the University of Marburg Medieval German Philology Department. The project enjoys international prestige. Researchers around the world use the HSC as a platform and center of expertise in addressing inquiries concerning medieval German language manuscripts and fragments. Concerning the HSC's goal, Wolf says: "It is our task to locate library holdings, then to analyze and describe them, thereby making them accessible to others for research." The research community networks which have resulted are an important byproduct of the project. "The open access database is intended to stimulate in-depth research into the individual manuscripts. We provide the material basis for this work. We uncover new discoveries in hope of them attracting attention from researchers." The academic disciplines in which the HSC's content is called upon include history, legal studies, theology, the social sciences, literary studies, art history, medicine, and the natural sciences.

Many unknown text manuscripts remain to be discovered

Approximately 26,000 medieval German language manuscripts are currently known. They are found in more than 30 countries dispersed among 1,500 libraries, archives, museums and private collections. Wolf estimates approximately 10,000 manuscripts or fragments remain yet to be discovered. The HSC receives notices of new discoveries on a weekly basis, out of which spectacular finds such as the Bardewik Codex of the "Lübeck Law Code" (das Lübische Recht) have emerged. This is one of the most significant manuscripts of legal historical and national historical interest. Two Russian German language scholars discovered the Codex in the History and Art Museum of Yuryevets on the Volga. Wolf comments: "The manuscript was kept unnoticed in the library for years, while it was sorely missed back in Lübeck." The magnificently ornate parchment manuscript originated from the Lübeck chancellery in 1294 and was continuously amended well into the middle of the fourteenth century. With the support of the HSC, an international research team is planning the publication of a facsimile edition of the 99 folio manuscript which has been in Moscow since 2018 undergoing restoration. A further sensational discovery was made by Busch during a manuscript workshop at Melk Abbey in Austria. There he identified a fragment of an unusual and scandalous text on a remnant parchment strip used to fortify the binding and cover of a medieval monastic codex. This is the "Rose Thorn" (Rosendorn), a sort of forerunner of the "Vagina Monologues." Up until this point, such obscene texts were attributed at the earliest to the outgoing Middle Ages. Because the parchment strip dates to around 1300, the discov-

The *Lübeck Law* manuscript was rediscovered in a museum in Russia.

Photo: Project Handschriftencensus

ery necessitates a new look at literary history and the history of the customs and modes of life of the era. It hardly came as a surprise when the international press reported on this sensational discovery.

Not only is the HSC globally acknowledged as the primary point of contact to which all questions pertaining to German language medieval manuscripts are addressed, it is also above all recognized as the defining authority on the subject. Thereby, many doors are opened to Jürgen Wolf, Nathanael Busch and their team, doors to private collections and holdings not generally accessible to the public. Wolf is often abroad in Eastern Europe in search of manuscripts or entrusted with the task of their evaluation. In this way, for example, the German language scholar discovered 40 hitherto unknown manuscripts in Riga, Latvia, among which Guild-books were included. These not only afford a glimpse into how the craftsmen and merchants of the late Middle Ages organized themselves, they spotlight their involvement in the economy, politics, society and cultural institutions of their day as well.

In Eastern Europe more and more manuscripts which were presumed lost in the aftermath of the Second World War are being rediscovered. For example, a parchment fragment of "Tristan and Isolde," the Middle High German courtly love romance by Gottfried von Strassburg, previously believed to have perished, surfaced unexpectedly in Siberia. Two Russian German language scholars discovered the manuscript in 2008 at the Tomsk State Library. Researchers date the origin of the folio to the end of the thirteenth or the beginning of the fourteenth century. Documentary evidence was found in context of the medieval parchment folio. For instance, it bears a receipt stamp which reveals the fragment was archived at the State and University Library of Hamburg (SUB Hamburg) from 1911 to 1928. Subsequent to the beginning of the war, the fragment's path cannot be traced. However, it is now once again available to researchers and is included in the HSC database. Nonetheless, not all discoveries are examples of looted pieces or art, as Wolf adds. "Many manuscripts are found right where they have long since been, even well before the Second World War."

Jürgen Wolf and Nathanael Busch discussing a German-language manuscript from the Middle Ages.

Photo: Henrik Isenberg

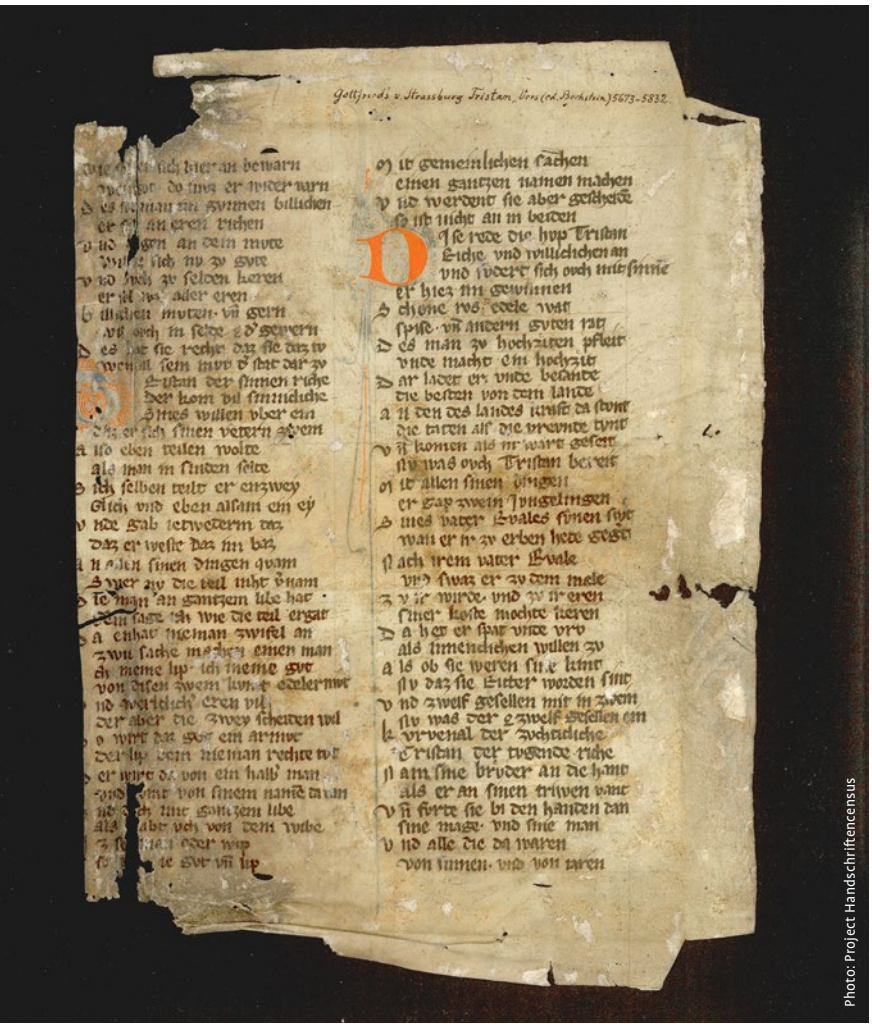


Photo: Project Handschriftencensus

Parchment fragment of
Tristan and Isolde

Arduous Manuscript Evaluation

"As manuscripts are discovered we receive digital reproductions from the institutions which house them," explains Wolf. Consequent to a new find, an intensive scholarly evaluation ensues. The Marburg medieval philologists ascertain a wide range of information about each manuscript, to which belong its regional provenance and date of origin. Even the exact scriptorium from whence it emerged and its dialectical attributes can be determined. The content of the script is also identified and digital images are produced. "With the aid of paleography, script characteristics can facilitate the dating of a manuscript to within 20 or 30 years," maintains Wolf. The Marburg German language scholars are often in demand as expert appraisers, in the assessment of manuscript authenticity, for example. The information regarding manuscripts is recorded according to an established system. Standardized manuscript title designations are developed within the scope of the project which are recognized world-wide. The HSC works in partnership with the German National Library (Deutsche Nationalbibliothek) which maintains the Integrated Authority File (GND – Gemeinsame Normdatei) together with numerous other libraries, archives and institutions.

Interconnectivity with other databases is a prerequisite for the HSC in reaching its goal of completely cataloging all German language medieval manuscripts. As it stands, databases for Old High German manuscripts, gloss manuscripts and Freidank manuscripts are integrated into the HSC. "We are introducing a new database so as to interface with additional contributions as well with as with the German National Library catalog," remarks Wolf. "The capabilities of our current solutions, in place since the 1990s, have reached their limits." The new database will demonstrate portal competencies and display an intuitive user-friendly front-end system. The featuring of interactive functions is anticipated. "For example, we intend to provide script-analysis and dialect-analysis tools. The idea is for users to have the ability to identify a manuscript's origin date and region as well as the characteristics of its dialect with the aid of an intelligent timeline," says Wolf, looking forward to the future. A need for such capabilities is shared by other disciplines, as in the case of cultural historians or natural scientists who, for example, look to identify herbal or alchemical books.

The project team works closely with Research Data Management (RMDO), the Library (UB – Universitätsbibliothek) and the Computer Center (HRZ – Hochschulrechenzentrum) of the Philipps-Universität on the development of the database portal. The University Library (UB) assists by developing uniform standards for registering and networking the data. The University Computer Center (HRZ) and the Mathematics and Computer Science Departments contribute IT competencies. "We certainly need personnel with dual expertise in IT and medieval philology," comments Wolf in regard to the HSC's staffing requirements. "Because this combination is so uncommon, we actively train people ourselves." A great deal of work remains for the project to do: "We have manuscripts which have been only partially and rudimentarily registered and that with scanty data," says Wolf. "A great many medieval

Photo: Henrik Isenberg

German studies scholars Nathanael Busch (left) and Jürgen Wolf (back right) are working on the *Handschriftencensus* project closely with a team from the Marburg University Library.

manuscripts have yet to be discovered, for example, in cases in which the parchment was recycled into book covers or envelopes in the sixteenth and seventeenth centuries."

The HSC operates at the intersection of traditional philology and the digital humanities. The utility of digitalization is all too evident: data can be kept up to date, searched and dynamically arranged. Furthermore, the data pool can be networked among the research community. Approximately 80 Marburg academics are expected to take advantage of the HSC's digital content. With this in mind, the University founded the "Marburg Center for Digital Culture and Infrastructure" (MCDCI) in collaboration with the Herder Institute for Historical East Central European Research (Herder-Institut für historische Ostmitteleuropaforschung), the Hessian State Archives (Hessisches Landesarchiv), the State Office for Regional History of Hessen (Hessisches Landesamt für geschichtliche Landeskunde) and the Archives School Marburg, University of Applied Studies for Archival Science (Archivschule Marburg, Hochschule für Archivwissenschaft). Jürgen Wolf is acting spokesperson for the new Center. ▪

PROFILE

Project:
Handschriftencensus – a survey of the hand written traditions of medieval German language manuscripts. A Project of the Mainz Academy of Sciences and Literature

Department:
German Studies and Arts,
Institute for Medieval German Philology

Directors:
Prof. Dr. Nathanael Busch
Prof. Dr. Jürgen Wolf

Term:
since 2017

FOR MORE INFORMATION

www.handschriftencensus.de

Accompanying career paths

Doctoral candidates and postdoctoral fellows contribute greatly to research at the Philipps-Universität. In Marburg, they find a productive environment that supports them on their career paths – from doctorate to established positions in or outside academia. Support services include coaching, counseling, and networking events, as well as service institutions, such as the Office for Young Academics, the Gender Equality Office, Family Services, the International Office, and the Welcome Center.

Regardless of whether students wish to pursue a career in science, science management, or business, it is crucial that they receive excellent support that will promote the individual development of each doctoral candidate. An essential element for designing the dissertation phase is therefore the supervision agreement. It captures the mutual rights and obligations by doctoral candidates and their supervisors. The agreement contains work and time schedules, and both parties commit themselves to a regular exchange on the progress of the doctorate. "Constructive cooperation is crucial for the success of the doctoral dissertation," says Prof. Dr. Sabine Pankuweit, Vice President for Gender Equality and Young Academics at the Philipps-Universität Marburg. Starting in 2020, the university will therefore confer an award for excellent doctoral supervision.

Research on the topics of the future

Integration into scientific projects and networks is another factor to ensure success for doctoral candidates. The Philipps-Universität supports "structured doctoral programs" and currently holds speakerships for five Research Training Groups funded by the German Research Foundation (DFG). These programs provide intensive supervisory support for doctoral candidates, a curriculum of courses, and plenty of free space for own initiatives.

A special feature is the cooperation of the Philipps-Universität with the Max Planck Institute (MPI) for Terrestrial Microbiology. Since 2003 there has been a outstanding doctoral program, which is attracting young female and male scientists from all over the world. The program of the International Max Planck Research School for Environmental, Cellular and Molecular Microbiology (IMPRS-Mic) offers interdisciplinary further education in modern microbiology, a research infrastructure on the latest state of the art and a supervision by top female researchers and researcher.

Academy for young scientists

At the Philipps-Universität Marburg, human resources development for young scientists is bundled in the MArburg University Research Academy (MARA). The academy promotes the dialogue of young researchers about the limits of scientific cultures and disciplines. MARA supports equal opportunities and the compatibility of scientific career and family. Core task of MARA is interdisciplinary extra-disciplinary further training. PhD students and postdocs acquire professionally relevant competencies in research and teaching, leadership and management. Furthermore MARA offers financial subsidies, advice and support in building networks.

Plannable future

Opening up reliable career paths to professorship for scientists and scholars has been a concern of the Philipps-Universität for many years. In 2019, the university has received funding for 21 tenure-track professorships from the Federal Ministry of Education and Research. In future, the university intends to fill 20 to 30 percent of all professorships that become vacant as planned using the tenure-track procedure. This is intended to attract outstanding talents who have the potential to contribute to the university's profile development. To this end, they will be provided with their own personnel and material resources. The "Marburg Young Faculty Network" is to play an important role in this process. For example, it offers help in establishing contacts with foreign researchers. These offers are also open to those who are interested in other temporary training positions work, for example at the top a junior research group or owners of a Heisenberg-Professorship.

For more women professors

By providing interdisciplinary support for women, the Philipps-Universität would like to contribute to the fact that more female scientists are pursuing the path to a professorship. Family commitments, in particular, mean that many highly qualified women forego the leap to the next qualification level after completing their doctorates. At Marburg University, support for women already begins during their studies. In the program ProMotivation, female students and graduates are accompanied in their decision process for a doctorate.

The Philipps-Universität is involved in the Mentoring Hessen program, which offers various lines of support. Around 40 young female scientists were supported by one of the programs in 2019. ProCareer.MINT supports female students of scientific and technical subjects in their professional and personal development. Through the Pro-Career. Doc program, doctoral students and postdocs receive support in their career planning. (Post-)doctoral students who wish to pursue a career in science will be supported by the programme ProAcademia. Aim of the program ProProfessorship is the scientific profile building, strategic Career planning and support in application procedures for a Professorship.

Photo: Katja Trachte

Up high: Conservation biologist Dr. Katrin Heer on her way up to one of the observation towers in Ecuador's mountain rainforest.

THE NEXT STEP TO BECOME A PROFESSOR

The Marburg nature conservation biologist Dr. Katrin Heer participated in the ProProfessur mentoring program. The funding supported her in her next career step as a scientist: starting in 2020, she will be heading an Emmy Noether Junior Research Group investigating the phenology of tropical tree species. With the Emmy Noether Program, the DFG gives outstanding young researchers an opportunity to qualify for a university professorship over a period of six years by independently managing a group of young researchers.

"During the mentoring program I benefited greatly from the workshops that provided detailed insights into the process on how to apply for professorships. They also provided the framework for a critical examination of my own research profile. I experienced the meetings with my mentor as very enriching. She discussed her own and my scientific career very openly and constructively. She also provided the decisive impulse to apply for an Emmy Noether Junior Research Group, and gave valuable recommendations for completing my application, and later for the presentation at the DFG."

FOR MORE INFORMATION

All information relevant for doctoral candidates or interested parties can be found here: *www.uni-marburg.de/en/research/young-academics*

Workshop at MARA

Photo: Rolf K. Wegst

BRIDGE TO THE SCIENTIFIC CAREER

Dr. Maria Männig received a one-year bridge scholarship from MARA in 2018. The funding is provided by the German Federal and State Program for Women Professors and benefits female scientists during the phase of their education when they conceive a habilitation project and seek funding to finance their research. The scholarship funded Männig's research project, which aims at investigating the history of images and media in art history from the perspective of slide projection. The project had an interdisciplinary orientation. Dr. Männig was attached to the Institute of Media Studies at the Philipps-Universität Marburg with Prof. Dr. Jens Ruchatz (Professor of Media Studies specializing in audiovisual transfer processes) as her supervising advisor.

"With the scholarship, I drafted a project application and, working together with Prof. Dr. Hubert Locher, I organized a conference entitled 'Media in the Teaching of Art History' in Marburg at the German Documentation Center for Art History – Bildarchiv Foto Marburg. The funding made it possible to implement these projects in an environment with a specifically interdisciplinary orientation. By bringing my project into the context of media studies teaching, I was able to gain experience in a field that had been unfamiliar to me until that time. Since I'm not a graduate of the Philipps-Universität, this format also enabled me to get better acquainted with the institution and make some new contacts here."

Photo: Felix Grünschloß

Dr. Maria Männig

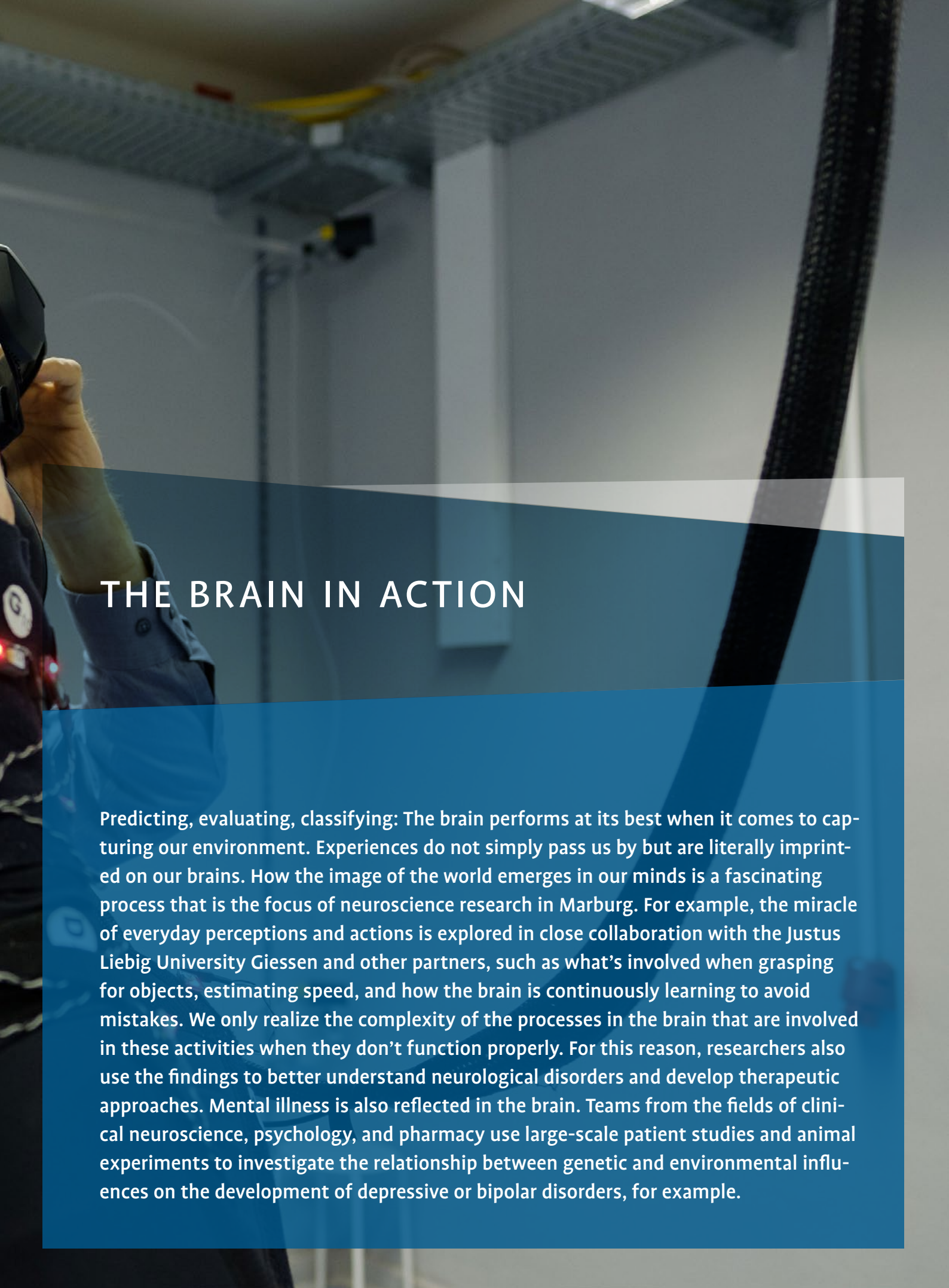
Prof. Dr. Elke Pogge von Strandmann is leading the new Research Training Group in tumor biology.

