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The Emergence of a Global Knowledge Network

Beginnings and Foundations of the Global Dissemination of Knowledge in Europe and China from Antiquity to Early Modern Times. Some Historical, Theoretical, and Methodological Annotations

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Abstract: Today we live in a global network of knowledge–as shown recently by the worldwide interactive research on Covid-19. Nevertheless, knowledge is distributed differently around the world and is perceived and valued differently in different cultures. This also applies to different strata within societies. The fact of a global world of knowledge and its horizontally and vertically different perception, interpretation and usage raises several problems. These can be explained above all by the sociogenesis of the global knowledge world and its fundamental lines and moments of development. Even a brief look at history shows that knowledge has been and is exchanged from earliest times till nowadays. This fact in turn raises questions and problems that we want to address systematically. What is "knowledge"? Sciences? Arts and crafts? When, by whom, in what form was knowledge disseminated? What is knowledge transfer? Exchange? Is it a mere transport, a deliberate exchange, or a kind of silent appropriation of foreign knowledge? In the following, some of these questions will be dealt with systematically. The historical material as well overarching question is the exchange of knowledge in Eurasia and here specifically the transfer and exchange of knowledge between Europe and China. After a preliminary clarification of terms and questions, the transfer of knowledge between Europe and China from the earliest times up to the Yuan Dynasty will be surveyed. Subsequently, the basic concepts and questions can be discussed and sharpened for further research. An outlook on the historical phase of a deliberate transfer and finally

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exchange of knowledge between China and Europe since the early modern period concludes the study. The aim of this work is not primarily to describe the historical course of individual exchange processes, but to clarify questions and problems for future empirical studies regarding the research landscape.

Keywords: global history; knowledge exchange; knowledge networks; knowledge transfer

1 General Problems and Preliminary Terms and Questions

A first and more than superficial look at history reveals a variety of knowledge transfer and exchange between East and West. From today's perspective, an interactive global research network research can be observed in the current Covid-19 pandemic. The exchange of knowledge through official contacts, publications, congresses, meetings and above all the new possibilities offered by the world wide web is most likely. In historical research we can observe a mixing/interpenetration of traditional knowledge and modern sciences and techniques (e.g.: chemical, biochemical, molecular analysis of (medicinal) herbs: Nobel prize Tu Youyou). Equally well known is the exchange by imitation or by theft of intellectual property. In 1887, for example, the British Parliament invented the term "Made in Germany" for copied, inferior goods from Germany. "Made in Japan" followed in the 1980s, "Made in China" in the late 20th century. Nowadays, all these pejorative names are trade names for well-known commodities around the world. These days, knowledge and goods are protected by patents, trademarks a.s.f. Supporting programs for the invention of internationally sought-after goods have existed for centuries—in some cases combined with the threat of the harshest penalties in case of failure. Sometimes this kind of forced knowledge production leads to success—as the production of the much sought-after Chinese porcelain 1708 in Saxony. Much more often, however, we see the slow spread of products and skills including the material prerequisites and techniques due to urgent necessities of life (e.g., water supply) or other—e.g., agrarian, economic, military—reasons. In this process knowledge was possibly always slightly modified and led eventually to new products. Also, to be considered is the fact that new knowledge and new techniques can emerge in different places in the world without any contact with each other in nearly the same range of time.

The global spread of modern science and modern scientific technology between Europe and Asia in the late 19th and early 20th centuries raises a particular problem: This transfer took place in a forced, almost disruptive form in the wake of the

imperialism and colonialism of the West—from Europe and the USA finally also from Japan. In this process, the need to adopt sciences and techniques was countered by the need to preserve the character of one's own culture as much as possible. Thus, in the background appears the general question of whether sciences and techniques can be exchanged without having to take over the cultural preconditions behind them—a question that has unleashed enormous forces in the last decades of global history (e.g., Iran since 1979, Afghanistan since 1979). This brings us to the field of the history and sociology of knowledge. Here, the basic assumption is that cognition and knowledge are fundamentally embedded in a social, cultural, and historical context. At the same time, this means that knowledge is not arbitrarily transferable, but presupposes—or results in—certain conditions. These processes indicate that the transfer and adoption of foreign knowledge can be a highly complex process in which the most diverse reference systems, variables and transfer paths must be distinguished. Anyway: It is clear, however, that knowledge and knowledge transfer depend to a large extent on social, cultural, and historical conditions.