Photo: Gabriele Neumann

FOCUS ON BASIC RESEARCH AND DEVELOPING THERAPIES

The newest DFG Research Training Group (RTG) at the Philipps-Universität Marburg will start in 2020 in the field of tumor biology. The focus will be on tumor secretome, which means all of the substances secreted by tumor tissue. The goal is to investigate the influence of the secretome on tumor growth, the formation of metastases, and therapeutic resistance. The participating research teams from Marburg and Giessen want to find out whether the secretome contains relevant biomarkers that can be used for novel therapeutic approaches. “It is our objective to establish an internationally competitive research center equipped for the structured education of outstanding doctoral candidates in this field and to thereby do our part in making Marburg an internationally attractive location for tumor research,” says the chairperson of the Research Training Group Prof. Dr. Elke Pogge von Strandmann of the School of Medicine at the Philipps-Universität. “The RTG contributes to the education of a generation of young scientists that engages in basic scientific questions, as well as clinical research.”

Photo: Rolf K. Wegst



THE BRAIN IN ACTION

Predicting, evaluating, classifying: The brain performs at its best when it comes to capturing our environment. Experiences do not simply pass us by but are literally imprinted on our brains. How the image of the world emerges in our minds is a fascinating process that is the focus of neuroscience research in Marburg. For example, the miracle of everyday perceptions and actions is explored in close collaboration with the Justus Liebig University Giessen and other partners, such as what's involved when grasping for objects, estimating speed, and how the brain is continuously learning to avoid mistakes. We only realize the complexity of the processes in the brain that are involved in these activities when they don't function properly. For this reason, researchers also use the findings to better understand neurological disorders and develop therapeutic approaches. Mental illness is also reflected in the brain. Teams from the fields of clinical neuroscience, psychology, and pharmacy use large-scale patient studies and animal experiments to investigate the relationship between genetic and environmental influences on the development of depressive or bipolar disorders, for example.

CONTROLLING PERCEPTION AND BEHAVIOR

It's all in your head

Turning a page, setting down a glass, or catching a ball — seemingly simple actions that depend on complex processes in the brain. That these operations are not obvious only becomes clear, when a problem occurs. Research teams from Marburg and Giessen explore the workings of the brain and the mechanisms it uses to process the many environmental stimuli. The findings help us understand neurological and psychiatric disorders, and much more.

The first thing that we reach for in the mornings is a coffee mug in the cupboard. We set it under the spout of the espresso machine. With the press of a button, we hear and see beans being ground up, we hear the hiss of hot water, and we watch steam rise. The smell of the coffee reaches our noses, and we enjoy the aroma. We don't consciously think about such a routine process, but the brain is actually perceiving and processing a variety of impressions: movement, sound, smell, and taste. How do our brains manage to coordinate so many stimuli and movements so that we can successfully execute an action? And what happens inside the brain, when we reach and miss, and the coffee mug ends up in shards on the floor?

Neuroscientists from Giessen and Marburg who joined forces for a special research project funded by the German Research Foundation (DFG) titled "Cardinal Mechanisms of Perception" explain perception on the basis of three basic mechanisms: prediction, valuation, and categorization. "With these mechanisms, the brain creates and updates mental models of the environment," says Marburg neurophysicist Professor Dr. Frank Bremmer. "These models are continuously updated by the brain. They enable us to predict the future state of our environment and the consequences of our actions, assess the potential risks and benefits of stimuli and responses and categorize the infinite quantity of environmental stimuli to make it easier for the brain to process them." Since 2014, Bremmer has been conducting research as part of the research group, together with about 70 other researchers from the fields of physics, medicine, psychology, biology, sport science, and linguistics.

THE UNEXPECTED IN SIGHT

To avoid brain overload due to countless sensory stimuli that the brain must process in parallel, non-relevant stimuli are filtered out, and the information that is important at a given moment is further processed. However, something may suddenly happen that isn't in the forefront of our attention — e.g., when a pedestrian suddenly crosses the road while we're focusing on the vehicle ahead. Bremmer and his team have found that the brain nonetheless perceives such an unforeseen motion, and it predicts what is likely to happen next.

The research team demonstrated this in an experiment: the test subjects sat in front of a screen and were given the task of focusing on a dot in the center of the screen. They were instructed to press a button when the dot would change its shape. However, this task served only to occupy the subjects' attention. The actual experiment began, when a second dot moved horizontally from left to right through the field of vision. In the center of the screen, its motion was hidden. Behind the cover, the dot moved in part along a different trajectory. During the experiment, the brain waves of the test subjects were measured using an electroencephalogram (EEG).

"If it's true that our brains continuously monitor the environment around us and make predictions about processes without us noticing it, our brains would have to respond to the unexpected change in the trajectory of the dot, even if our attention is focused elsewhere," Bremmer explains. And in fact, the EEG showed an enhanced brainwave signal at the time of the sudden deviation of the trajectory. Neuroscientists speak of a "mismatch negativity." Applied to the example of the suddenly appearing pedestrian, this means, because our brains have an idea of how the traffic around us is supposed to flow, it can respond this quickly to the presence of the pedestrian. The pedestrian's unexpected appearance is at odds with the internal prediction, thereby triggering an activation inside the brain — the mismatch negativity. The result shows how our behavior adapts to continuously changing environmental conditions but can also remain stable vis-a-vis short-term, random changes.

Brain wave readings of a test subject

Photo: Rolf K. Wegst

PREDICTIONS REDUCE STRESS ON THE BRAIN

The brain distinguishes between signals that are generated by one's own movement and signals that are perceived from the environment. "To successfully interact with the environment, it's essential that we perceive our own actions and the sensory impressions they generate," explains Professor Dr. Benjamin Straube of the Department of Psychiatry at the University of Marburg. The effects of one's own actions are usually predictable. For example, when knocking on a door, we see the hand moving, we feel the pressure against the knuckles, and we hear the knocking sound. Researchers have studied the predictive mechanisms of the brain for a long time only for individual sensory impressions — e.g., for visible, audible, or tactile stimuli. However, Straube and a team of researchers from the psychology and medicine departments in Central Hessen queried how the brain predicts the effects of actions that involve the use of multiple senses.

The scientists combined the senses of sight and hearing in their experiments, specifically showing dots on a screen and playing sounds via headphones. The test subjects either triggered the stimuli themselves by pushing on a button or by passively perceiving them. Magnetic resonance imaging (MRI) was used to observe how the brain processes the stimuli. This imaging technique can be used to measure brain activity indirectly. The team observed that in instances when test subjects triggered the stimuli themselves, the activation of the regions of the brain that are responsible for processing visual and acoustic

stimuli was significantly lower than in situations when the subjects received the stimuli passively. “Apparently, the work load for the brain is reduced, if we can predict that a sound will be heard, or that a dot will be seen on the screen,” Straube says. “These predictive mechanisms reside in the cerebellum.”

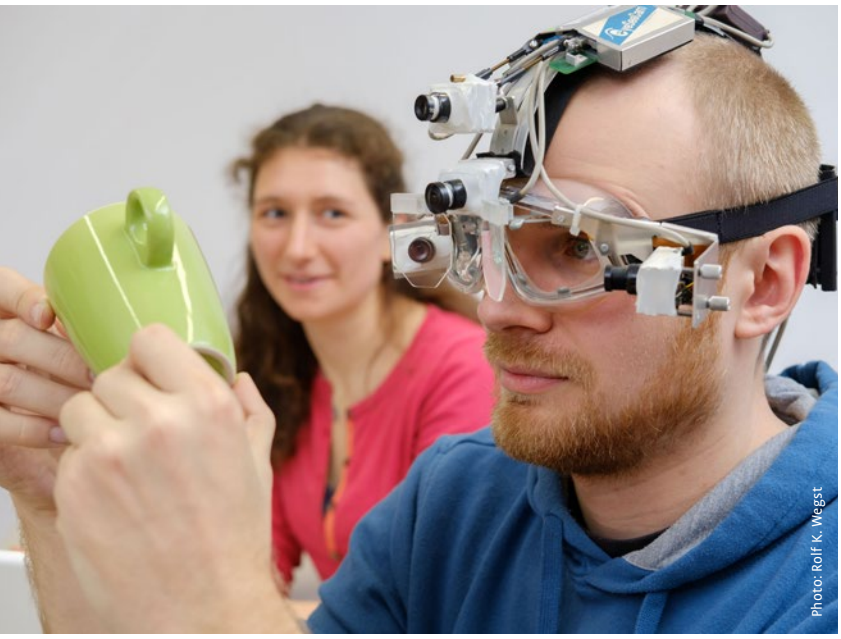
These findings help to better understand neurological and psychiatric disorders. For example, while the distinction between one’s own actions and the actions by another person is functional as a matter of course in healthy individuals, schizophrenia patients cannot with any degree of certainly attribute actions to themselves or to another person or persons. The researchers now investigate how perception works precisely in schizophrenia patients and what causes the faulty processing mechanisms.

ESTIMATING SPEED

We receive a large portion of our sensory input via our eyes. We gather information about our environment by moving our eyes to different points. But there are always many possible targets for eye movements. To decide whether and where we should direct our gaze, we need to evaluate the possible targets. Marburg psychologist Professor Dr. Alexander Schütz and scientists from Giessen studied how eye movements influence visual perception.

For example, how does the brain manage to perceive the writing on a destination display of a moving bus? “In order to be able to read the writing, the fovea — that’s the point of the sharpest vision on the retina — must be directed at the display,” Schütz explains. There are two different eye movements. On the one hand, there is the saccade, a very fast jump from one point to the next that also occurs when reading a static text, for example. On the other hand, there is smooth pursuit, whereby the eyes move continuously while they follow moving objects. This allows readers to adjust their eye movements to the speed of a passing bus and read the display that indicates the vehicle’s destination.

“If the target is too far away or moves too fast, the pursuit system needs the support of the saccade system,” Schütz says. “Information on the interaction of these different eye movements and their effects on our visual perception is still relatively scarce.” The research team wanted to explore how saccades, i.e., rapid gaze jumps, influence the perception of speed. The psychologists chose experimental conditions where the same stimulus was tracked either with pursuit only or a combination of pursuit and saccadic eye movements. The test subjects were instructed to track a horizontally moving dot as closely as possible with their eyes and then estimate the dot’s speed. “Surprisingly, we found that saccades influenced the perceived speed of the target object,” Schütz says. People who used saccadic eye movements to track the object with their eyes estimated higher speed values. When they performed a saccade in the opposite direction, they estimated slower speeds. When the subjects used pursuit eye movements alone, the estimated speed and the actual speed matched.



Eye movements are followed with the eye tracker.

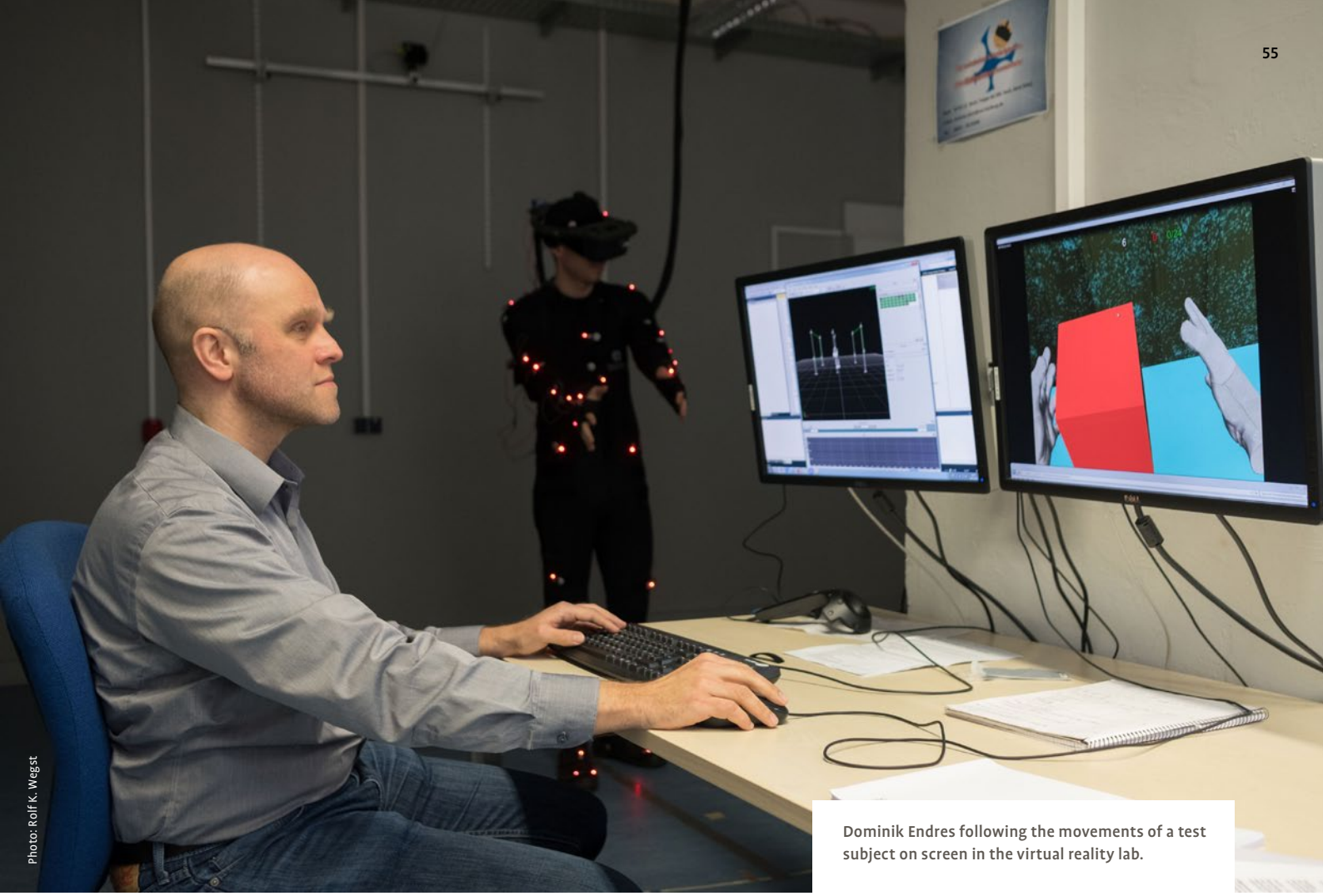


Photo: Rolf K. Wegst

Dominik Endres following the movements of a test subject on screen in the virtual reality lab.

LEARNING FROM MISTAKES

Eye movements are controlled by the cerebellum, among other structures. Even with simple tasks, such as looking from left to right or from top to bottom, small deviations can occur. In such a case, the neurons in the cerebellum send out alarm signals — just before we repeat an eye movement. “This helps us learn and adapt the movement the next time it is performed,” says Marburg psychologist Professor Dr. Dominik Endres. He has been studying the mechanisms at work between the cerebellum and eye movements working in conjunction with neuroscientists from Tübingen. “We knew that the cerebellum collects all the information needed for optimum movement in the Purkinje neurons. This includes signals from the so-called climbing fibers. But their functionality had not been precisely deciphered,” Endres reports.

One experiment yielded the unambiguous result that the climbing fibers are clearly responsible for error signals: rhesus monkeys tracked a dot on a screen that occasionally changed its distance relative to the center causing it to appear where the animals did not expect it. Their gaze thus landed next to the target. The measurement of the Purkinje neurons in the monkeys’ brains indicated that the climbing fibers conveys a signal at the same time that the movement error occurs. Shortly before the animals performed another eye movement, the signal was also conveyed, specifically as a function of the error committed earlier. Apparently, the cerebellum remembers mistakes and ensures that they are not repeated. In this way, the cerebellum controls eye movement but also other movements, such as lifting a cup, brushing one’s teeth, typing, or speaking. Patients suffering from multiple sclerosis or ataxia, after strokes, or presenting with brain tumors cannot precisely control these movements. The researchers are hopeful that their findings will help bring about treatments for these diseases in the long run.

PUTTING EMOTIONS INTO WORDS

Perception is often about how we experience objects and how we adapt our behavior to interact with them. It's also about how some illnesses prevent patients from properly processing information related to space and movement, or how some patients can see objects correctly but cannot grasp them. The perception of emotion is different from this. Emotion is a construct of the human mind. Emotion is conveyed via language and cannot be seen, nor seized. Recognizing and naming one's emotions is part of human communication and the basis of social relationships. The expert in clinical linguistics at the University of Marburg is Professor Dr. Christina Kauschke who explores, with her team, the question of how individuals express their feelings and how they understand and process words and facial expressions that represent emotions. What are the consequences if communication about feelings fails? To this end, Kauschke's team studies children of different ages both with and without speech and language disorders.

Together with the University of Giessen's developmental psychologist Professor Dr. Gudrun Schwarzer, Kauschke looks at how children process emotional information when categorizing words and faces. One of their studies examined how elementary school children perceive words that are used to express feelings. Children between the ages of six and nine years, as well as adults, listened to recordings of 24 emotion terms. As their first task, the participants were asked to indicate whether they knew the words or not. And as their second task, they were asked to evaluate the words as positive or negative. Third, they were given a set of incomplete sentences and asked to complete them with one of four optional terms. Example: "If I come home too late, my parents will be . . . worried — afraid — hopeful — hungry." Finally, the children filled in the blanks with appropriate emotion words, without any guidance. Example: "If the bus drives away right in front of me, I'm — unlucky."

The six-year-olds gave correct or acceptable answers more than 80 percent of the time for the first three tasks; the nine-year-olds achieved over 90 percent for the same tasks. The value for adults was about 98 percent. For the most difficult task of productively finding a suitable word without assistance, the results declined somewhat for all groups. "The ages between six and nine seem to be a phase during which the processing of emotion terms evolves considerably," Kauschke says. "The performance of nine-year-olds is nearly adult-like," summarizes Kauschke.

By acquiring terms that are suitable to express feelings, children take important steps toward building abstract categories. "This is an essential prerequisite for other cognitive and linguistic requirements, which are demanded of school-age children," says the scientist. In addition, she continues, the ability to communicate about feelings promotes emotional competence, such as regulating one's emotions, and is therefore greatly important for the overall healthy development of children. "Talking about emotional experiences within families will have a positive effect on the emotional and linguistic development of children," Kauschke says. Further studies will explore how children with developmental language disorders process emotional expressions.

Pooled expertise

The research presented here is part of a total of 19 projects by the Collaborative Research Center under the project heading "Cardinal Mechanisms of Perception". The research group belongs to the Center for Mind, Brain, and Behavior (CMBB) that was founded in 2018, an interdisciplinary scientific institution of the Universities of Marburg and Giessen within the context of the Research Campus of Central Hessen. At the CMBB, numerous research groups and associations, projects and graduate training groups are represented and network on questions concerning the functionalities of the brain. "Researchers from Marburg and Giessen have been working together since 2004 in the field of neuroscience," says Frank Bremmer, managing director of the CMBB. "By organizing the Center, we are pooling the expertise of currently about 250 members."

The two universities also focus on developing their junior researchers: Since 2013, Frank Bremmer has led the international graduate program "The Brain in Action", a German/Canadian collaborative project. The graduate program provides doctoral students with a solid foundation in theory and experimental techniques. "Outstanding expertise and an international network are crucial to making further advances in the neurosciences," Bremmer emphasizes.

Test subject with motion sensors

Photo: Rolf K. Wegst

SOFTWARE IMPROVES THE CAPABILITY OF DIAGNOSING PARKINSON'S DISEASE

Translational projects supplement the basic research by the research groups and the CMBB. One example is the development of software for the early diagnosis of neuropsychiatric diseases, including Parkinson's disease. The project, funded by the Federal Ministry of Research, aims to use eye movements as a kind of biomarker for signaling diseases. "Diseases, such as Parkinson's or schizophrenia, are associated with subtle but characteristic changes in eye movements. Using artificial intelligent based algorithms, we can detect these changes" neurophysicist Frank Bremmer explains. His research group develops and validates the software and hardware, working together with the Marburg neurologist Prof. Dr. Lars Timmermann and medical technology company Thomas Recording GmbH, which is based in Giessen, a spin-off of the University of Marburg. Dr. Stefan Dowiasch works there. As a doctoral student and postdoctoral researcher in Bremmer's work group, he completed important preparatory work on the diagnostic software and is now contributing on its further development until the software can be brought to market.

"The new software can be operated on commercially available tablets and is currently undergoing testing with sick and healthy volunteers," Bremmer explains. Here is how the examination is conducted: participants look at the display and track dots that move back and forth with their eyes. A video camera that is built into the tablet records the movements of the user's head and eyes. The advantage of the mobile system is that measurements can be taken at home, not only in the lab. The eye movement test facilitates an early and precise diagnosis of relevant deficits. For example, patients suffering from PSP, a Parkinson's-like disease, are not able to execute vertical eye movements.

To date, neuropsychiatric disorders are diagnosed mainly based on the symptoms the patient exhibits, such as motor disorders, slowed movements, and tremors, or by analyzing elaborate imaging processes. Because the initial symptoms are nonspecific, it often takes several years pass until the patient is given a diagnosis. The mobile system is slated to assist in starting the patient much sooner on the correct, individualized therapy. ■

PROFILE

Project:
Cardinal Mechanisms of Perception: Prediction, Evaluation, Categorization
(DFG SFB-TRR 135)

Spokesperson:
Prof. Dr. Karl Gegenfurtner (Giessen)

Board:
Prof. Dr. Frank Bremmer,
Prof. Dr. Anna Schubö,
Prof. Dr. Alexander Schütz (Marburg),
Prof. Dr. Katja Fiehler,
Prof. Dr. Gudrun Schwarzer,
Dr. Jutta Billino, Dr. Philipp Schmidt (Giessen)

Participants:
Justus Liebig University Giessen,
Philipps-Universität Marburg

Disciplines:
Physics, medicine, psychology, biology, sport science, and linguistics

Term:
since 2014

FOR MORE INFORMATION

About the project:
www.allpsych.uni-giessen.de/sfb/index_en.html

International Research Training Group "The Brain in Action":
www.uni-marburg.de/en/irtg1901

Center for Mind, Brain and Behavior (CMBB):
www.cmbb-fcmh.de/en

Research Campus of Central Hessen:
www.fcmh.de/Research/Campus%20Focus/Mind%2C%20Brain%20and%20Behaviour

THE NEUROBIOLOGY OF MENTAL ILLNESS

Trauma leaves an imprint on the brain

Genes or the environment — what causes mental illness? The answer: both. But how these factors act in concert is still unknown. A research group from the Philipps-Universität Marburg carries out extensive studies experimenting to identify the causes of mental illness. This much can be seen already: classic diagnostics are insufficient to understand how the interactions of genes and environment influence the development of the brain.