But: What is knowledge? Knowledge is a form of cultural practice—oriented to solving problems (Bödeker et al., 1999; Detel, 2007, 2009; Labisch, 2014; Renn, 2015). This happens in a line of purely pragmatic knowledge, of handicraft, humanities, technical, social and natural sciences. Cultures, in a simple empirical form, are practices that consist in rule-following activities. Knowledge as cultural practice is tied to background beliefs that articulate or justify the methods and goals of the practices. Here the connections to the historical and social context, to the culture and the values of a society are given. The practices are cumulatively handed down (groups, communities, society). Furthermore, these cultures are bound to power relations (rules, state). With these specifications of cultures of knowledge, knowledge in general, including the knowledge of craftsmen/handicraft and—peripheral—inventors, is thus initially covered.

In older studies on the history of knowledge and knowledge exchange in the 19th and 20th centuries, knowledge is often understood as scientific knowledge. In contrast, in the recent history of science, and thus also in this paper, it is assumed that scientific knowledge, including science-based techniques, is also a form of cultural practice. Thus, science is not an independent form of knowledge production, but a subset of the entire knowledge production distinguished by special practices. The distinction is particularly important because knowledge and skills have been exchanged over millennia that cannot be understood as scientific or scientific-technical knowledge in the modern sense. The understanding of what science itself might be has changed drastically over the centuries in different cultural contexts.

The general and the specific specifications are directed at the respective concrete activity of historically specific actors, the products of their activity and the context of justification of the activity. In this way, it is also possible to empirically record the

generation, spread, effect and, if necessary, the repercussion of knowledge in other areas of knowledge-based cultures at the place of genesis or encounter, as it were.

What is knowledge transfer? What is knowledge exchange? The term "transfer" suggests a one-way "transport" of knowledge from a knower to a learner. In organisational sociology, where knowledge transfer has been discussed for decades, knowledge transfer is understood as the transmission or dissemination of knowledge and the provision of contributions to problem solving (Blackler, 1995: 1021): "Knowledge (…) is analyzed as an active process that is mediated, situated, provisional, pragmatic and contested. (…) attention should be focused on the (culturally located) systems through which people achieve their knowing, on the changes that are occurring within such systems, and on the processes through which new knowledge may be generated." Thus, knowledge transfer aims to organise, create, capture, or disseminate knowledge and ensure its availability to future users. Knowledge transfer is therefore a complex process that requires the participation of all involved. In the history of science, the term "transfer" has been advocated (see e.g. (Ash, 2006)). However, to avoid the somehow still pejorative undertone of "knowledge transfer", the term "knowledge exchange" is used for obvious reciprocal exchange processes. To emphasise the process of mutual or possibly independent exchange of knowledge, one could also speak of "travelling knowledge" or "circulation of knowledge" in the given case or narrative.

Having these clarifications in mind, the following areas of our first examples are of interest for the historical-empirical investigation:

- When, by whom and in which form is knowledge/science transported, transferred, and exchanged?
- What are places of transfer and exchange (centers or peripheries)?
- How do places of transfer and exchange, including economic markets, respond to and regulate the influence of knowledge and science?
- How is new knowledge formed (cooperation? confrontation? interference?)?
- How is knowledge adapted to new circumstances, how is it transformed and recirculated?
- How are sciences formed (e.g., classification, classification systems, role of epochal personalities)?
- How does the mutual influence of markets as well as of knowledge and science take place, how is it organised, possibly also regulated (e.g., trade fairs, monopolies, patents, "factory espionage")?
- How is scientific/technical knowledge exchanged on national and international level (e.g.: papers, talks, conferences, invitation of experts, internet asf.)
- Which role does the materiality of knowledge play in the process of knowledge exchange?
- Is practical knowledge different from embodied knowledge and intellectual, second or third order knowledge?

This brings us back to the overarching questions:

- The establishment of a global knowledge network,
- the global diffusion of "modern" scientific and technical knowledge over wide areas and/or lots of people and finally
- how was China integrated into the emerging global knowledge network—of modern science, technology, and humanities?

Before we go any further in our reflections, finally here a few remarks on the state of research and the literature on knowledge transfer and exchange used in this paper. There are masses of literature on the basic theoretical and methodological questions as well as on the empirical results. For example, on the enormous significance of the "steppe" and the early "silk roads" for the exchange of knowledge between East and West, there are now major international projects with an almost unmanageable number of individual studies (see e.g., International Association for the Study of Silk Road Textiles: https://www.mpiwg-berlin.mpg.de/research/projects/international-association-study-silk-road-textiles; The International Centre for Silk Roads Archaeology & Heritage: https://www.ucl.ac.uk/archaeology/research/silk-roads). The same applies to many other epochs that are only briefly mentioned below—e.g., on the importance of early Islam as a translator, producer, and mediator of knowledge between antiquity and modern times from Western Europe to Central Asia. In the following, however, only that literature is listed which is necessary for the course of thought. An extensive documentation, especially of the literature from East Asia in general and China in particular, will later follow in an elaborated review. The works of Jürgen Renn and Peter Burke will serve as a general theoretical and methodological basis (Burke, 2000, 2012, 2015; Renn, 2012). At this point, the vast findings resulting from the Chinese research and published in Chinese are missing in such a way that the following thoughts can only be described as preliminary. As a substitute for further reading—from a Western point of view—see (Elman, 2004, 2005, 2006; Lackner & Vittinghoff, 2004; Nappi, 2017; Szonyi, 2017). Thus, references to the East Asian, especially the Chinese state of research are urgently required.