Many people go through phases, when they experience sadness, anxiety, or lethargy. Most of the time, such symptoms pass after a short period of time. However, in some patients, these symptoms may be strong enough or persist long enough to suggest that a patient suffers from a mental illness. Mental illness is very common and affects about one third of the population at least once during their lifetime. However, good treatment options are available. The research group "Neurobiology of Affective Disorders," headed by Marburg physician Prof. Dr. Tilo Kircher and funded by the German Research Foundation (DFG), intends to find out why mental illness is so commonplace and why the brain functions differently in patients suffering, e.g., from depression or bipolar disorder in comparison to a healthy person. "The risk for mental illness is based on two factors," Kircher explains. "The first factor is a person's genetic susceptibility. The second factor depends on environmental influences during childhood and adolescence, such as social isolation, abuse, migration, cannabis abuse, or growing up in a big city." The research group includes about 50 scientists from the fields of medicine, psychology, and pharmacy. They are from Marburg, Münster, Bonn, Mannheim, Kiel, Munich, and Zurich.

Kircher explains the research group's approach. "We're moving away from the classical diagnostics for mental illness. For example, the combination of various symptoms, such as lethargy, loss of interest, difficulty concentrating, irritability, and nonspecific pain would lead to a diagnosis of depression." Over the past hundred years, researchers have been looking for somatic correlations with symptoms, which means relationships between mental and physical phenomena — e.g., between brain and blood. "But we didn't find much that was relevant for treatment," Kircher says. "Now, we want to create new categories. The new categories are no longer based solely on symptoms but on constellations of genes, environmental factors, life events, brain structures, and various blood results." With such a comprehensive approach, the research group wants to help make diagnoses, such as a diagnosis of depression, more differentiated that will facilitate more targeted treatments.

The entire genome is searched

The research group started a study with 2,500 test subjects from Marburg and Münster. "The large sample is important to get valid results," Kircher says. One thousand patients diagnosed with depression or bipolar disorder, as well as 500 healthy subjects with genetic or environmental risk factors, and one thousand healthy subjects without risk factors were enrolled. All participants underwent magnetic resonance imaging (MRI) of the brain. While the subjects were viewing images of people expressing grief, anger, or joy, the MRI images visualized how emotions are processed by the amygdala region of the subjects' brains. The research team was also interested in seeing how personal memories of the subjects would manifest themselves as brain activity in the hippocampus region of the brain and be visualized on the MRI. Using so-called diffusion-weighted MRI sequences, the researchers examined the white matter of the brain, which includes the neural connections between the areas of the brain that are highly networked.

Another component of the project is the analysis of biomaterials, such as blood, hair, stool samples, and saliva. "The genome of each individual yields about one million data points," Kircher reports. "We're also investigating, for example, inflammatory parameters in the blood, and bacteria in the gut and in the mouth whose compositions could signal the risk level of a subject for food mental health or illness." In addition, detailed interviews were conducted with the subjects about their personal histories, past illnesses, and significant life events. Two years after the initial data collection, the participants

Photo: Hessen schafft Wissen/Anna Schroll

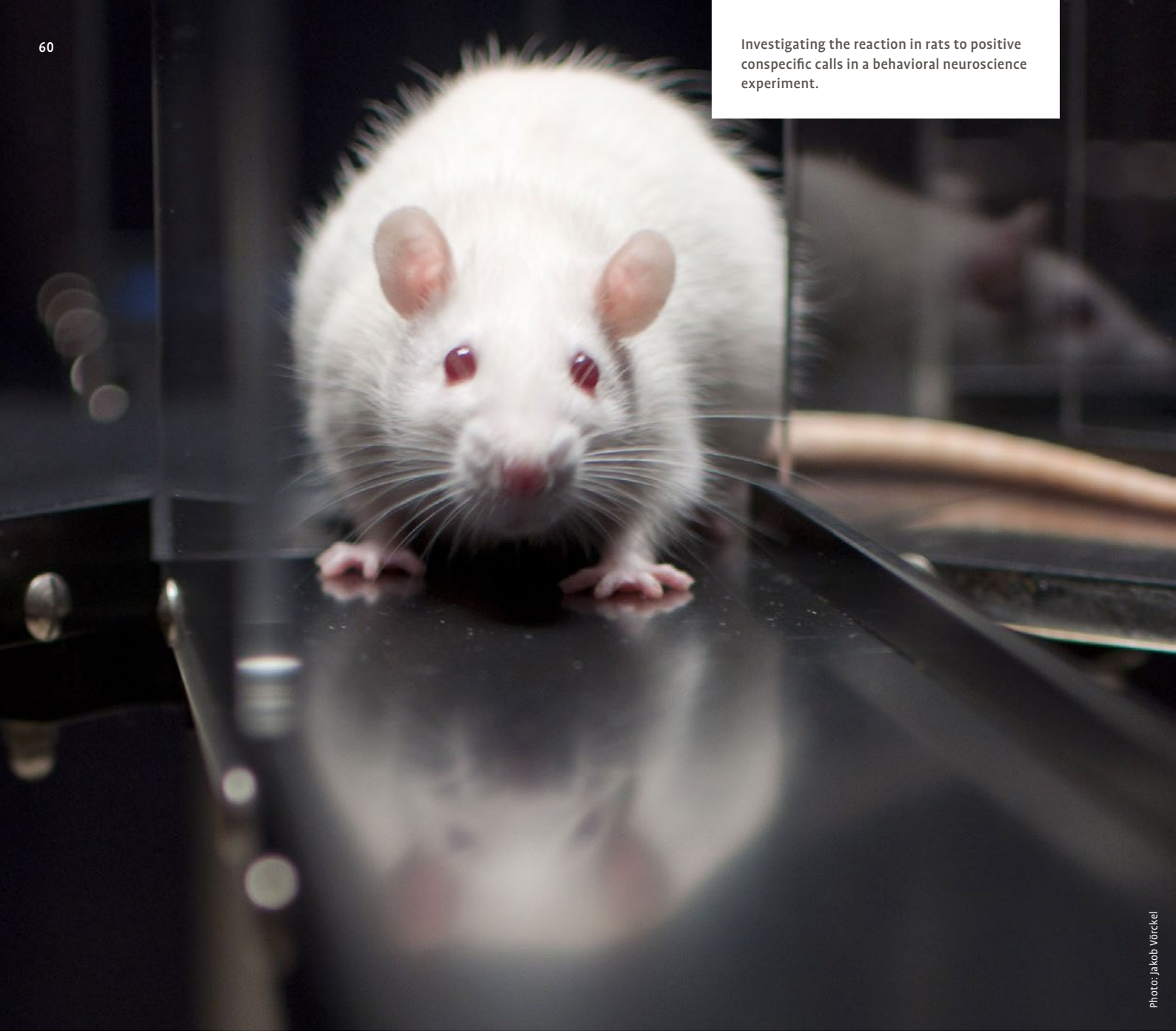
were reexamined — including MRI imaging and biomaterial analysis. “The second examination is very important,” says Kircher. “We are interested in how changes in the structures and functions of the brain progress over time and to what extent it is possible to predict how mental illness develops and the relapse risk of a given person, hopefully enabling us, in the future, to prevent an impending relapse.”

Genes change the structures of the brain

One of the achievements of the research group is a study with more than 1,600 healthy and clinically depressed volunteers from Marburg and Münster. The study yielded exemplary evidence suggesting that the genetic risk for mental illness relates to changes in the brain structure. Münster physician Dr. Nils Opel has been researching neuroticism, a personality trait that describes a person’s emotional lability. Every person carries this trait inside himself or herself — it is one of the five fundamental dimensions of personality - the Big Five Personality Traits -, along with extraversion, agreeableness, openness, and conscientiousness. How does a given person deal with stress, how does that person respond to other people, how does he or she see themself or herself in the world? People with a high neuroticism value are at risk of depression, schizophrenia, anxiety disorder, or addiction. Neuroticism is associated with a certain genetic basis. Opel investigated which brain structures correspond to the genetic variations in the genome of a person with a high neuroticism value. The genetic risk for neuroticism was shown to be associated with a reduced surface area in certain regions of the cerebral cortex. These regions are involved in cognitive processes, such as body perception or forms of expression, such as facial expressions and gesticulation. “The discovery of this link between genes and the structure of the brain is interesting because it helps us better understand the causes of many mental diseases,” Kircher says.

Formative childhood experiences

Survivors of child abuse are at a greater risk of falling victim to clinical depression. What are the implications of such an environmental factor for the brain? We know that the nerve fiber connections through which different areas of the brain communicate with each other are slightly reduced at certain locations in people with



Investigating the reaction in rats to positive conspecific calls in a behavioral neuroscience experiment.

Photo: Jakob Vörckel

a tendency to depression. Could this be the result of negative experiences during childhood? The Marburg professors Axl Krug, Andreas Jansen, Igor Nenadic, and Tilo Kircher, as well as professor Udo Dannlowski from Münster examined this question in two large samples of over 1,200 healthy and depressed subjects. Patients with depression reported negative childhood experiences more frequently than healthy persons. Both healthy and depressed subjects presented with reduced nerve fiber connections if they had survived traumatic childhood experiences. “This result shows that negative experiences and the chronic stress that is associated with such experiences can affect the human organism, especially during the critical phases of the brain’s development in childhood and adolescence, and it can have implications for the development of the central nervous system well into adulthood,” Kircher says.

Genetic defect dampens the joy of play

For a fundamental understanding of how genes and the environment are involved in the development of mental illness, the research group relies on animal models that facilitate the precise analysis of the genetic and environmental influences, as we have seen in human subjects, but also allow for specific manipulations. A team of Marburg psychologists that includes Dr. Markus Wöhr and Prof. Dr. Rainer Schwarting investigates the behavior and communication of genetically modified rats with targeted deletions. The scientists focused on the Cacna1c gene — which is known as a gene that heightens the risk for bipolar disorder, schizophrenia, depression, and autism in humans. The gene contains information about a calcium channel that is important for neurons. These channels are also located in the hippocampus, the center for learning and memory, and in the prefrontal

cortex, which is responsible for the complex control functions and the interaction of emotions, behavior, and experience. "We wanted to take a closer look at the functionality of the gene," Wöhr reports. "That's why we've compared animals with two copies of Cacna1c in the wild-type and genetically modified animals with only one intact copy of the gene."

Rats exhibit highly developed social behavior. Tests were intended to demonstrate whether the rats with only one copy of the Cacna1c gene display behavioral alterations. The research team first observed their social play behavior. "During rough-and-tumble play, rats produce positive calls at an ultrasound frequency of around 50 kilohertz," Wöhr reports. "They experience play as a reward." The genetically modified rats, however, produced fewer positive calls than their wild-type conspecifics. They perceived play as less rewarding. The team then wanted to know what would happen if recorded positive calls were played to the animals. "Wild-type rats pick up on the sound, want to make contact and start looking for their fellow rats," Wöhr says. "The animals with only one copy of the Cacna1c gene are less likely to search for social contact. This means there exist behavioral deficits, both in sending and receiving the calls."

A positive environment protects against disease

The research team also wanted to explore to what extent environmental factors, such as social neglect during childhood and adolescence have a disease-promoting effect — both in wild-type rats and in genetically modified animals with only one copy of the Cacna1c gene. They separated young rats of either genotype form each other keeping them in social isolation for four weeks. Other animals were kept in groups, as usual. A third group was placed in a particularly stimulating environment, where the animals lived in social groups, with abundant space and many opportunities to play. After several months, when the animals had already reached adulthood, the researchers tested how quickly the animals would find and remember the location where their food was being kept, and how quickly they would relearn if the feeding location was changed. The animals that had been in isolation showed deficits — they learned more slowly and had a difficult time adapting to a new situation. Of the animals that had been held under normal conditions, the genetically modified rats performed worse than their wild-type counterparts. "The best test performance was seen in rats that had lived in a so-called enriched environment," Wöhr says. "There were hardly any differences between the genotypes. This indicates that a positive environment acts as a protective factor guarding against mental illness and can compensate genetic risk factors."

Not only the cognitive abilities are negatively affected by Isolation. Isolation also causes changes in the brain that impair social behavior. "Working together with neuroscientist Prof. Dr. Gerhard Schratt, formerly of Marburg and now working from Zurich, we found that the isolated animals have a significantly elevated levels of microRNA 134 in the hippocampus," Wöhr reports. "We suspected that these small ribonucleic acid molecules were slowing down social behavior. Testing in mice, whose microRNA 134 had been switched off, showed that these animals engage in particularly high levels of social behavior. This result confirms the connection between this molecule and the regulation of social behavior."

Identifying biotypes

The research group has collected a huge amount of data with its studies. Specialists in medical informatics and statistics ensure that the data pool can be used. They develop statistical methods of analysis ("machine learning") that are used to distill the most important aspects from the data. "We need these analytical evaluations so help us constitute patient clusters, for example, from the complex data. In this way, we can identify biotypes of new mental illnesses. This is the basis for predicting how a given disease will progress and for developing new therapies," Kircher says. The research group also shares its data with other consortia in the field of neuroscience. This enables verifying results independently on the basis of large samples and for maximum benefit of the entire research field. ▪

PROFILE

Project: Neurobiology of affective disorders (DFG FOR 2107)

Spokesperson: Prof. Dr. Tilo Kircher (Marburg)

Deputy Spokesperson: Prof. Dr. Udo Dannlowski (Münster)

Participants: Philipps-Universität Marburg, University of Münster, and researchers from the Universities of Bonn, Mannheim, Kiel, Munich, and ETH Zurich

Disciplines: Medicine, Psychology, Neuroscience, Pharmacy

Term: since 2014

FOR MORE INFORMATION

About the project: *www.for2107.de/?lang=en*
Center for Mind, Brain and Behavior (CMBB): *www.cmbb-fcmh.de/en*
Research Campus of Central Hessen:
www.fcmh.de/Research/Campus%20Focus/Mind%2C%20Brain%20and%20Behaviour

A hotbed for start-ups

Much of the research that is underway at the university carries the potential for marketable products. But researchers are usually not entrepreneurs. If you want to organize a company that is spun off from the university, you will find a wide range of support services at the Philipps-Universität Marburg. The Marburg Institute for Innovation Research and Support of Business Start-Ups or MAFEX helps to found start-ups — by means of consulting and qualification. New additions are the university's start-up lab and a network for funding of start-ups.

Since April 2019, three rooms in the tower C of the philosophical faculty at the Philipps-Universität have been set aside for helping start-ups get off the ground. Students and university employees alike can flesh out their business ideas here. The new incubator for business start-ups is set up as a coworking space. Five to six start-up projects, each involving two to three people, can use the rooms at the same time. The European Union is participating in the financing of this project at the University of Marburg. But it is not just about space. The teams also receive training, coaching, and consulting for their start-ups.

The project is managed by MAFEX. Organized in 1998 as a foundation under the name of Marburg Center for the Support of Business Start-ups, MAFEX has been a scientific institution of the Philipps-Universität since 2015. "Over the past few years, MAFEX has supported about 500 start-ups that were spun off from the university," say managing directors Michael Stephan and Paul Alpar. Both managing directors are professors in the Department of Business Administration and Economics. The MAFEX start-up lab is designed to contribute to more start-up ventures and promote an entrepreneurial culture at the university. The Association for the Promotion of German Science and Humanities (*Stifterverband für die Deutsche Wissenschaft*) honors this commitment by admitting the University of Marburg as one of 15 universities to the community of its Innovation Club, a network of creative and innovative forces at institutions of higher education and science.

Fit for the market

Selected start-up teams spend a maximum of one year in the start-up lab. During this time, they receive a well-grounded qualification that is intended to help them implement their business ideas quickly and compete effectively as a company in the marketplace. Three phases are planned. During the first phase, business fundamentals and soft skills are on the agenda. Phase two focuses on the core aspects — how to turn an idea for a start-up business into a viable business model. Financing will also be addressed during this phase. The third phase is about the implementation, the actual founding of the start-up business and its public introduction, as well as finding first customers.

MAFEX accompanies all the foundation phases with consulting, coaching, and support services including the search for the right financing. "The entrepreneurial teams are empowered to make their own business decisions," Michael Stephan says. "We also support them in the implementation of their decisions, but we do not expect any particular decision during the consulting stage," stresses Paul Alpar. Members of the Philipps-Universität can make use of the consulting free of charge. As part of the EXIST network — the funding program by the German Federal Ministry of Economics and Energy — MAFEX advises anybody who is interested in organizing a start-up business in the Marburg-Biedenkopf region about the EXIST founders' scholarship.

In addition to promoting start-ups, another focus of MAFEX is innovation management. MAFEX monitors the market, analyzes technological developments and predicts general trends for the future. Empirical studies are conducted regularly in collaboration with the local Chamber of Commerce and Industry and other industry associations on how companies in the Marburg region and in Hessen can systematically manage innovations. The findings are also merged with the innovation counseling for companies in the region, as well as incorporated in continuing education and training courses, and workshops.

Central Hessian universities network their start-up support

In the spring of 2020, the Central Hessian start-up network StartMiUp will begin its work, in collaboration with the Research Campus of Central Hessen. In December 2019, the project won an award with funding for four years in the amount of three million euros in the "EXIST Potential" competition organized by the German Federal Ministry of Economics. Under the leadership of the Philipps-Universität Marburg, the universities of the Research Campus — which also includes the Justus Liebig University of Giessen and the Technische Hochschule Mittelhessen — developed a concept to support start-ups in the region. "Due to the collaboration of the three universities in Central Hessen in promoting start-ups," stresses Professor Dr. Katharina Krause, the president of the Philipps-Universität, "as well as networking efforts with business partners and diverse start-up activities, we can generate effects of scale and networking within the region that are otherwise reserved only for metropolitan areas." The universities expect a boost from the German federal government's support of the Central Hessian Start-up Initiative that will facilitate the intensified transfer of marketable results and product ideas from the campus world to the business world. With Prof. Dr. Michael Stephan of the Philipps-Universität Marburg, Prof. Dr. Monika Schuhmacher of the Justus Liebig University Giessen, and Dr. Christina Zinecker of the Technische Hochschule Mittelhessen, distinguished experts in technology, innovation, and start-up management work together at StartMiUp.

FOR MORE INFORMATION

www.uni-marburg.de/en/fb02/research/institutes-research-groups/further-institutes/mafex

Dr. Janis Müller, Prof. Dr. Gerhard Klebe, Alexandra Seiffermann, Dr. Stefan Merkl, Christian Rötz, Dr. Serghei Glinca, Anna Trodler and Bernd Scheld (left to right) from CrystalsFirst

Photo: Henrik Isenberg

CrystalsFirst accelerates the search for new drugs

The CrystalsFirst GmbH is an example of a successful start-up company that was spun off from the Philipps-Universität Marburg. The company started operations in March 2018. Its managing directors are Dr. Serghei Glinca, Dr. Stefan Merkl, Christian Rötz, and Bernd Scheld. CrystalsFirst uses a novel method to execute drug product screenings on behalf of pharmaceutical companies. Its technology stabilizes highly sensitive protein crystals preventing them from being destroyed during the screening processes, or from significantly losing their quality. This enables CrystalsFirst to provide many high-quality data very fast and reliably, which its customers urgently need for optimizing their drug candidates. The company applies the research results that were compiled over more than 20 years by the research group of Prof. Dr. Gerhard Klebe at the Department of Pharmacy at the Philipps-Universität. Klebe's research group is primarily concerned with devising methods for drug discovery and development. It is considered a pioneer of the so-called structure-guided and fragment-based drug discovery design. Klebe is today also one of the three members on the scientific advisory board of CrystalsFirst.

As a part of the support provided by MAFEX, the start-up team received an EXIST founders' scholarship. With this funding, the young entrepreneurs conducted extensive market research, devised a business model, and acquired pilot partners. They received further support from Bernd Scheld, an experienced entrepreneur and in a position to advance commercial planning. He also played a significant role in attracting the Hessen-Kapital I GmbH of the State of Hessen as a financial investor. The Philipps-Universität also holds an interest in the company. In 2019, the start-up company was the recipient of the Hessian Start-up Prize for the category "Innovative Business Idea."

FOR MORE INFORMATION

www.crystalsfirst.com

FROM THE ATOM TO FUNCTIONAL MATERIAL

Unlimited possibilities: physics and chemistry are related disciplines that, working together, will create the foundations for future technologies in communication and energy. Chemists synthesize molecules and materials that have specific characteristics, while physicists research their functionalities. Semiconductor research and optoelectronics are fields where Marburg has internationally recognized expertise. For example, a semiconductor material was successfully developed that produces a directional warm-white laser beam suitable for applications in medical technology and improvements on microscopic devices. Marburg scientists conduct research on many projects in collaboration with work groups from Giessen — including the Collaborative Research Center, which examines the dynamics and structures of internal interfaces. These interfaces play an important role in modern materials science. After developing a basic understanding of the processes that are at work at the transitions between materials, the research teams now focus specifically on finding ways to control and customize interfaces in a targeted fashion.

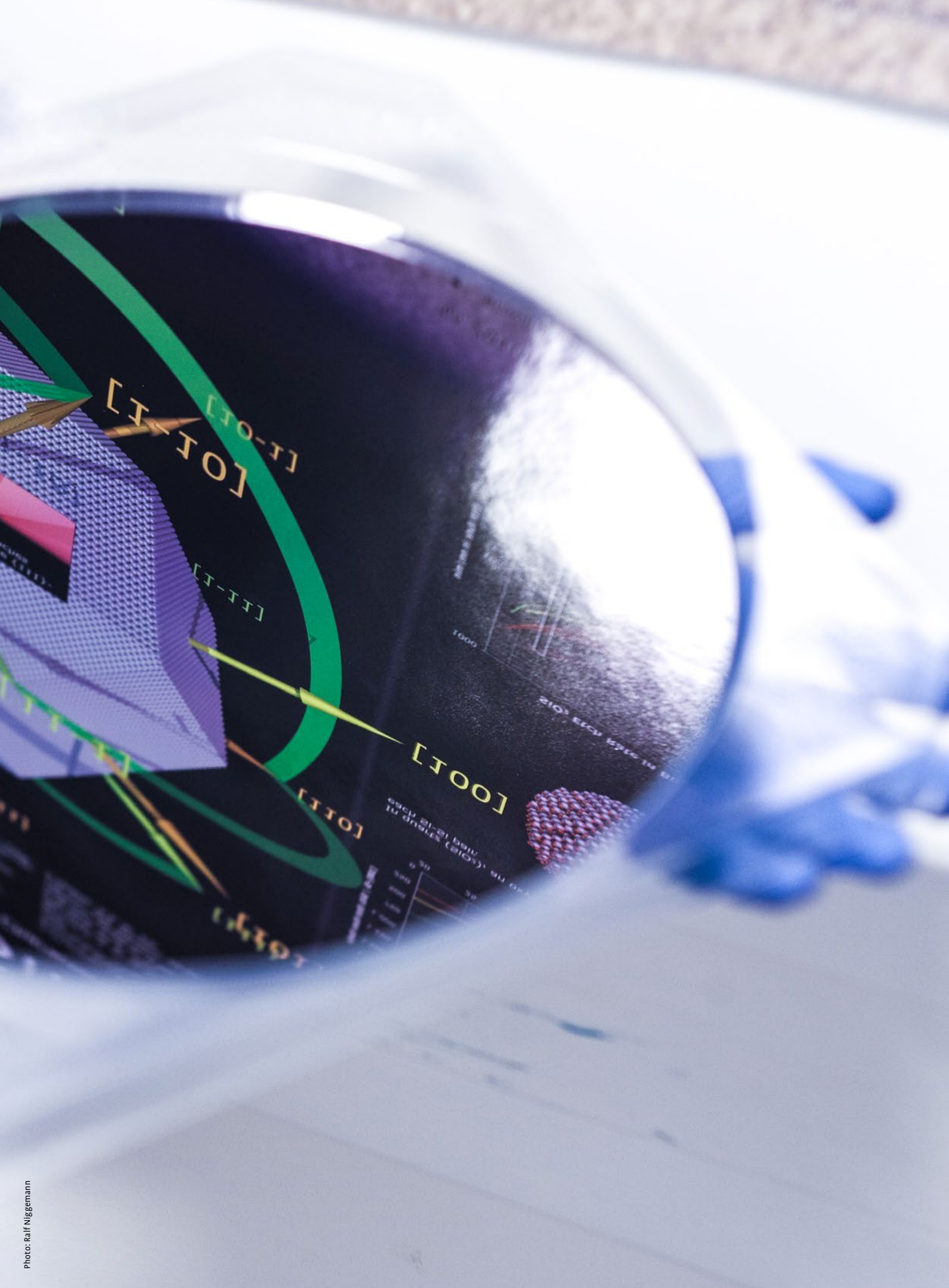


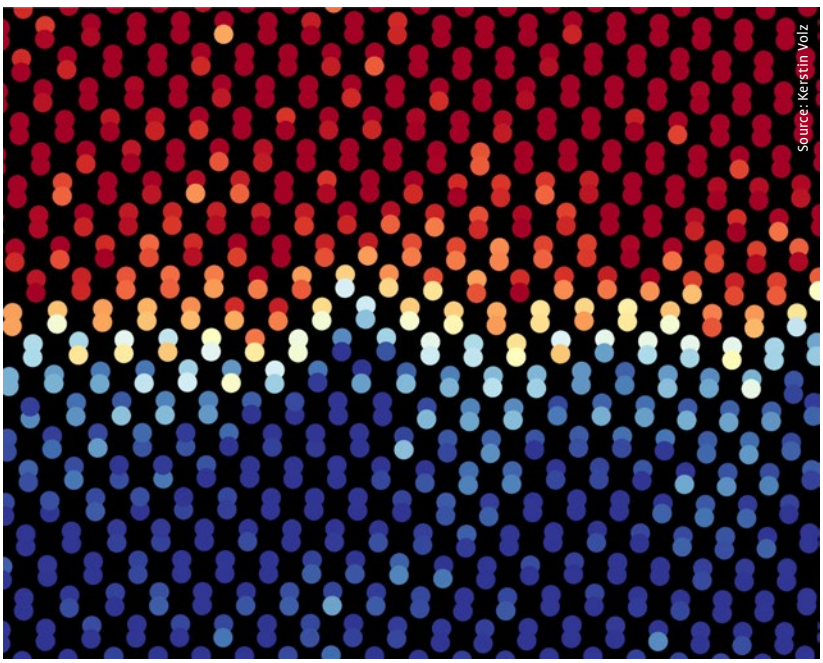
Photo: Ralf Niggemann

INTERNAL INTERFACES DETERMINE THE MATERIAL CHARACTERISTICS

Layering and mixing

Technical components such as computer chips or solar cells are getting smaller and more powerful. The electronic and optical properties of these materials depend on what happens at the internal interfaces between the used materials. Research teams from the physics and chemistry departments investigated the exact processes that take place at these interfaces, drilling down to the level of individual atoms. They now want to use their knowledge to develop new applications.

Many of the devices we use every day, such as smartphones, computers, or electronic displays, include tiny electronic components. Their technical features depend on how the electrons behave at the internal interfaces of the used materials. Electronic and chemical conditions arise at these locations that otherwise do not exist within the individual components and their atoms. Internal interfaces play a crucial role in modern materials science, when the goal is to improve the output of components or to develop materials with new characteristics. Areas of application include microelectronics, optoelectronics, sensors, nanotechnology, or solar power.



Surprising observation in the TEM: With pyramid-shaped elevations, silicon growing into gallium phosphide.

From model to novel applications

Despite their enormous importance, for a long time, our understanding of the microscopic properties of internal interfaces has lagged behind our understanding of the volume and surface properties of materials. At the “Structure and Dynamics of Internal Interfaces” Collaborative Research Center, which is funded by the German Research Foundation (DFG), about 80 researchers from the fields of physics and chemistry originating in Marburg, Giessen, Münster, and Jülich, as well as Spain, Japan, and the United States have joined forces to close this gap. Starting in 2013, they initially experimented on modeling systems to investigate the basic mechanisms of chemical bonding, electronic coupling, and the transfer of energy at interfaces— and how these properties change when different types of materials are used. “We’re now exploring ways of controlling interfaces and customizing them for novel applications,” says Marburg physicist Prof. Dr. Ulrich Höfer, the spokesman of the research alliance.

Surprising structures

The research teams got more than a single surprise when they took a closer look at what was happening at the interfaces. For example, it is known that characteristics of materials with different atomic lattice structures intermix. In experiments with silicon and gallium phosphide, the researchers found out that, even in materials whose structures are actually a match, the resulting atomic interfaces are not smooth. Instead, a pyramid structure is formed. This structure becomes visible under the transmission electron microscope (TEM). Using such a device — operated in Marburg since 2012 by the research group led by Prof. Dr. Kerstin Volz — an electron beam scans the boundary surface to make individual atoms observable.

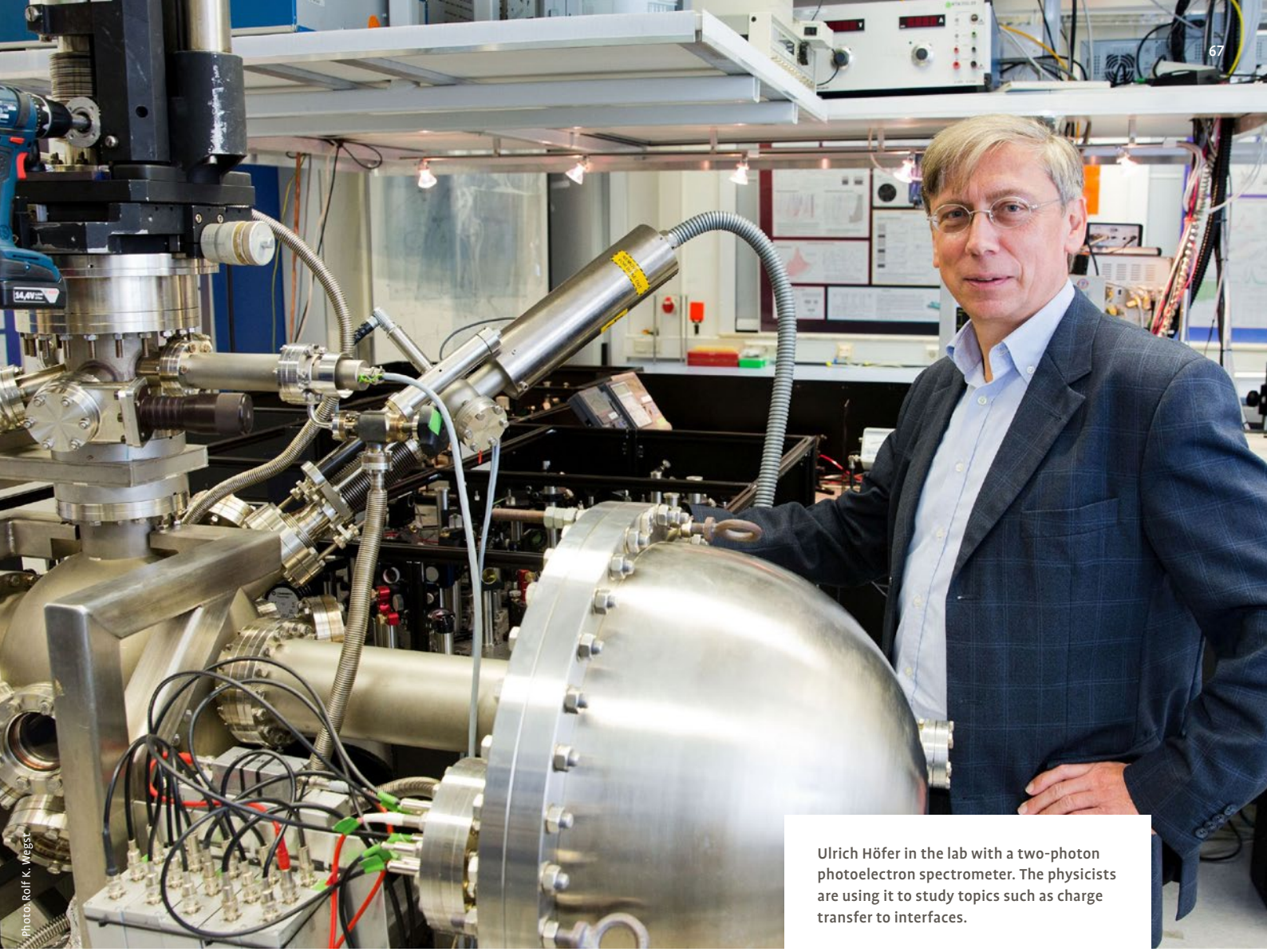


Photo: Rolf K. Wegst

Ulrich Höfer in the lab with a two-photon photoelectron spectrometer. The physicists are using it to study topics such as charge transfer to interfaces.

NOVEL LASER BEAM FOR FASTER DATA FLOW

The physicists led by Prof. Dr. Wolfgang Stolz and Prof. Dr. Stephan Koch also noted that internal interfaces do not have to be smooth to be efficient. They developed the prototype of a novel laser that only works if the internal interfaces of the layers of the used material are rough. With this new laser, in the long run, it will be possible to build infrared sensors, e.g., for a faster wireless data transmission. The laser can achieve a wavelength of more than two micrometers, which is considerably more than what has been customary to date. The research team refers to the “W-laser,” derived from the W-shaped band structure of the used semiconductor layer sequences. “Here, we see a specific opportunity for the potential use of our basic research in an industrial application in the foreseeable future,” Höfer says.

FOUNDATIONS FOR BETTER SOLAR CELLS AND MONITOR SCREENS

As one of its central research interests, the research alliance seeks to find ways of using novel conditions on the internal interfaces between materials and consciously design them. “Interface states can fulfill different functions,” Höfer explains. The effective separation of change carrier pairs (a negatively charged electron and a positively charged blank) at the interface is important, e.g., for the output of organic solar cells. The reverse process, i.e., when the positively and negatively charged spaces merge again, produces light from an electric current. This is crucial for LEDs. To avoid a loss of energy, it is important to have a fast charge transfer across the interface. For example, the speed at the interfaces of thin film transistors (TFT) determines the level of resolution of computer screens.

In this context, Höfer’s research team focused its attention particularly on the interface states between metals and organic molecules — an interesting combination, for example, in the development of miniaturized semiconductors. “The energy transfer between the materials is particularly efficient if the interfaces are just a few atom layers thin,” Höfer explains. Based on this knowledge, the contacts between metals and organic materials can be, perspectively speaking, optimized.

Experiments with different material combinations are also at the core of Prof. Dr. Martin Koch’s research. His team uses ultrashort laser pulses to observe how charge carrier pairs are formed in semiconductor heterostructures. The scientists found out that the electrons quickly migrate into an adjacent layer. The other part of the charge carrier pair does not change sides but remains linked with the electron. This is called a “charge transfer exciton.” Creating the charge transfer exciton is the first step in generating electricity in a solar cell, for example. “We want to see how quickly charge carriers traverse the interface and how fast charge transfer excitons form,” Koch says.

Not only in organic semiconductors but also in organic heterostructures, researchers try to link the dynamics of the charge transfer with the structure of the interfaces and the properties of the coating materials. The research group led by Prof. Dr. Gregor Witte successfully manipulated the emission of light on organic interfaces — solely by the alignment of the crystal layers.

Model-based research

The Collaborative Research Center “Structure and Dynamics of Internal Interfaces” is divided in two divisions. The first division comprises eleven project teams that develop model structures for layer systems. Because the interfaces on real components are often not precisely defined, the scientists produce idealized, especially prepared model layer systems and establish their physical properties on the atomic level. For example, synthesis chemists develop cluster-building components or organic molecules. Physicists prepare precisely separated semiconductor heterostructures made of different materials that are tested under the electron microscope.

The second division comprises seven further project teams that investigate the optoelectronic properties of these model systems. Utilizing spectroscopic analysis methods, they observe particularly the charge transfer across the interface. The weak interface signals can be detected using special measuring methods, some of which allow for a time resolution in the range of femtoseconds (a millionth of a billionth of a second).

With its projects, the Collaborative Research Center combines the chemical synthesis of interface materials, the structuring of the layers, spectroscopic examinations, and theoretical modeling. “Close links between and feedback from theory, experimentation, and physical characterization are a strength of research in Marburg,” Höfer emphasizes.

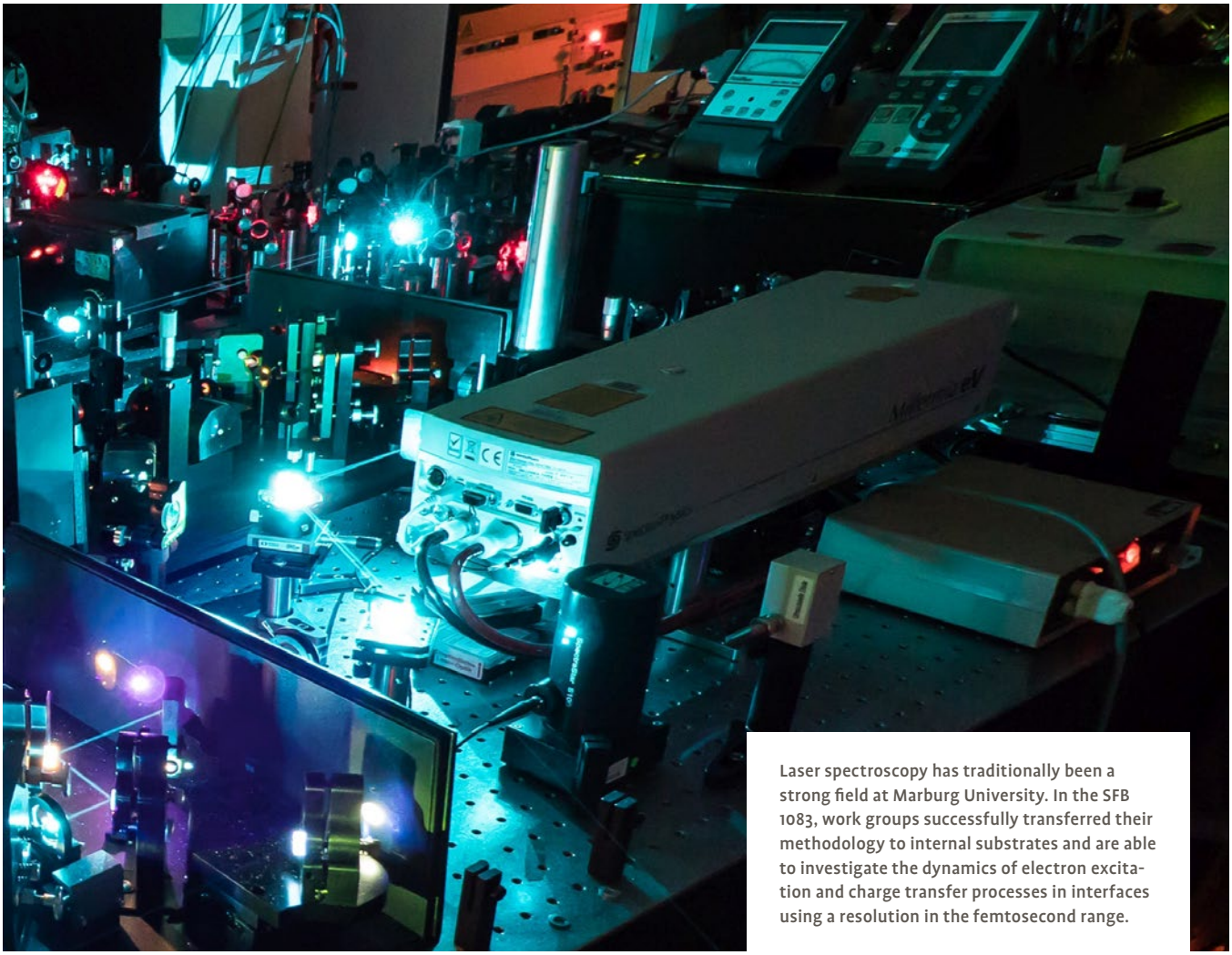


Photo: Till Schürmann

Laser spectroscopy has traditionally been a strong field at Marburg University. In the SFB 1083, work groups successfully transferred their methodology to internal substrates and are able to investigate the dynamics of electron excitation and charge transfer processes in interfaces using a resolution in the femtosecond range.

BONDING PROBLEM SOLVED

In the evolving field of new electronic components, researchers increasingly concentrate their efforts on blending combinations of inorganic semiconductors and organic materials. Of particular interest are silicon compounds. In fact, silicon is the most important material for electronic components and solar power systems up to date. The problem has long been that organic molecules are destroyed when they react with semiconductors, such as silicon. An exemplary instance of cooperation between chemistry and physics produced a solution for this problem: The team headed by Prof. Dr. Ulrich Koert discovered that the hydrocarbon compound cyclooctyne has the potential to form a bond with the surface of silicon. The physicists Prof. Dr. Ulrich Höfer and Prof. Dr. Michael Dürr (University of Giessen) confirmed the successful and, above all, reliable bond by means of optical spectroscopy. “The fundamental problem about creating a bond with the silicon surface has been solved,” Höfer emphasizes. “With this structure, we can continue our work and investigate the internal interface characteristics, such as charge transfer for additional functional layers and molecular groups.”

Two-dimensional materials in the crosshairs

Höfer and the teams of the research alliance want to transfer their findings on internal interfaces to novel material systems. In addition to semiconductors, they also have two-dimensional materials in their sights. These layers consist of a single layer of atoms. “As a concept, we want to organize a variety of these solids into layers and mix their characteristic properties. This way, we could produce synthetic materials that do not exist in nature — with characteristics upon request.” Höfer explains. “For these materials, which consist practically only of a surface, interfaces are extremely important. These can be well controlled so that it’s easy to develop model systems. The field of solid-state physics is going in this direction worldwide.” ■

PROFILE

Project:
Structure and Dynamics of Internal Interfaces (DFG SFB 1083)

Spokesperson:
Prof. Dr. Ulrich Höfer

Vice Spokesperson:
Prof. Dr. Kerstin Volz

Participants:
Philipps-Universität Marburg, Justus Liebig University Giessen, Forschungszentrum Jülich, University of Münster

Departments:
Physics, Chemistry

Term:
since 2013

FOR MORE INFORMATION

About the project: *www.internal-interfaces.de*

Research Campus of Central Hessen: *www.fcmh.de/Research/Campus%20Focus/material-molecule-energy*

DEVELOPING HIGHER-PERFORMANCE SEMICONDUCTORS

Transcending boundaries

Today, modern semiconductor components often reach their performance limits and are only difficult to use, or they are not usable at all in the applications of the future. The reason: The material structures have reached their physical limits. The Research Training Group "Functionalization of Semiconductors" is taking on this challenge. Doctoral candidates in Marburg and Giessen combine novel materials with conventional semiconductors to advance their functionality and performance.

Computers are not getting faster, lighting systems are not optimal, and sensors are not as sensitive and flexible as we would want them to be — in everyday life, we are often confronted with the limitations of our current technology. This is where the German Research Foundation (DFG) Researching Training Group (RTG) "Functionalization of Semiconductors," which was organized in 2012 at the Philipps-Universität Marburg, gets started. Doctoral candidates and postdoctoral fellows concern themselves with finding ways to combine semiconductors with novel materials or structures to produce entire systems that feature the desired characteristics. This research opens up new fields of application in electronics or photonics.

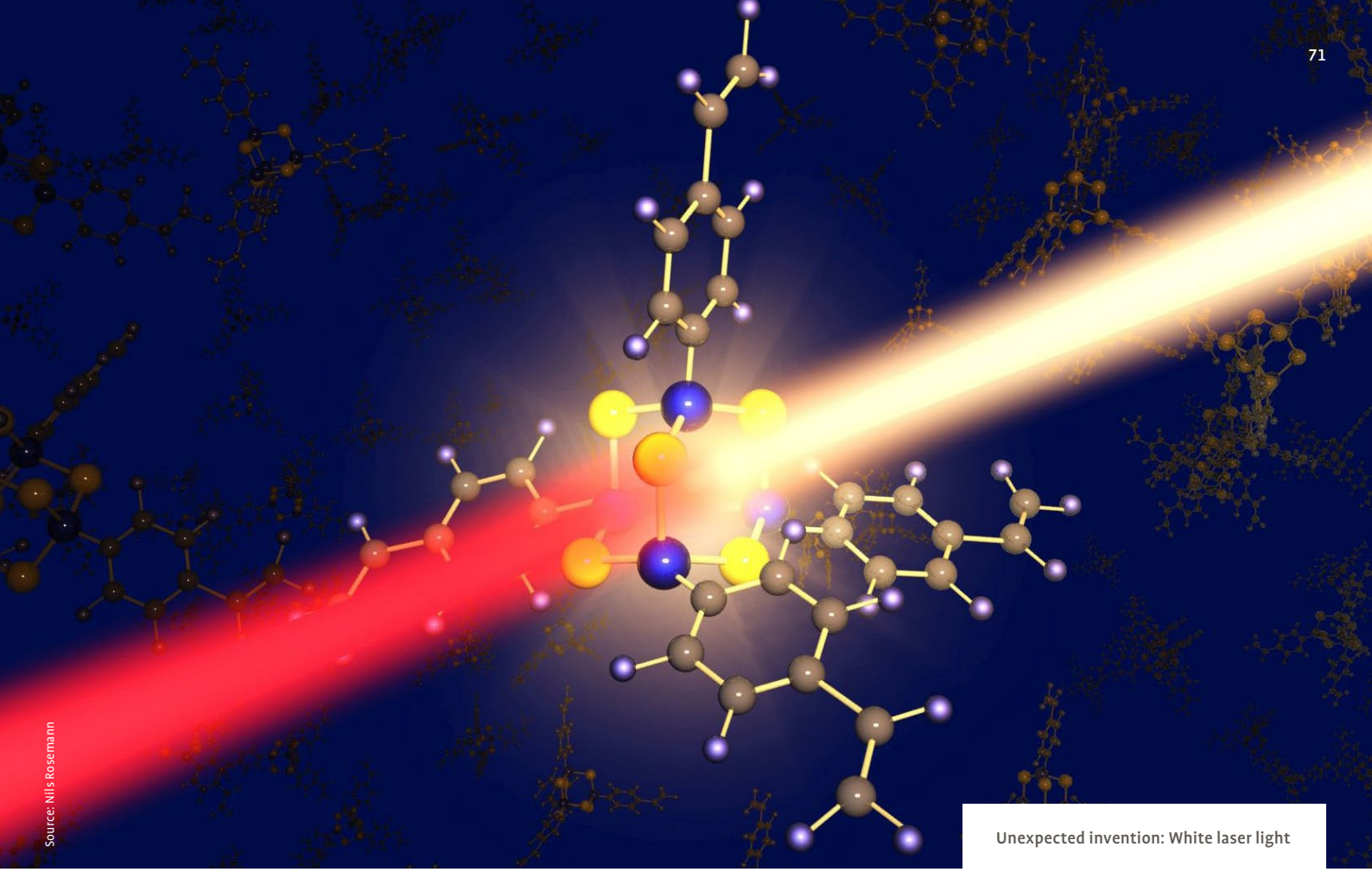
"For many applications, such as computer chips or solar cells, we need new concept designs," says Marburg physicist Prof. Dr. Kerstin Volz, a spokesperson for the RTG. For example, the silicon-based electronic signal transmission is too slow for today's demands. For the past few years, developmental fields have been oriented in the direction of a light-based signal transmission. One of the areas of concentration of the RTG is therefore the development of material compounds that generate laser light and "fit" with silicon.

The Universities of Marburg and Giessen are both participating in the RTG. A total of 13 work groups from the physics and chemistry departments work closely together. Although, in terms of content, these are adjacent disciplines, they use very different concepts and operational methods. "We've got to align our technical jargons," Volz explains. "It's essential that we engage with each other in a two-way communication." The doctoral candidates on the RTG act accordingly. They organize seminars for their colleagues from the other discipline. Using this platform, they explain the basics of their work to each other and conduct tours through their respective lab. "This promotes cooperation, and the doctoral candidates engage in intensive discussions with each other," Volz says. When the physicists visit the chemistry work groups, they see and learn how to prepare chemicals and learn about the involved process, sometimes lasting for months, behind it. When the chemists, on the other hand, visit the physics lab, they learn how the molecules they have produced are incorporated into entire structures. For example, they can see under the transmission electron microscope (TEM) how atoms are positioned at the interfaces between two materials.

UNEXPECTED DISCOVERY: WHITE LIGHT WITH LASER-LIGHT PROPERTIES

The close exchange between the physics and chemistry work groups is certainly worthwhile. "Our doctoral candidates have already achieved impressive research results," Volz emphasizes. For example, scientists working in synthetic chemistry as well as experimental and theoretical semiconductor physics worked on a semiconductor material to produce a directional warm-white-light laser beam. This beam combines the characteristics of light bulbs and laser lights. Light bulbs produce white light; but they emit this light evenly in all directions. Laser diodes, for example, of the kind found in CD drives, generate a directional light. The "white laser light" offers many opportunities in terms of application. For example, it has interesting potential for medical technology, such as for equipping endoscopes with an improved light source. White light can also open up new possibilities in the microscopy field of high-precision measurement instruments.

The invention came about unexpectedly, resulting from a collaboration by the work groups of synthesis chemist



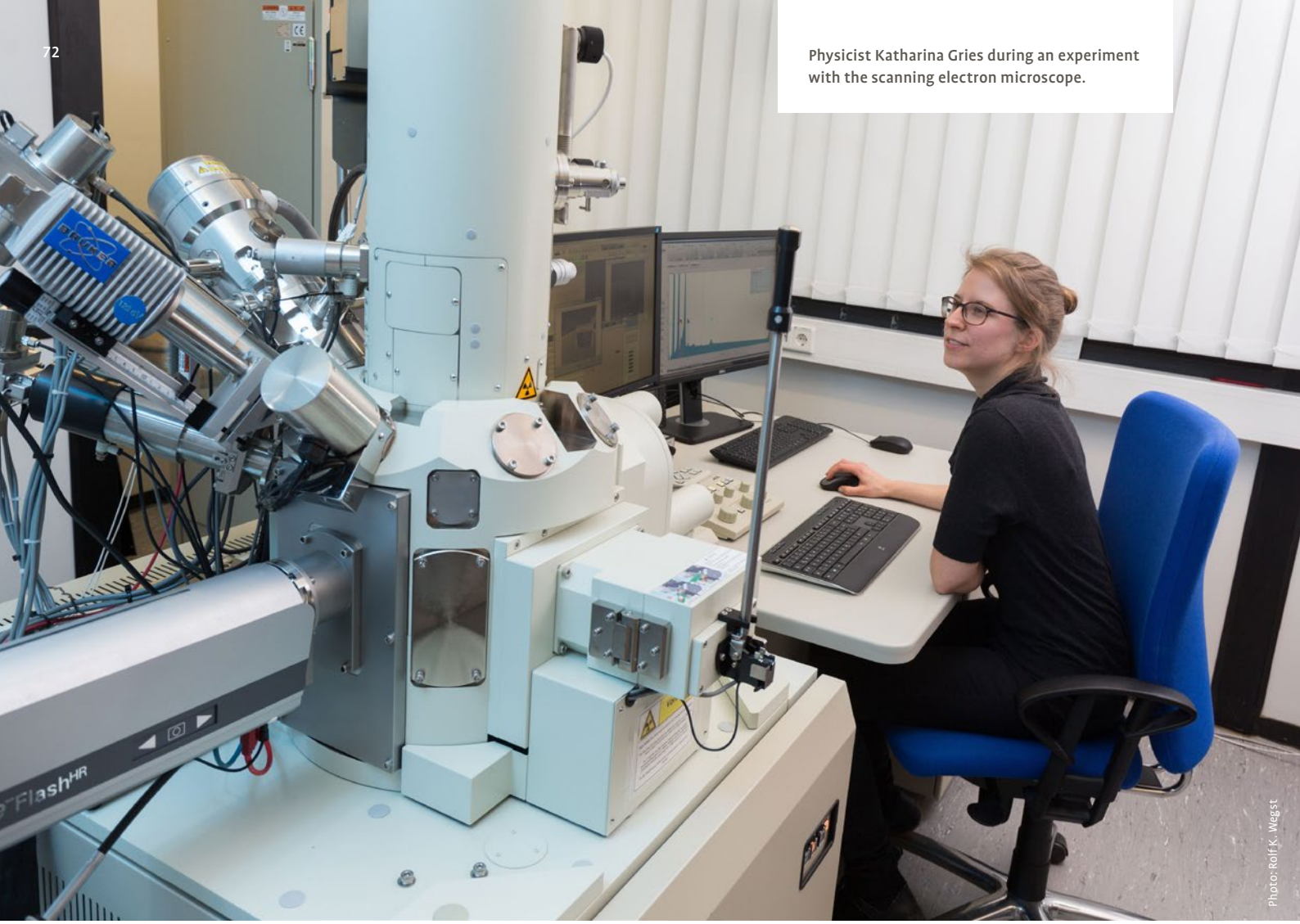
Source: Nils Rosemann

Unexpected invention: White laser light

Prof. Dr. Stefanie Dehnen, former Marburg and now Giessen physicist Prof. Dr. Sangam Chatterjee, who specializes in optical spectroscopy, and Prof. Dr. Stephan W. Koch, as well as Prof. Dr. Kerstin Volz, who specializes in semiconductor physics. Dehnen's team investigates the targeted synthesis and the properties of cluster molecules. These are large molecules that often consist of an inorganic core and an organic shell. Normally, such molecular clusters form crystals, wherein they are arranged in regular patterns. However, in a newly created powder containing clusters of tin, sulfur, carbon, and hydrogen, the molecules were completely disorganized.

The chemists suspected that, due to their structures, the molecules should be able to act as frequency doublers, according to what we know from green laser pointers. The physicists on Chatterjee's team, however, found that the material did in fact not behave this way, but that it exhibited a behavior that has not been seen to date. Using low-energy infrared radiation from commercially available laser diodes, the electrons in the cluster were set in motion and, to the astonishment of the researchers, emitted a visible warm-white light — without losing the beam properties of the laser light. The cluster molecules have so-called nonlinear optical properties, which enable the conversion of infrared light into white light. The cluster molecules were also successfully fixed to the surfaces of semiconductors.

The scientists are continuing their research on this theme. Within the framework of a DFG research group, they investigate the preconditions and processes associated with the creation of directional spectral broadband light. For example, they are working on a "library" of substances that are suitable for compounds producing such directional white light.



Physicist Katharina Gries during an experiment with the scanning electron microscope.

Photo: Rolf K. Wegst

PROMISING: INCREASED EFFICIENCY OF SOLAR CELLS

The members of the RTG are also involved in developing the foundations for the production of a new generation of solar cells. These should achieve a higher efficiency level and thus be better adapted to conditions in Central Europe, for instance. “The problem we have is that the sky is often cloudy and the light is scattered. This means solar cells don’t work as efficiently as in the desert, for example,” Volz explains. Together with the Fraunhofer Institute for Solar Energy Systems in Freiburg and the Technische Universität Ilmenau, they experimented with silicon and other semiconductor compounds. In a first layer, a compound of gallium — an element from Group III of the Periodic Table — and phosphorous — from Group V — were applied to silicon — Group IV. The successive layers contain other elements from Groups III and V: Gallium, arsenic, nitrogen, and bismuth. “By combining silicon and III/V semiconductor compounds, it is possible to cover different wavelengths of sunlight,” Volz explains. Since light is not only absorbed by silicon but also by the other used materials, the energetic utilization of the solar spectrum is much improved.

Only for the past few years, scientists have allowed III/V semiconductor layers be grown directly on the silicon solar cell, particularly without using additional substrates growing the crystals. For this purpose, the semiconductor materials are sprayed onto silicon substrates at 500 degrees Celsius in their gaseous state, where they then grow together. Several hundred trials were needed to achieve the best possible result. While conducting the experiments, the temperature, pressure, and the mixing ratio of the materials were changed time and again. The determinative factor that will ensure success is controlling the atomic structures at the interfaces. For example, gallium and phosphor atoms must occupy their correct positions in the crystal lattice at the site of the transition to silicon. Research teams from Marburg and Ilmenau worked several years on fixing the defects in the crystal lattice structure and optimizing the solar cells.

Photo: Ralf Niggemann

Research Training Group doctoral candidate in the lab

Science or industry: many paths are open

The RTG helps doctoral students get an intensive preparatory introduction to a career in science or industry. Since 2012, 46 doctoral candidates have earned their doctorates. In 2019, 30 doctoral candidates were members of the RTG. Young scientists contributed to the results presented here, who have taken different career paths since earning their Ph.D. qualifications. Dr. Jens Peter Eussner, the inventor of the cluster molecules for white light, was a doctoral student under Professor Dehnen and works today for a global company in the semiconductor industry. Dr. Nils Rosemann, who discovered the novel white light process as a doctoral student under Professor Chatterjee, works as a postdoctoral fellow in Sweden today. Dr. Andreas Beyer has also stayed in the sciences. Even as a doctoral candidate under Professor Volz, he worked on the use of electron microscopy in the atomically precise analysis of semiconductor structures. As a postdoctoral researcher, he continues to devote himself to structural research. This expert in transmission electron microscopy conducts research in the Structure and Technology Laboratory, an institution of the Scientific Center for Materials Science at the Philipps-Universität Marburg. ■

PROFILE

Project:
Functionalization of Semiconductors (DFG RTG 1782)

Spokesperson:
Prof. Dr. Kerstin Volz

Deputy Spokesperson:
Prof. Dr. Stefanie Dehnen

Participants:
Philipps-Universität Marburg, Justus Liebig University Giessen

Departments:
Physics, Chemistry

Term:
since 2012

FOR MORE INFORMATION

About the RTG: *www.uni-marburg.de/en/grk1782*

Scientific Center for Materials Science: *www.uni-marburg.de/en/wzmw*

Research Campus Central Hessen: *www.fcmh.de/Research/Campus%20Focus/material-molecule-energy*

Region of cutting-edge research

"During a time of globalization, growing challenges and exponentially advancing knowledge, we need innovative forms and cooperations that maximize synergies and mediate among the specializations and disciplines. This is an important cornerstone for cutting-edge research," Prof. Dr. Katja Becker of the German Research Foundation commented on the founding of the Research Campus of Central Hessen in November 2016.

Traditionally, the science landscape of Central Hessen is characterized by a high degree of cooperation among its three universities – the Justus Liebig University Giessen, the Philipps-Universität Marburg, and Technische Hochschule Mittelhessen University of Applied Sciences. As early as 1991, the universities established a joint transfer institution and in 2005 signed a cooperation agreement that provided for collaboration in almost all academic fields. In 2012, the universities of Giessen and Marburg intensified their cooperation in selected areas of cutting-edge research through an institutionalized Research Alliance.

Following this successful cooperation, the next step was establishing the Research Campus of Central Hessen (RCCH) in 2016, incorporating also the Technische Hochschule Mittelhessen University of Applied Sciences and the research institutions in the region. The Hessen State Ministry for Higher Education, Research and the Arts funded the organization and establishment of the Research Campus over the period of the first five years. Professor Dr. Katharina Krause, president of the Philipps-Universität Marburg stresses: "A particular strength of our alliance is that the research foci of the three universities overlap extensively while, at the same time, their disciplines are complementary in many regards. Therefore, we are stronger together than each individual university alone."

Strength through diversity

Scientists of all career stages will have access to the networks and partnerships of the Research Campus. This includes the research institutions in the region, the Herder Institute for Historical Research on East Central Europe in Marburg, the Max Planck Institute for Terrestrial Microbiology in Marburg, the Max Planck Institute for Heart and Lung Research in Bad Nauheim, and the Research Division Bioresources of the Fraunhofer Institute for Molecular Biology and Applied Ecology (IME) in Giessen.

At the Research Campus of Central Hessen, scientists work together to develop new research projects. Pioneers of this idea include, for example, the collaborative research groups that are funded by the German Research Foundation, specifically "Dynamics of Security" and "Cardinal Mechanisms of Perception" at the Universities of Giessen and Marburg. "These domestically and internationally renowned projects, operate in the fields of historical security research and perceptual research. They achieve a level of comprehensiveness in terms of their broadness and the depth of academic inquiry that one university alone could not have mustered," says Prof. Dr. Michael Bölker, Vice President of Research at the Philipps-Universität Marburg.

The Research Campus offers start-up funding to promote new joint research initiatives. This way, emerging fields of research can be developed, and existing, established Campus Research Foci and Profile Areas advanced. The Campus Research Foci also receive funding for tenure track professorships. To promote and facilitate the cooperation between the universities on all levels, the Management Office of the Research Campus in Giessen functions as a central coordination and contact point.

The Research Campus also promotes the transfer of knowledge and technologies to society at large – by working together with partners in industry, business, and public life. If scientists want to develop their research accomplishments into marketable products, they will find several contact points at the Research Campus that offer advisory services on how to start their own businesses. This includes the Start-Up Network Central Hessen StartMiUp, being funded through the EXIST program by the German Federal Ministry of Economic Affairs and Energy. It will begin operation in the spring of 2020. The network's support for founders includes, for example, finding ideas, monitoring industry sectors, developing business plans as well as patent applications, innovation management, and financing opportunities.

Doctorate in Engineering Sciences in Central Hessen

One of the objectives of the Research Campus is to provide outstanding young scientists with a productive environment for their professional development, which is not only a benefit to the university, but to the economy overall. By establishing the Research Campus, the three Central Hessen universities act as development engines, thereby making use of the entire region.

A joint doctoral platform enables cooperative doctorates in current research fields and introduces doctoral candidates from all three partner universities to the questions and problems of cutting-edge research. A special feature of the Research Campus is the "Graduate Centre for Engineering Sciences". It opens the way for graduates of both types of German universities – either traditional universities or universities of applied sciences – to earn a doctorate in engineering.

"Although we are not a technical university, the Graduate Centre for Engineering Sciences enables us to award the doctor of engineering degree," Bölker says. "For the first time, our graduates for example in computer science, materials science, and physics can decide which doctorate they prefer for their professional development."

Research Campus of Central Hessen: Miriam Jüngling is a doctoral candidate at the Graduate Center for Engineering.

Photo: Christine Buhl

Future workshop of the Research Campus of Central Hessen in Rauischholzhausen Castle near Marburg

Photo: Franziska Külbel

Research Campus of Central Hessen

Campus Research Foci:

- Biomedical Informatics and E-Health
- Mind, Brain, and Behaviour
- Insect Biotechnology and Bioresources
- Hospital Hygiene
- Cardiopulmonary Medicine
- Material, Molecule, and Energy
- Microorganisms and viruses
- Security – Conflict – Order
- Space Applications

Profile Areas:

- Climate and Climate Change Impact Research
- Infection and Inflammation Research
- Reproduction in Humans and Animals
- Tumor Research and Immunology

For more information: www.fcmh.de/en

BUILDING BLOCKS OF LIFE

Understanding what life is all about: bacteria are present everywhere, including in the human body. There, they act as invisible helpers or as disease triggers. Microbiologists at the Philipps-Universität Marburg research how bacteria work. Their findings can help find new antibiotics. The Marburg Center for Synthetic Microbiology unites research teams that, using engineering methods as a model, reconstruct cellular parts and processes, integrating them into modules, and combining them into complex functional units. In this way, it is possible to produce, for example, new chemicals, biofuels, and medicines. One research project that was started in 2020 aims to take on the greatest challenges of the digital age: long-term data storage. Nature provides the approach for solving the problem. DNA molecules have been storing information in the smallest space possible for thousands of years. Microbiology is not the only department dealing with the building blocks of life, which also include natural resources. The Department of Geography investigates how humans have shaped nature for their own needs for thousands of years and the impact this has had on ecosystems and the climate. Their search for clues has led them to the high mountains of Africa and the rainforests of South America.

Photo: HA Hessen Agentur GmbH/Steffen Boettcher

HOW BACTERIA ORGANIZE THEIR INNER LIVES

GPS for navigating cells

You don't see them, but they're everywhere. Bacteria rule the world, but no one knows exactly what is going on inside of them. What are the principles that make them function? Research teams from the fields of microbiology, biochemistry, and physics at the Universities of Marburg, Giessen, and Munich are investigating this question. In the long term, they want to be able to replicate the basic functions of bacteria to make them available for new technical and medical applications.

Humans cannot live without bacteria. As tiny helpers, for example, they form a protective film on the skin that prevents pathogens from penetrating the skin barrier. They are also important in food. Products like yogurt, cheese, or bread would not be possible without them. But they can also trigger dangerous infectious diseases, and some strains are difficult to fight. Resistance to antibiotics is therefore a major problem that calls for solutions. "Whether we want to use bacteria or fight them, we must first understand how they work," says Marburg microbiologist Prof. Dr. Martin Thanbichler.

Bacteria belong to the group of the prokaryotes; unlike the eukaryotes, they have no nucleus and no clearly defined cellular compartments. For a long time, the internal organization of bacteria was misunderstood. It was known that the approximately 1,500 different proteins in bacteria are distributed in a targeted fashion over particular parts of the cell, such as the cell membrane or the cell interior. But within these areas, their arrangement was assumed to be random. "We know today that's not true. Bacterial cells arrange many of their components with great precision at defined locations," Thanbichler says. "Their internal structure is usually dynamic and variable over time, depending on the cell cycle or external signals." These dynamics over space and time determine basic cellular processes, such as cell division, cell growth, the transmission of genetic information, and motility.

Searching for universal principles

Due to the current advances in microscopy and imaging technology, the structure and dynamics of cellular components can now be analyzed in detail down to the level of individual molecules. "We are interested in arriving at a quantitative and mechanistic understanding of the internal organization of bacterial cells," says Thanbichler. "We want to find out if there are universal principles at work that apply to all bacteria." Thanbichler heads the Collaborative Research Center "Spatiotemporal Dynamics of Bacterial Cells" of the German Research Foundation (DFG), where 58 scientists from Marburg, Giessen, and Munich work closely together to investigate the molecular mechanisms of the internal structure of bacterial cells. They also want to identify functional modules that are responsible for the positioning of particular cellular components. As a long-term goal, they want to enable the use of these studies as basis for producing components for synthetic cells that can be sourced in medical or industrial applications.

Bacteria with very different shapes were selected for their studies. These include rod-shaped species, such as the intestinal bacterium *Escherichia coli* or the soil bacterium *Bacillus subtilis*. Myxobacteria are also rod-shaped – they play an important role in the production of antibiotics and substances used to fight tumors. The bacterium *Corynebacterium glutamicum*, which is also being studied and whose shapes range from egg-like to irregularly rod-like, is used in industrial applications for the production of glutamate and many other biotechnological products. The cholera bacterium Vibrio cholerae has a curved shape. Finally, bacteria that proliferate their cells via a budding process are also being examined. "We want to understand how and why bacteria developed such a great variety of shapes during the course of their evolution," explains Thanbichler. "Are the shapes based on shared molecular mechanisms? Do the shapes determine how processes are regulated, such as cell division?" Some bacteria have flagellae, the rotating, filamentous structures that are anchored in the cell's membrane and used for locomotion. The research teams study how the flagellae form and how they reach their positions. "A detailed understanding of how bacteria move is important for understanding, among other things, how diseases develop," says Thanbichler.

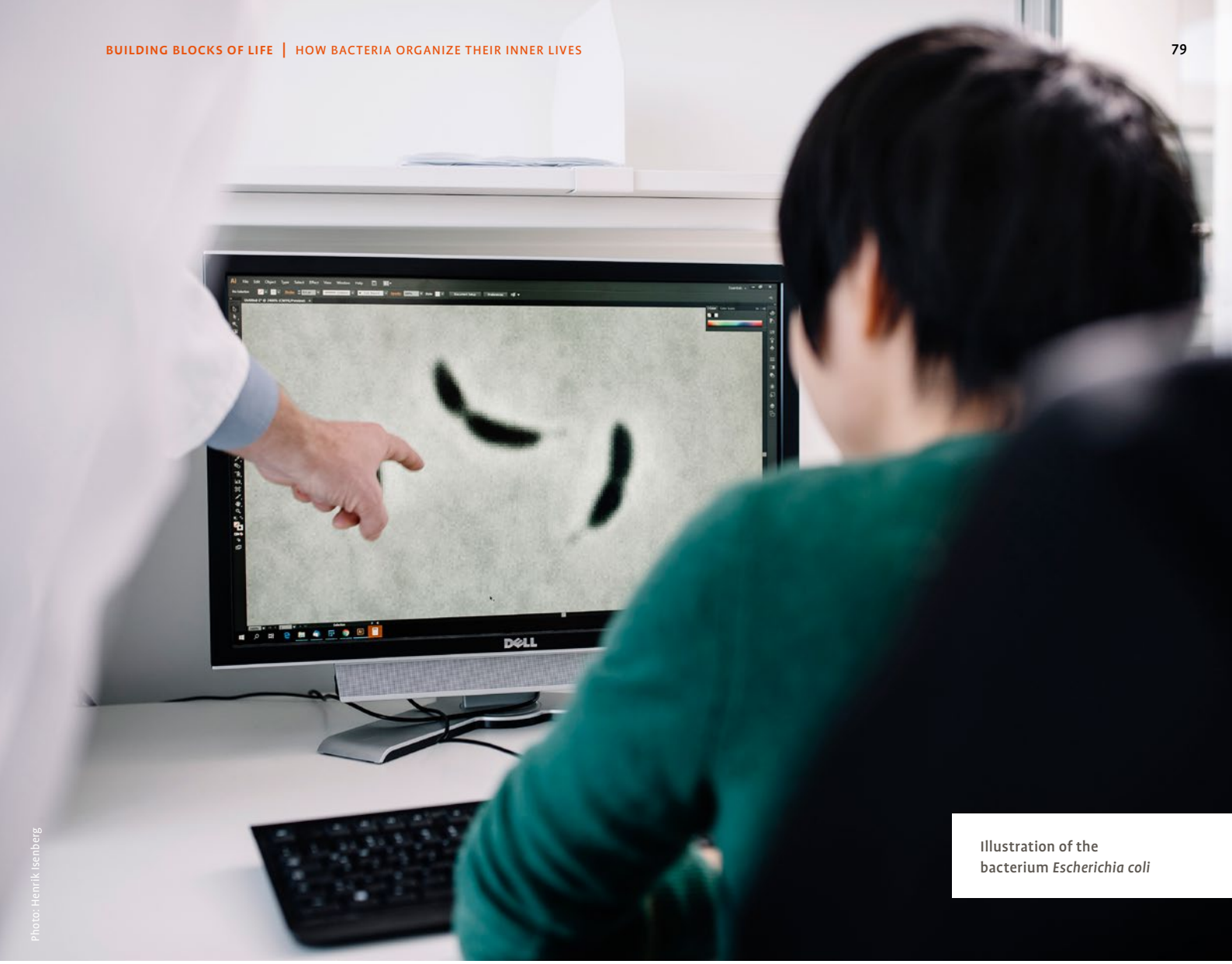


Photo: Henrik Isenberg

Illustration of the bacterium *Escherichia coli*

Same components — different tasks

All bacteria have similar components, but these often control different processes inside the cells. “Proteins that determine the location where cell division occurs in one bacterium control movement in another bacterium,” explains Thanbichler. “Obviously, the evolution of individual mechanisms is associated with certain fitness advantages so that bacteria can better survive in their respective environments.” The scientists use an interdisciplinary approach to establish the kind of tasks that the cell components perform in the different types of bacteria. “We combine fluorescence microscopy studies of living cells with biochemical analysis, mathematical models, and synthetic biology,” says Thanbichler.

This is how the research teams proceed: they use high-resolution microscopes to monitor the collective behavior of molecules inside the cell. In addition, they isolate cellular components to examine *in vitro* their biochemical properties and mutual interactions. These experiments provide information on the individual functions of the cell’s components and their behavior within the overall system. The physicists of the research group are working on transferring their findings from the level of experimental series to mathematical models that will explain how all the factors inside a bacterial cell are integrated into a functioning unit. “The ultimate test for demonstrating our understanding of how cells work is re-creating selected bacterial systems,” Thanbichler says. “This work is done by the synthetic biologists.” The results of their experiments, in turn, help us improve the models that we devised previously. This way, we gradually deepen our knowledge of the molecular mechanisms in bacterial cells. Over the long term, the scientists intend to use methods from synthetic biology to produce new functional modules that can be used in existing or artificial cells and enable the implementation of novel cell features.

In the meantime, much basic research continues to be on the agenda. One topic that occupies many of the research group’s 16 subgroups is the role of particular proteins that are referred to as “P-loop ATPases” in the literature. They perform numerous tasks in bacterial cells, including the

Photo: Henrik Isenberg

Martin Thanbichler

Martin Thanbichler, born in 1973, studied biology in Munich and earned his doctorate in microbiology. Since his time as a postdoctoral fellow at Stanford University from 2002 to 2006, he has been working on the cellular biology of prokaryotes. In 2007, he moved to Marburg as an independent research group leader at the Max Planck Institute for Terrestrial Microbiology. In 2008, Thanbichler became a junior professor, and in 2014 an assistant professor of microbiology at the Philipps-Universität Marburg. He conducts his research at the university's Center for Synthetic Microbiology (SYNMIKRO). In 2015, the Max Planck Society made him a Max Planck fellow for his outstanding achievements in the field of microbial cell biology.

controlling of DNA distribution, cell division and cell mobility. An example of the obtained findings includes that research teams from Marburg and Munich, working together, decoded the system that controls the cell division in the soil bacterium *Myxococcus xanthus*. They found that P-Loop ATPase forms a large complex with two other proteins and that said complex operates like a GPS system. It navigates exactly to the center of the chromosome, which is exactly in the center of the cell, and stimulates the cell division at that location.

Approaches for new antibiotics

The knowledge of how bacterial cells work will open up new technical and medical applications for the uses of bacteria in the future. Bacterial cells are ideally suited to function as a basis because their architecture is relatively simple, compared to eukaryotic cells, and thus considerably more controllable. The research center helps acquire the necessary basic knowledge for these applications. The researchers also want to identify new points of action for antibacterial agents. "Proteins that mediate the spatial organization of bacterial cells are crucial for their fitness, but the antibiotics used to date do not act on any of these structures," says Thanbichler. "We want to provide scientific approaches for finding inhibitory molecules for these structures, thereby supporting the global effort to overcome antibiotic resistance." ■

Photo: Henrik Isenberg

PROFILE

Project:
Spatiotemporal Dynamics of Bacterial Cells (DFG SFB-TRR 174)

Spokesperson:
Prof. Dr. Martin Thanbichler (Marburg)

Deputy Spokesperson:
Prof. Dr. Kirsten Jung (Munich)

Participants:
Philipps-Universität Marburg, Ludwig-Maximilians-Universität München, Justus Liebig University Giessen, Technical University of Munich, Max Planck Institute for Terrestrial Microbiology (Marburg), Max Planck Institute for Biochemistry (Munich)

Disciplines:
Biology, Chemistry, Biochemistry, Physics

Term:
since 2017

FOR MORE INFORMATION

About the project: *www.trr174.org*

Research Campus of Central Hessen: *www.fcmh.de/Research/Campus%20Focus/microorganisms-viruses*

GENETIC MATERIAL AS LONG-TERM ARCHIVE

From the cloud into the DNA

Digitally stored information could be lost for future generations because the capacity for storing information by means of storage media is limited, and information may one day become unreadable. Nature is providing a model for a solution: DNA molecules reliably store information for thousands of years. Teams from the fields of microbiology, computer science, chemistry, and physics work on the foundations for a technology that will encode digital data into genetic material and preserve it for posterity.

Every day, the world creates vast amounts of data that are stored digitally in a cloud and on CDs, DVDs, or hard drives. Libraries, archives, and enterprises for the most part trust magnetic tape for their long-term information storage needs. But all of these storage media have disadvantages: they back up data for only a few years. After that, they have to be copied to new data carriers. Another problem is that file formats are changing. Worst case scenario, valuable knowledge and historical documents of the twenty-first century may be lost for future generations because the new technologies do not support access to legacy systems. You could always transfer data to storage media that are current at any given time. But for the ever-increasing amounts of data, the effort would be immense. The research teams of the project "Molecular Storage for Long-term Archiving" (MOSLA) — funded by the State Initiative for the Development of Scientific and Economic Excellence (LOEWE) — are looking at a more efficient solution: DNA data storage.

"Nature has shown us that DNA is durable," says Marburg bioinformatician Professor Dr. Dominik Heider, a spokesperson for the research project that began in 2019. "For example, the genetic material of long-extinct animals can be analyzed even after several thousand years. For the durability of molecular storage media, we are aiming for a solution that will last for a hundred to ten thousand years." The information density in DNA is very high. "A maximum of 10^{19} bits can fit in gram of DNA. If only one millionth were to be used, that would be equivalent to one terabyte or about 250 million written pages. This enormous storage capacity offers enough space to guarantee the retrieval of information even in the event of errors by using especially designed coding methods," microbiologist Professor Dr. Anke Becker predicts. She is the director of the Center for Synthetic Microbiology (SYNMIKRO) at the Philipps-Universität Marburg and co-spokesperson for the MOSLA research project. Scientists of the University of Giessen also contribute to the project.

Soil bacterium well-suited as storage medium

DNA is made of four different nucleotide components: adenine, thymine, guanine, and cytosine (ATGC). While all digital information nowadays is based on a binary code consisting of a sequence of zeros and ones, such information can also be converted to a quaternary code comprising long strings of the letters A, T, G, and C. "However, DNA must be protected from environmental influences in order for it to be stable," says Becker. "One possible option is the use of a microbial cell as a container, because it protects DNA and repairs damage caused by environmental influences, such as UV radiation. Moreover, it also provides a simple copying mechanism due to cell proliferation. The soil bacterium Bacillus subtilis is a suitable option, for instance." The cells of this bacterium still offer another characteristic that makes it interesting for researchers. The cells can form endospores, which help bacteria survive adverse environmental conditions, such as heat, radiation, and dehydration, and remain stable over several thousand years. "In the context of this research project, we want to test the possibility of storing data inside the cells and spores of this bacterium," Becker says. "The storage media can in part be constructed through automation, using robotics."

But while the spores of the bacteria can resist adverse environmental conditions, they are not completely immune to errors. This is why computer scientists develop codes and mechanisms as error correction tools. "The storage means must be robust against errors

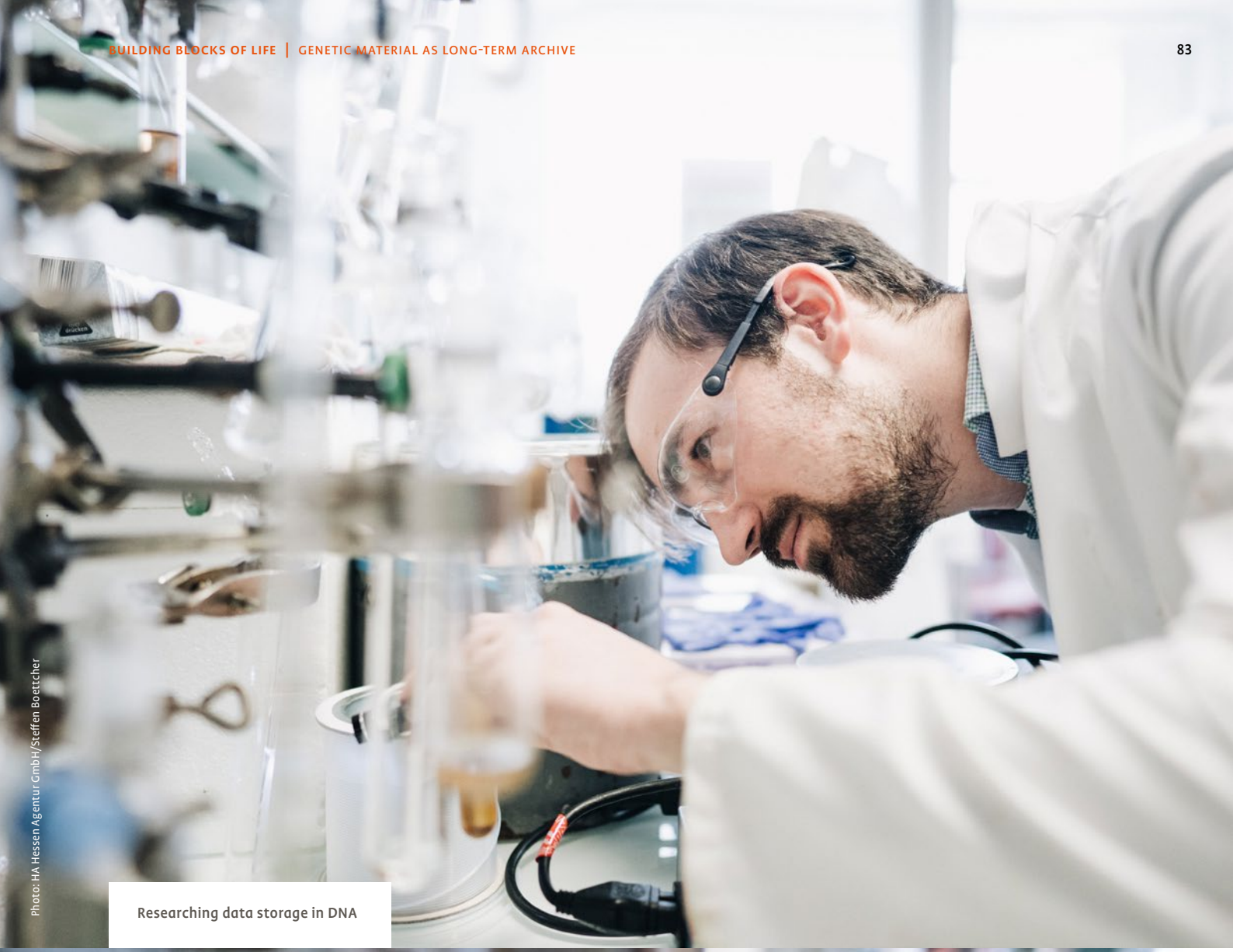


Photo: HA Hessen Agentur GmbH/Steffen Boettcher

Researching data storage in DNA

Photo: HA Hessen Agentur GmbH/Steffen Boettcher

because information can be lost during its transmission, reading, and storage," Dominik Heider says. We're looking for a solution to prevent information loss while requiring minimal additional work steps and minimal additional storage space." So-called erasure codes are being developed to correct errors, for example. Aside from the technical implementation of long-term DNA storage, the error-free reading of the data that was stored in microorganisms is another central field of inquiry. In this context, scientists want to combine genetic and chemical information coding. "We also want to find index solutions whereby it will be possible to read out only parts of the stored data," Becker says.

Molecular biology solutions are not the only path that the research teams have been exploring. Research teams from chemistry and physics departments develop molecules that are applied to a planar substrate using light. The objective is, for example, to create a DVD-like storage medium. As its objective, this technology is to have the capacity to store a data volume of up to 1 terabyte for 100 years.

Researchers collaborate with specialists from the aerospace industry in the development of storage technologies. Together, they conduct testing to see whether the developed solutions can be stable over the long term, and whether, for example, they can withstand cosmic rays – the natural enemies of molecular storage media.

Grimms' fairy tales stored in DNA

Scientists are testing the codes and materials in pilot projects. "We store selected climate data in a structured manner in DNA," says Becker. "Specifically, we use ocean temperature data, which is relevant for the global climate. These data are publicly available and therefore ideally suited for long-term storage tests." To compare codes, Grimms' fairy tales are stored in DNA. "We chose those texts intentionally," says Becker. "They're an important piece of our cultural heritage, they are known internationally, and they have close ties to our research location in Marburg."

The production of DNA storage means from living cells is promising. In addition, researchers are also working on the approach of using synthetic nucleotides in addition

SYNMIKRO – Center for Synthetic Microbiology

The MOSLA focus within LOEWE is currently one of SYNMIKRO's primary research areas. The research center studies major questions that involve small organisms, i.e., microorganisms. Microorganisms are in fact the most common form of life on our planet. Due to their metabolic contributions and interactions with plants, animals, and humans, they fundamentally influence life on Earth. These diverse metabolic contributions offer a great potential for designing sustainable circulatory systems for the environment, for climate, and biotechnology. The center utilizes modern methods from the fields of molecular and cellular microbiology, as well as concepts from synthetic biology to help understand the diversity and functionality of microorganisms and develop potential applications.

Synthetic biology uses modularization and standardization concepts that are borrowed from the engineering field. Accordingly, cellular components and processes are reconstructed and combined into modules that can then be combined into ever more complex functional units. Cells that are constructed in this way could be used in the future to produce chemicals, biofuels, new drugs, and food additives - cost-effectively and environmentally friendly. In addition, basic knowledge gained from synthetic-biological approaches also facilitates a better understanding of the interconnections that characterize more complex environments and deriving future, promising practices for environmental protection and agriculture.

From 2010 to 2018, SYNMIKRO received funding in the amount of a total of about 47 million euros from the research promotion program of the state of Hessen, the State Initiative for the Development of Scientific and Economic Excellence (LOEWE). Since 2019, the center has been a permanent institution of the University of Marburg. SYNMIKRO brings together about 40 research groups from the Philipps-Universität and the Max Planck Institute for Terrestrial Microbiology working in the fields of microbiology, genetics, medicine, cellular biology, chemistry, physics, mathematics, information technology, pharmacy, sociology, and bioethics.

www.synmikro.com

Bioinformatician Dominik Heider leads the LOEWE focus area MOSLA.

Photo: HA Hessen Agentur GmbH/Steffen Boettcher

to the four natural DNA building blocks ATGC, which could be used to chemically expand DNA storage means for storage operations outside of the cells. An extension to a five-digit or six-digit code is conceivable. “One obstacle that stands in the way of storage in DNA is the still high cost of any DNA synthesis,” says Anke Becker. “Although the cost of DNA synthesis is continually coming down, a major technological leap that would facilitate the production of large quantities at a low cost has not happened so far.”

Long-term storage of valuable data has become an enormous cost factor for archives, libraries, and large companies. A digitized book page costs about five euros today. This is considering all the costs that are incurred, including the costs for facilities, digitalization, storage space, personnel, and data loss,” estimates Becker. DNA storage means could be the solution of the future for our archiving problems, because they can potentially provide options for the reliable storage of huge amounts of data with minimal space requirements. The novel storage media are not intended for private use – conventional digital storage media are cheaper and at the current time sufficient for individual users. They are also more suitable due to their faster data access. ▪

PROFILE

Project:
MOSLA – Molecular Storage for Long-Term Archiving (LOEWE Research Cluster)

Spokesperson:
Prof. Dr. Dominik Heider

Deputy Spokesperson:
Prof. Dr. Anke Becker

Participants:
Philipps-Universität Marburg,
Justus Liebig University Giessen

Disciplines:
Information Technology, Biology, Chemistry

Term:
since 2019

FOR MORE INFORMATION

About the project: *mosla.mathematik.uni-marburg.de/gb/*

Research Campus of Central Hessen: *www.fcmh.de/Research/Campus%20Focus/microorganisms-viruses*

HOW HUMANS CHANGE THE ENVIRONMENT

Children of Prometheus

Humans have been influencing nature for millennia. Marburg scientists investigate the effects of these interventions in different parts of the world. In the high-altitude afro-alpine ecosystems of East Africa, they reconstruct how a human-made environment has developed there since paleolithic times. In the rainforests of Ecuador, they study the impact of land use on ecosystems and climate. They also work on new methods for environmental monitoring.

When does the Anthropocene begin? That's the epoch when humans began to shape their environment and intervene in the processes of nature. The geographer Georg Miehe, Senior Professor for Comparative High-Altitude Mountain Research, has had this question on his mind for his entire career as a researcher in Marburg. He is especially interested in establishing when humans started adapting high-altitude mountainous terrain — presumably hostile to life — into cultural landscapes. Miehe has been doing research in the Himalayas for 40 years and in Tibet for 30 years.

Since 2016, the "Mountain Exile Hypothesis" research group, with funding from the German Research Foundation (DFG), has been able to continue with studying the environmental history of Africa's largest alpine ecosystem in the Bale Mountains of southern Ethiopia. Because these questions can only be answered within an interdisciplinary framework, Miehe works with an international research team representing, in addition to geography, expertise in archeology, soil science, glacier research, paleoecology, zoology, population genetics, and environmental informatics. "Thinking of alpine highlands, many people imagine hostile, largely untouched, and sacred mountains," Miehe says. His hypothesis: humans have been exploiting the afro-alpine highlands since early on in human history. "During the Ice Age, possibly people found refuge there," says the high-altitude researcher. "As water was being deposited in glacier ice, the lowlands, like the Sahara, turned into hostile deserts. The highlands with their higher rainfall became a migratory destination for humans and animals. Paleolithic hunters presumably followed the game to places with water — the mountains."

When reconstructing alpine cultural landscapes, traces of the use of fire are a central feature pointing to the human impact on the landscape. "We are the children of Prometheus," says Miehe, referring to the book by Hermann Parzinger (*Die Kinder des Prometheus*, Munich 2014). "Our research team found evidence in the Bale Mountains that humans were living in the highlands as early as 47,000 years ago. We suspect that hunters used fire to clear spaces for hunting, thereby creating forest-free landscapes."

Archeological teams unearthed camp sites used by Mesolithic hunters and found, through mineralogical analysis, that these hunters fashioned their tools from obsidian, a volcanic glass available at 4,240 m above sea level. To understand how cultural landscapes have developed, researchers also study the spread and population history of a species of animal that is exclusive to a specific region, presently: the Giant Molerat. The zoo-archaeological record suggests that Mesolithic hunters consumed these rodents in large numbers. The animals still populate the highlands even today, with their earth mounds, but only in the open spaces — not in places where giant heather shrubs (*Erica trimera*) grow. These shrubs are typical for the vegetation of the Bale Mountains. "We pursue the hypothesis that humans burned down Erica forests, thereby creating a larger habitat for the rodents," Miehe says. Fluctuations in these mole rat populations can be reconstructed based on genetic studies by the research group of Prof. Dr. Nina Farwig, Department of Biology at the University of Marburg. In conjunction with archeological and soil studies, as well as paleoclimatic data, it is possible to divine the environmental history of this ecosystem that was influenced by the climate and by human actions.

A novel technique is used to extract genetic trace evidence of the humans who once lived here from the piles of refuse they left behind at their camp sites. This task is assigned to an international team that is coordinated by Marburg biologist Prof. Dr. Lars Opgenoorth. The studies are to provide information on the Ice Age migrations of our ancestors in North-East Africa. "Aside from the much-debated issue of defining when the "out of Africa" migration occurred and what fluctuations in the climate

Photo: Georg Miehe

Cultural landscape in the Bale Mountains

triggered it, with the Mountain Exile Hypothesis, we are probing a new question. When did the mountainous highlands become a destination for human migration?" explains Miehe. "The environmental history of the mountains of North-East Africa is likely to be rewritten. After these initial results, we are expecting more surprises to come."

For Miehe, the research group is a multigenerational model. The contributing scientists range from age 20 to 82. Miehe believes the generations complement each other perfectly: "The strengths of the older researchers are their experiences and the ideas and interconnections that these experiences feed. The strengths of the younger researchers are based, apart from their greater physical resilience, on their knowledge of new techniques and methods that can be used to answer previously unsolvable questions." Accordingly, the project "Nature 4.0," which was launched in 2019 and is funded by the Hessen Excellence Initiative LOEWE, is dedicated specifically to developing such new techniques that are intended to help capture and evaluate processes in nature in a comprehensive way, true to every detail.

PROFILE

Project:
The Mountain Exile Hypothesis (DFG FOR 2358)

Spokesperson:
Prof. Dr. Georg Miehe

Participants:
Philipps-Universität Marburg, University of Bayreuth, University of Cologne, Martin Luther University of Halle-Wittenberg, Technical University of Dresden, University of Bern, Aberystwyth University (Wales), Addis Ababa University (Ethiopia)

Disciplines:
Geography, Biology, Prehistory and Protohistory

Term:
since 2016

FOR MORE INFORMATION

About the project:
www.uni-marburg.de/en/fb19/dfg2358

Research Campus of Central Hessen:
www.fcmh.de/Research/profile%20areas/climate_climatechangeimpact

Radio tracking: In the University Forest near Marburg, the Nature 4.0 team observes animal movement, among other things, to draw conclusions about the development of the forest ecosystem.

Photo: Christoph Reudenbach

INDISPENSABLE FOR CLIMATE RESEARCH: MATHEMATICS AND INFORMATICS

Environmental informatics specialist Prof. Dr. Thomas Nauss, who also oversees the climate stations of research groups working in the Kilimanjaro region and the Ethiopian highlands, coordinates the Nature 4.0 project, with contributions by scientists from Marburg, Giessen, Darmstadt, and Frankfurt. The team develops tools and models to answer questions such as: What factors, interrelationships, and processes are involved in the extinction of animal and plant species? What is the reason for the massive insect die-off? What does the extinction of species mean for the ecosystem?

The basic idea of the project envisions establishing a network of sensors that enables a detailed and continuous collection of environmental data. To date, it was only possible to collect either data with much detail on small areas or data with fewer details on large areas. “Such compromises limit the possibilities for conservation planning and possible actions,” Nauss says. “It is our aim to provide a system for a comprehensive, high-resolution monitoring of species, habitats and processes relevant to nature conservation.” This is to provide a better basis for sustainable species protection and the safeguarding of ecosystem functions.

For example, the research teams collect data on locations, movement profiles, microclimate, light intensity, as well as sound recordings and images of the observed objects and organisms. They use satellites, drones, and robot rovers for this purpose. Animals are also equipped with sensors. In addition, the experts utilize data from scientific surveys, or by interested citizen. Altogether, the results are spatial-temporal high resolution but at the same time irregular data sets with temporal and spatial gaps. “We need environmental models that do more than explain what is happening in nature. We need models that also indicate how and why something happens. And for that, we need consistent data,” Nauss stresses. Accordingly, the project develops a database that integrates and prepares data in a suitable way to enable data analysis. Machine learning methods are developed to derive information that is relevant for nature conservation and analyzing interrelations in the ecosystem. Research teams from mathematics and computer sciences work on algorithms that are designed, for example, to enable the automatic detection of bird and bat species on the basis of sound recordings.

Merging small-scale, detailed data and area-wide remote sensing data (e.g., aerial images or radar measurements) allows creating high-resolution and high-detail raster maps that provide information on biodiversity and ecosystem properties. They also facilitate the analysis of functional relations and interactions between

Measuring sap flow of trees in the University Forest near Marburg

plants, animals and climatic conditions. Last but not least, the objective of Nature 4.0 is also about establishing an early warning system. “For example, if time series analysis reveals a decline in biodiversity, we now have the capability of early intervention to initiate nature conservation measures,” Nauss explains.

The test area for Nature 4.0 is the University Forest in Caldern, near Marburg. This is a typical forest ecosystem with an area of 2.2 km². For example, the researchers study trees as habitats and their interactions with animal and insect species. They examine the importance of tree-dwelling insects for the forest’s ecosystem, preferred resting spots of animals, the hunting behavior of bats, the question of how animals and plants are interconnected in food webs and how they react on changes in the ecosystem. The University Forest is not a biodiversity hotspot. But the research team believes that’s not necessary for the development of the prototype of Nature 4.0. The instruments that are developed as part of the project will also be used for research on the tropical mountainous rainforest in Ecuador, one of the hottest biodiversity hotspots in the world.

PROFILE

Project:
Nature 4.0 (LOEWE Research Cluster)

Coordinator:
Prof. Dr. Thomas Nauss

Deputy Coordinator:
Prof. Dr. Jörg Bendix

Participants:
Philipps-Universität Marburg, Justus Liebig University Giessen, Technical University of Darmstadt, Senckenberg Biodiversity and Climate Research Center (Frankfurt)

Disciplines:
Geography, Biology, Information Technology

Term:
since 2019

FOR MORE INFORMATION

About the project:
www.uni-marburg.de/en/fb19/natur40

Research Campus of Central Hessen:
www.fcmh.de/Research/profile%20areas/climate_climatechangeimpact

ACCOUNTING FOR BIODIVERSITY

"To predict how the climate in Ecuador's mountainous rainforests will change by the year 2100, numerical models are needed," says Marburg climate geographer Prof. Dr. Jörg Bendix. But a model for a complex ecosystem is not built in a few years. On this point, the scientists of the research group "Environmental Changes in the Biodiversity Hotspot Ecosystems of South Ecuador: System Response and Feedback Effects" (RESPECT) agree. The researchers are led by Bendix and, since 2018, have received funding from the German Research Foundation (DFG). The participants come from the fields of geography, hydrology, soil science, biology, and environmental modeling. They originate from eight German universities and research institutes. Bendix explains why the research is necessary: "For the tropics, we to date have a land surface model only whose computations are based on a single tree species," he explains. "In Ecuador, however, there are around 140 species of trees that grow on a single hectare. This is why the current models at hand cannot work properly. We need models that account for biodiversity."

Trees being cleared in the mountain rainforest of southern Ecuador to create grazing areas.

Bendix has been conducting research on the Ecuadorian mountainous rainforests in various interdisciplinary projects for almost 20 years. Initially, the research focus was on capturing and understanding the biodiversity of the region and on explaining how this diversity had evolved. Later, he studied how the ecosystem organizes and maintains itself; for example, by recording how some species take over substitute functions from other species when the latter have disappeared. Bendix explored the impact of human interventions in the rainforest on its ecosystem functions, such as water regulation and carbon storage. In addition, the climate geographer established a rain radar network in Ecuador and introduced environmental monitoring. He was particularly interested in functional indicators, such as evapotranspiration as a sign of the ability of trees to release water into the atmosphere.

The current project is a continuation of this research. "Climate and land use changes are threatening the species-rich ecosystem in the mountainous rainforest of Ecuador. We suspect that a natural forest is more resistant to the impact of climate change than grassland or tree plantations. But we also expect that it will be possible to improve the resilience of the entire ecosystem by implementing sustainable land use systems," explains Bendix the hypothesis of the project team.

For future projections and to be able to demonstrate options for action, we collect a wide variety of data as site. These data are relevant for two central ecosystem functions: biomass production and the flow of water. A statistical analysis of old and newly collected data shows which biological processes, such as herbivory of insects, are most important for the functions of the ecosystem. These processes are then integrated as modules in a land surface model. In addition, the model is adapted for the large number of tree species. The result is a "biodiversified" land surface model that is ready to use for species-rich regions of the Earth.

The mountain rain forest in southern Ecuador is the investigative focus of the RESPECT research group.

Photos: Jörg Bendix

Handroanthus tree in southern Ecuador, a region with especially rich biodiversity

With the model, it is possible to play through climate change and land use scenarios to determine under which conditions the stability of the studied ecosystem functions is warranted or not. It is also possible to predict how the environment will respond to climate change and how these responses in turn will feed back to the climate. For example, climate change could reduce seed dispersal by birds, and therefore the growth of new trees, or it could increase leaf losses from trees due to leaf-eating insects. However, fewer leaves translate into a change in the surface structure of the ecosystem. Less heat and water vapor are transported into the atmosphere, which in turn contributes to climate change.

As its long-term goal, the research group seeks to support sustainable land use. Bendix can already offer some recommendations based on his many years of doing research in the mountainous rainforest. “Intensive grazing is not sustainable,” he advises. “Bracken fern is spreading all over the pasture land. And bracken is hardly controllable. After two to three years, the overgrown pastures will be abandoned. When that happens, another section of the pristine forest is cleared. It would make more sense to use existing land areas more intensively and not burn down more forest.” He continues: “The indigenous population should be involved in the development of a new land-use system, because their traditional land use strategies are sustainable in most instances.” ■

PROFILE

Project:
RESPECT — Environmental Changes in South Ecuador’s Biodiversity Hotspot Ecosystems: System Response and Feedback Effects (DFG FOR 2730)

Spokesperson:
Prof. Dr. Jörg Bendix

Participants:
Philipps-Universität Marburg, Justus Liebig University Giessen, Karlsruhe Institute of Technology, University of Bayreuth, Friedrich Alexander University of Erlangen-Nuremberg, University of Göttingen, Goethe University of Frankfurt, Senckenberg Biodiversity and Climate Research Center (Frankfurt), Brandenburg Technical University of Cottbus-Senftenberg

Disciplines:
Geography, Environmental Management, Biology

Term:
since 2018

FOR MORE INFORMATION

About the project:
www.TropicalMountainForest.org

Research Campus of Central Hessen:
www.fcmh.de/Research/profile%20areas/climate_climatechangeimpact

Set up for the future

In recent years, the Science Council, the most important scientific advisory body in Germany, made recommendations for four research buildings at the Philipps-Universität Marburg. The new buildings, financed with funds provided by the German federal government and the HEUREKA University Construction Program of the State of Hessen, contribute to setting the focus and interdisciplinary alignment of academic inquiry, as well as to the international competitiveness of research at the university.

The research buildings program, which the Science Council carries out on behalf of the federal and state governments, has been in existence since 2007. The Philipps-Universität has so far been very successful in securing funds from this program. The new buildings will contribute to further strengthen outstanding research in Marburg. In 2014, the first research building, the Center for Tumor Biology and Immunology, opened its doors on the Natural and Life Sciences Campus Lahnberge. In 2016, the German Language Atlas Research Center was inaugurated on the Social Sciences and Humanities Campus in the city center of Marburg. The new building for the Center for Synthetic Microbiology will be operational in 2020 at Lahnberge Campus. The fourth research building is the German Documentation Center for Art History – Bildarchiv Foto Marburg, that will be built on the Firmanei Campus, slated for completion in 2021.

Center for Tumor Biology and Immunology (CTI)

The CTI was built opposite the Biomedical Research Center, the Clinical Research Building, and in the neighborhood of the University Medical Center. Research at the CTI is dedicated in particular to tumor biology and the regulation of the immune system, with a focus on the interface of inflammation and tumor development, progression, and resistance. The CTI offers excellent working conditions for scientists of the Department of Medicine in cancer research, combining basic research and the development of therapies. The infrastructure is instrumental for the success of research. The workgroups have direct access to advanced techniques and equipments, including spectroscopy, imaging equipment, and analytical methods. The CTI brings scientists from various fields in medicine, pharmacy, chemistry, and biology together under one roof. This promotes interdisciplinary work and scientific exchange.

Photo: Markus Farnung

FOR MORE INFORMATION

About the Center for Tumor Biology and Immunology
www.uni-marburg.de/en/fb20/departments/zti

More information on the architecture of the CTI and data on the construction project
www.uni-marburg.de/de/universitaet/presse/baukommunikation/campus-lahnberge/zti

Photo: Ellen Thun

Research Center Deutscher Sprachatlas (DSA)

Founded in 1876, the DSA is among the world's most venerable linguistic research centers with a richly impressive history. Linguistic research in Marburg focuses on language dynamics and the relationship between language and cognition. This research focus, starting in 2000, is the result of a collaboration of the field of Theoretical Linguistics and the DSA's Research Center for Linguistic Variation and Change. The research approaches by individual disciplines, the research questions and methods are integrated in a way that sustainably promotes progression in linguistic knowledge. The research building provides the contributing disciplines with a common infrastructure and enables networked research: experts of variational linguistics and neurolinguistics work under the same roof with psychologists and linguists, as well as with language historians.

FOR MORE INFORMATION

About the Research Center Deutscher Sprachatlas (DSA)
www.uni-marburg.de/de/fb09/dsa

For more information on the architecture of the DSA and data on the construction project
www.uni-marburg.de/de/universitaet/presse/baukommunikation/campus-firmanei/dsa

Visualization: Nickl & Partner Architekten

Center for Synthetic Microbiology (SYNMIKRO)

A milestone in the history of SYNMIKRO, the research building opened its doors in 2020 on the Lahnberge Campus of the Philipps-Universität Marburg. The building accommodates 250 scientists. A department of the Max Planck Institute for Terrestrial Microbiology (MPI) is also moving in – Systemic and Synthetic Microbiology. In addition to the nine existing work groups, teams made up of young scientists will also work in the new building, in direct proximity to the MPI. “We appreciate the short distances that make our cooperation considerably easier,” stresses SYNMIKRO Director Anke Becker. In conjunction with the new research building, the center’s excellent research infrastructure will also be further expanded. For example, a new electron microscope will be purchased for the structural biology department. “Until now,” explains Becker, “we used protein crystallography for the spatial analysis of protein structures. With the new microscope, it is also possible to analyze proteins and protein complexes using individual particles. This yields images from which we can reconstruct the three dimensional structure.”

FOR MORE INFORMATION

About SYNMIKRO
www.synmikro.com

For more information on the architecture of the SYNMIKRO Research Building and data on the construction project
www.uni-marburg.de/de/universitaet/presse/baukommunikation/campus-lahnberge/forschungsbau-des-zentrums-fuer-synthetische-mikrobiologie-zsm-2

German Documentation Center for Art History — Bildarchiv Foto Marburg with seminar building. Visualization: dichter Architekturgesellschaft

German Documentation Center for Art History – Bildarchiv Foto Marburg (DDK)

By the end of 2021, the DDK will get a new research building in the immediate vicinity of the Research Center Deutscher Sprachatlas. It will be a nationally and internationally operating research and service facility, funded by the Philipps-Universität. The Center's mission comprises collecting, exploring, and communicating photographs of European art and architecture, as well as researching the history, practice, and theory of the tradition of the visual cultural heritage – especially the exploration of the associated media transformation processes, the conditions for storing knowledge in visual form, and the importance of remembrance as part of the visual culture in society. With about 1.7 million images, the DDK is one of the largest image archives on European art and architecture. By establishing cooperative structures, Bildarchiv Foto Marburg supports documentation work at museums, heritage offices, libraries, and research institutes. With the publication of image material and development data from more than 80 partner institutions, the DDK serves publishers, editorial departments, researchers, and other interested parties.

FOR MORE INFORMATION

About the German Documentation Center for Art History — Bildarchiv Foto Maburg (DDK)
www.uni-marburg.de/de/fotomarburg

For more information on the architecture of the DDK and data on the construction project
www.uni-marburg.de/de/universitaet/presse/baukommunikation/campus-firmanei/ddk

Photos: HAVessen Agentur GmbH/Anna Schroll

SERVING PATIENTS

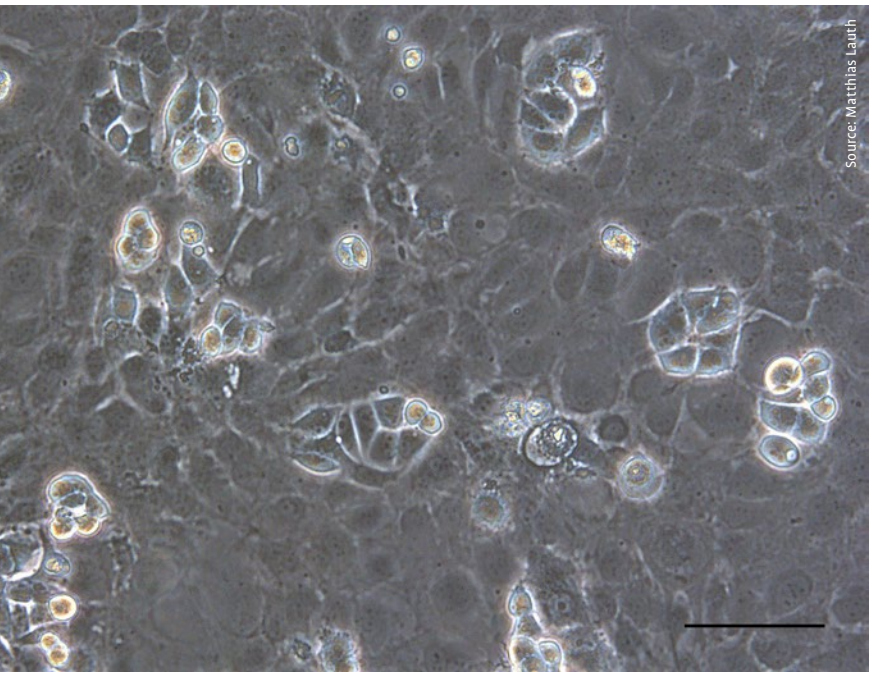
Basic research and patient-based research are growing together: The University Hospital of Giessen and Marburg is one of the largest university hospital centers in Germany, which places the Philipps-Universität in the midst of a region that excels in medicine. In addition to focusing on tumor biology and oncology, infectious and inflammatory diseases and immunity, as well as neuroscience, the School of Medicine at the Philipps-Universität also features basic research in cell biology and gene regulation. Researchers from different areas collaborate closely to identify, for example, the causes and connections that are involved in the development of tumor diseases. The Center for Tumor Biology and Immunology offers sophisticated technologies, as well as modern applications and methods for basic research. These modalities support the development of therapeutic approaches, e.g., for pancreatic cancer that is difficult to treat. In infectious disease research, researchers focus on virology and the development of vaccines. The High-Security Laboratory (BSL4) provides the necessary infrastructure. In the fight against highly pathogenic viruses, such as the Ebola virus, the virologists at Marburg collaborate with international consortia on the development of vaccines and drugs.

PANCREATIC TUMOR RESEARCH

Breaking through walls

Pancreatic cancer is usually diagnosed late, it metastasizes early on in the disease, and it is difficult to treat. Although researchers have been successful in extending the median survival from a few weeks to more than a year, progress has been slow. Searching for new therapeutic approaches, Marburg scientists study the connective tissue that suppresses the immune system, which would normally fight the cancer.

The pancreas fulfills important functions: it produces digestive enzymes and regulates the blood sugar level with the hormones insulin and glucagon. Every year, about 17,000 people in Germany are diagnosed with pancreatic cancer, most of them with the ductal adenocarcinoma subtype. Initially, the tumor does not cause any specific complaints. It is usually only detectable via imaging technology when it measures at least one centimeter. In most cases the disease is already well advanced at the time of the diagnosis. With about seven percent, pancreatic cancer has the lowest five-year survival rate among all cancers. Moreover, it is the fourth most common cause of death from cancer.



Cell islands on stromal fibroblasts

One of the biggest problems hampering treatment is the heterogeneity of this cancer. “There are twenty to thirty different subgroups of the tumor for each of which, in principle, we would need different drugs or drug combinations,” says Marburg physician Prof. Dr. Thomas Gress, Director of the Clinic for Gastroenterology, Endocrinology, Metabolism and Clinical Infectiology at the Medical Center of the University of Marburg. Until 2011, there was only one drug for the treatment of pancreatic cancer, which resulted in a median survival of four to five months. In recent years, drug combinations have been identified that increase survival of patients to 9 to 15 months. “It is our hope that we will help double the median survival,” Gress says. He is the spokesperson of an interdisciplinary clinical research group funded by the German Research Foundation (DFG). The researchers of this consortium have been working since 2018 on improving early detection and treatment options for this particularly aggressive cancer.

Reprogramming the tumor environment

“According to what we know today, novel therapeutic approaches will involve targeting the immune system,” Gress explains. Immunotherapies are already working quite well in the treatment of melanoma and lung cancer. But research is still at the very beginning for pancreatic cancer. “Tumor cells are densely surrounded by connective tissue that separates the tumor cells like a wall from action by the immune system and by drugs,” Gress says, thereby explaining a major reason why the usual cancer treatments have little effect. The prominent connective tissue, also termed desmoplastic reaction, of pancreatic tumors is characterized by a small number of blood vessels, thus preventing cancer drugs from reaching the tumor cells. However, simply removing the connective tissue around the tumor cells is not a solution, as the connective tissue also contains components that slow the tumor’s growth. “Without it, the tumor would grow even faster and produce metastases,” explains Prof. Dr. Matthias Lauth, head of the clinical research group. The team therefore focuses not only on

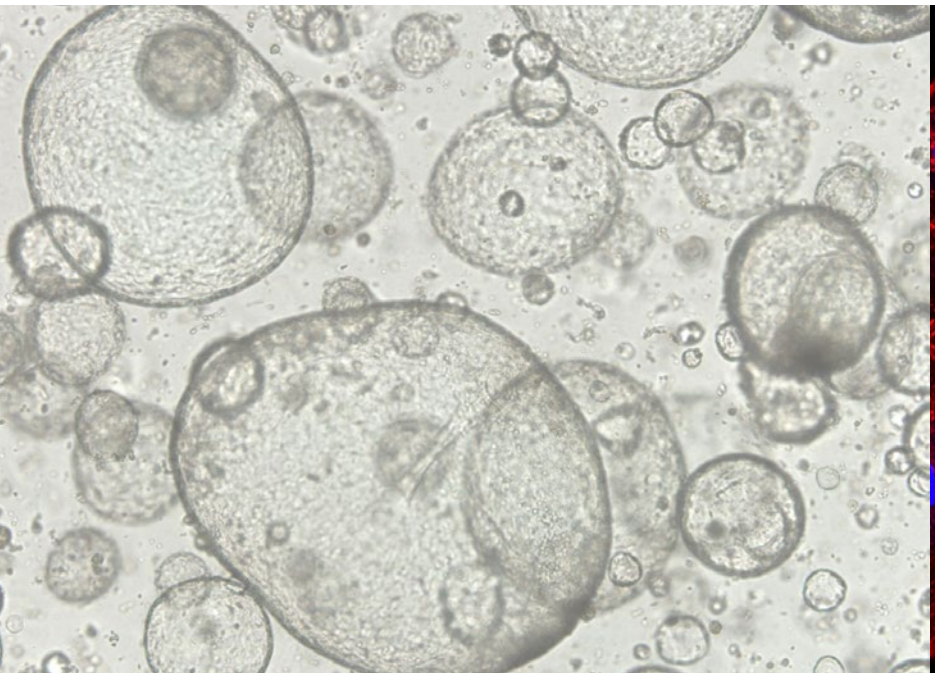
Photo: Henrik Isenberg

Matthias Lauth conducts research at the Center for Tumor Biology and Immunobiology.

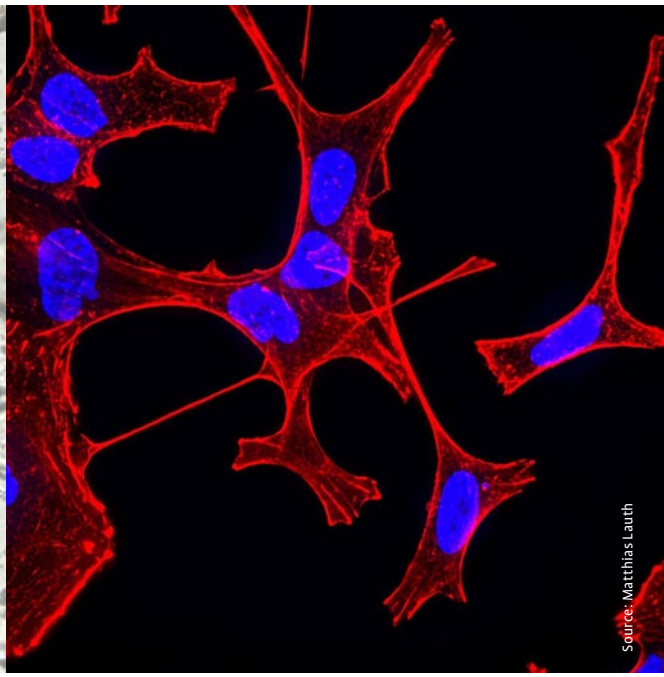
the tumor cells but also their interactions with their immediate microenvironment. This is probably the key to reactivate the suppressed immune cells of the pancreas. “We are looking for ways to reprogram the tumor’s microenvironment, that is to strengthen the components that decelerate tumor growth and weaken the components that promote tumor growth,” explains Lauth.

In the context of these efforts, the research teams look at different cell populations that interact in the tumor tissue. They want to understand what makes cells, that are actually part of the immune system, promote cancer. One focus is, for example, on T-cells. T-cells detect pathogens and regulate the immune response. Although they infiltrate tumor tissue in pancreatic carcinoma, they lose their ability to fight the tumor. One project investigates the mechanisms behind the inactivation of the T-cells inside the tumor. In addition, other cell types and proteins are also under investigation: Scientists from the immunology department are working on toll-like receptors (TLRs). These receptors can typically be found on immune cells, but are also produced by cancer cells and connective tissue cells. The question is whether and to what extent the TLRs promote the tumor growth and if they can be considered as treatment targets.

Tumor biologists also focus on extracellular vesicles that regulate, for example, the activity of natural killer cells (NK cells). The researchers want to study the influence of these vesicles on the pancreatic tumor microenvironment and on the NK cell-driven anti-tumoral response in order to identify new drug targets for immunotherapies. Researchers from the molecular biology and visceral surgery departments examine the role of certain proteins (ADAM8, PRMT1) in the interactions of the tumor with its microenvironment. These proteins are highly expressed in pancreatic carcinoma tissue. The research team investigates for instance whether inhibiting these proteins will produce a therapeutic effect.



Organoids are artificial tumors created in test tubes.



Tumor cells in a fluorescence microscope

The future belongs to immunotherapy

The tumor biologists work in close collaboration with the department of medicinal chemistry to find new treatment options. They seek for an active substance that facilitates reprogramming of the tumor cells and connective tissue cells in patients with pancreatic cancer. To this end, one cellular signaling system they evaluate is the Hedgehog (HH) signaling pathway. This pathway is responsible for the formation of abundant connective tissue in pancreatic tumors. Paradoxically, HH signaling also helps to inhibit tumor formation and to promote cell differentiation. The active substance sought after should possess these properties and selectively develop its protective efficacy inside the connective tissue.

“Basic science and clinical research are optimally supported at the Center for Tumor Biology and Immunology (CTI) at the Philipps-Universität Marburg,” Gress and Lauth emphasize. The research teams study many cellular processes using mouse models of pancreatic cancer, which correspond to the human situation. It is therefore very helpful that the CTI hosts facilities for advanced imaging techniques, such as magnetic resonance imaging (MRI) and positron emission tomography (PET), as well as a small-animal ultrasound device for examining live mice. A two-photon microscope enables the observation of living cells within mice. Using a spinning disk microscope, particularly fast movements and interactions of the tumor cells can be measured with high resolution and tracked in time-lapse. In addition, 3D cell cultures, so-called organoids, are also produced at the CTI. These artificial tumors are created in a test tube and are used to test newly developed substances for their efficacy as possible medications.

Photo: Henrik Isenberg

Researching pancreatic cancer: Marburg University scientists Matthias Lauth, Thomas Gress and Malte Buchholz (left to right)

Many researchers at the CTI make use of a central biobank. Among other things, researchers at the biobank characterize patient tumors, analyze gene sequences, and document clinical courses of the tumor development. Standardized blood samples from cancer patients and mice are tested, using high-throughput devices, for biomarkers that indicate pancreatic cancer. Identifying biomarker profiles for the various subtypes of pancreatic cancer is an important goal of the research group. Such profiles in the blood provide information on the exact subtype of cancer and facilitate precision-controlled therapy. “To date, we’ve had to wait and see if a patient would respond to a particular therapy and adapt it accordingly afterwards,” Gress reports from practical experience. “It would be important to know even before starting a treatment which therapy is best suited for each individual patient.”

With their application-based research, the Marburg scientists want to play a key role in the development of novel therapies for pancreatic cancer, in particular targeting the immune system. “In a small group of patients with a certain tumor subtype, immunotherapy succeeded in repressing the tumor,” says Gress. “Though it lasted only for a short period of time, I’m certain that the future belongs to this procedure.” ■

PROFILE

Project:
Clinical relevance of tumor-stroma interactions in pancreatic cancer
(DFG KFO 325)

Spokesperson:
Prof. Dr. Thomas Gress

Coordinator:
Prof. Dr. Matthias Lauth

Participants:
Philipps-Universität Marburg,
University Hospital of Marburg (UKGM)

Departments:
Medicine, Pharmacy

Term:
since 2018

FOR MORE INFORMATION

About the project:
www.uni-marburg.de/en/fb20/departments/zti/cru325

Center for Tumor Biology and Immunology:
www.uni-marburg.de/en/fb20/departments/zti

Research Campus of Central Hessen:
www.fcmh.de/Research/profile%20areas/Tumour%20Research%20and%20Immunology

RESEARCH INTO HIGHLY PATHOGENIC VIRUSES

Hope in the fight against *Ebola*

In 2014, the Ebola epidemic in West Africa served as a wake-up call that joined forces around the world in the fight against the virus. Virologists at the Philipps-Universität Marburg contributed to the development of a vaccine. Other dangerous pathogens are also under investigation at the Marburg High Security Laboratory. The objective is to develop vaccines. The pathogens are known, for example, as Nipah, Lassa or MERS-Corona. And they are classified as RNA viruses.

In the Democratic Republic of Congo, cases of *Ebola* virus infections have been reported starting in August 2018. The threat of an epidemic was looming. The World Health Organization (WHO) launched a vaccination campaign with a vaccine that had not yet been approved. Marburg's Institute of Virology contributed to its development. By December 2019, more than 200,000 people had been vaccinated in the central African country – under difficult logistical conditions, as the country is at war. It was one of the most severe *Ebola* outbreak since the virus was discovered in 1976.

The *Ebola* virus is one of the most dangerous pathogens ever identified. Infected patients can transmit the virus, which is named after a river in the Congo, through bodily fluids, such as blood or sweat. After an incubation period of up to three weeks, symptoms appear. Symptoms are like those of a flu, and ultimately victims suffer from internal bleeding. About half of the people who are infected do not survive. *Ebola* is related to the Marburg virus, which appeared in 1967 in a laboratory at the Behringwerke industrial park in Marburg. Since then, the Philipps-Universität has been working with highly pathogenic viruses. At the heart of and as a prerequisite for this kind of research, we have the High-Security Laboratory (Biosafety Level 4) in Marburg Lahnberge. It is one of four high-security laboratories in Germany and the only one with the highest biological protection level located at a university. Prof. Dr. Stephan Becker, Director of the Institute of Virology at the Philipps-Universität, works there and in the adjacent Biomedical Research Center together with his team. Becker's research focus is the molecular biology of filoviruses, a group of RNA viruses that include *Ebola* and the Marburg virus, as well as the development of vaccines.

Vaccine against *Ebola* works

In the fight against *Ebola*, there is hope for an experimental vaccine called rVSV-ZEBOV. First steps of its development were taken in Marburg and it was further developed in Canada in 2003 and tested in a preclinical trial in 2005. rVSV-ZEBOV is a live vaccine that is based on an attenuated, genetically altered vesicular stomatitis virus (VSV). rVSV-ZEBOV carries the surface protein of the *Ebola* virus. The immune system of vaccinated people will form antibodies against this protein. In the case of *Ebola*, it was not until the epidemic in West Africa that all forces worldwide were mobilized, and clinical trials initiated with rVSV-ZEBOV. In 2014, the WHO initiated four Phase I clinical trials in Africa and Europe, with a total of 158 healthy subjects, to generate comprehensive data on the safety, tolerance, immunogenicity and vaccination dose. The German Center for Infection Research (DZIF) – the virologists from Marburg are members of the DZIF – participated in the preparation of the studies and conducted one of the Phase I clinical trials in Hamburg.

The vaccine proved to be well tolerated and safe in the studies. Stephan Becker's team at the Philipps-Universität investigated the immune response of all the subjects. "The respective immune systems in all participants of the study formed antibodies after a few days," says Becker, who heads a consortium at the DZIF that conducts research in the fight against *Ebola* and other newly emerging infectious diseases. "These antibodies inhibited the infection with the *Ebola* virus in the test tube and could still be detected after six months." The results have been incorporated into further studies. The vaccine was also tested in phase II/III trials in West Africa on several thousand subjects. In particular, medical staff and persons coming into contact with *Ebola* sufferers were given a vaccination. The European Medicines Agency approved the vaccine in November 2019. But much

Philipps-Universität Marburg researches highly pathogenic viruses in the high-security lab.

Photo: HA Hessen schafft Wissen GmbH/Anna Schroll

remains to be done. For example, the vaccine only has efficacy against the *Ebola* virus of the "Zaire" subtype. That's why members in the association that Becker coordinates, developed vaccination platforms to be able to produce vaccines against different *Ebola* strains more quickly.

The global alliance accelerates progress

Researchers from the Becker-led association also work on other dangerous pathogens that can suddenly occur, like *Ebola*. This includes the MERS corona virus, which erupted in Saudi Arabia in 2012 and caused severe lung disease that was transmitted through the air. A vaccine candidate for the MERS virus was developed by the DZIF and is now undergoing clinical trials. Overall, much has been done following the *Ebola* epidemic in West Africa, Becker says. For example, the WHO developed a directive for the accelerated research and development of new vaccines. "We are reaching the clinical phase faster today," says Becker. A global alliance of the WHO, national governments, research institutions, and nonprofits also contributes to this development. The objective of the Coalition for Epidemic Preparedness Innovations (CEPI) is the development and clinical testing of vaccine candidates for the most hazardous pathogens. First, the Coalition, of

Marburg University virologist Stephan Becker

Photo: Rolf K. Wegst

which the DZIF is a participant, dedicates its efforts to the pathogens Lassa, Nipah, and MERS-corona. CEPI also provides funding for vaccine testing. “Clinical trials, starting with Phase II trials and onward, that involve large groups of subjects cost millions, costs that cannot be shouldered by academic research institutions alone,” Becker stresses.

The Institute of Virology at the Philipps-Universität Marburg is part of a broad network for research on viruses and neglected tropical diseases. In Hessen, the virologists cooperate with the Justus Liebig University Giessen, the Goethe University Frankfurt and the Paul Ehrlich Institute in Langen in the LOEWE Center DRUID, which is funded by the Hessen state government. Researchers here search for new approaches in the fight against various neglected tropical pathogens. Stephan Becker is also the spokesperson for the Collaborative Research Center 1021, which is funded by the German Research Foundation (DFG), and where 15 research partners investigate a dozen different RNA viruses, including *Ebola*, the Marburg virus, Nipah, Lassa, as well as the corona and influenza viruses. RNA viruses are a particular challenge for researchers. “Their genome propagation has a high error rate. This results in genetically diversified viral populations. Virus variants that are adapted to changing conditions and that proliferate very efficiently evolve over a very short amount of time,” says Becker, explaining this essential capability of RNA viruses. The researchers want to understand how RNA viruses proliferate. They are also investigating how the virus affects the cell and why it causes such serious illnesses. The interferon system plays an important role here. Each cell has

an arsenal of interferons that induce the formation of antiviral proteins, when an infection occurs. “However, the viruses, in turn, have developed mechanisms that interfere with this system,” says Becker. Another line of inquiry is how cells react to an infection. What defense or repair programs are executed and how can they be supported or modified? There exists a standard procedure that makes observations on how the various viruses behave over the course of an infection comparable. “All work groups are using the same cells and infect them in the same way with the viruses,” says Becker. “This makes it easier for us to find common mechanisms that inhibit as many pathogens as possible from the RNA virus family.”

With regard to *Ebola*, the development of an active substance that is capable of inhibiting the virus is still pending. But Becker, working together with cell biologists and biochemists, made an important step forward. They developed an artificial inhibitor that suppresses the interaction between cellular phosphatase and the virus, thereby significantly slowing the proliferation of the *Ebola* virus. “This could facilitate the development of a drug against *Ebola*,” hopes the Marburg virologist. ■

PROFILE

Project:
RNA Viruses: RNA Metabolism, Host Response and Pathogenesis (DFG SFB 1021)

Spokesperson:
Prof. Dr. Stephan Becker

Participants:
Philipps-Universität Marburg, Justus Liebig University Giessen, Paul Ehrlich Institute (Langen), University Medical Center Giessen and Marburg (Giessen site)

Departments:
Medicine, Pharmacy, Veterinary Medicine, Chemistry

Term:
since 2013

FOR MORE INFORMATION

About the Project: *www.sfb1021.de*

DRUID LOEWE Center “Novel Drug Targets against Poverty-Related and Neglected Tropical Infectious Diseases”:
www.uni-giessen.de/research/research-organizations/loewe-projects/druid?set_language=en

German Center for Infections Research:
www.dzif.de

CEPI Coalition for Epidemic Preparedness Innovations:
www.cepi.net

Research Campus of Central Hessen:
www.fcmh.de/Research/Campus%20Focus/microorganisms-viruses

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