After this preliminary clarification of terms and questions, the exchange of knowledge between Europe and China from the earliest times up to the Yuan Dynasty will be surveyed. Subsequently, the basic concepts and questions can be discussed and sharpened for further research. An outlook on the historical phase of a deliberate exchange of knowledge between China and Europe since the early modern period concludes the study. The aim of this work is not primarily to describe the historical course of individual exchange processes, but to clarify questions and problems for future empirical studies regarding the research landscape.

2 Transfer of Knowledge from the Earliest Beginnings to the End of the Yuan Dynasty

Transfer of knowledge processes in the broadest sense seldom encounter a primeval soil. Rather, transfer processes are based on historical and cultural depths, which in turn represent an amalgam, an inseparable mix of previous transfer processes (Renn, 2012). Based on the results of historiography, archaeology, and recent molecular-biological research in the broadest sense, it can be assumed that there has been an exchange of materials, products, skills, plants, and living beings—animals and humans—as far back into the millennia as we can explore at all with the methods available. This suggests that knowledge has been always exchanged since humans existed. In this context, (mass-)migration, war, and conquering campaigns play a prominent role. The imitation of knowledge can also be traced in the spread of working and livestock animals, of plants, crops and the referring skills and abilities. The transport of knowledge might have been like that of goods: by means of traded goods and products and of migrating skilled people or through prisoners of war or slaves, knowledge was transported, skills and abilities were assimilated, and possibly new practices and thus new knowledge created. This knowledge is not bound to writing and thus not to literacy but takes place in a personal exchange. Farm animals, such as the donkey for the short-distance transport of goods or the famous Bactrian camel, the heavy goods vehicle of the Silk Road, found their way from West to East thousands of years ago. Wine cultivation, first developed in what is now Georgia in Middle Asia, also spread westwards and eastwards thousands of years ago to establish a high wine culture in China, which is now mainly forgotten (Kupfer, 2020). Many new crops—e.g. wheat, later cotton, fruits—e.g. grapes—or spices—e.g. ginger, came from India, Southeast Asia, Central Asia or Persia to China (Labisch, 2018a; Li, 2021).

A brief critical note on “genetic history”, an international term, which in fact is a “molecular historiography” due to its elaborate molecular-biological procedures (Labisch, 2018b) In the study of pre-literacy times from the earliest beginnings far into antiquity, the most modern methods of archaeology and, in particular, of molecular biology are playing an increasingly important role (Axelsson et al., 2008; Comas et al., 1998; Labisch, 2018a; Wang et al., 2021; Zhao et al., 2015). Primarily, “molecular historiography” and archaeology deal with remains that result less from individual action than from the nature of people and their environment. The primary findings of different materials are to be processed in terms of natural science or life science. Even with comprehensively given biological material, only general spaces of action or individual circumstances of life can be recorded. Human action in all its conditions cannot be captured with the methods of “molecular historiography”

and archaeology. So, the question emerges: what is history all about? The short version of an answer is: (a) History in general is about relevant human action in the past in its context and contingency, based on a critical analysis of all remnants and presented in a coherent narrative. (b) If the history of humankind and its habitat is to be elucidated over time, i.e., if a history of the "Anthropocene" is to be written, cooperation between all disciplines is essential.

Meta-thinking, "second-order thinking", originated in the world in independent places between 8th and 2nd centuries BCE. This new reflection of human beings on their existence in the world encompassed nature (meta-physics), society (social science; conceptions of societal order; moral and ethics) and the self (religion, morality, ethics, and personal conduct). But also, the invention of fundamental techniques took place independently at various places in the world and in comparable time horizons —be it in Eurasia, Africa, or the Americas. Only with the merging of spaces, e.g., through large migratory movements over large distances or through overseas shipping, the possibility arose for a supra-regional exchange of knowledge and skills. In Eurasia this exchange of knowledge began in neolithic times. Micro-historians fight against the concepts of axial age developments from individual studies. But the question remains: what are the reasons why both the spiritual, moral, and scientific contemplation of the world and the beginning of technical mastery of the world occurred largely independently of each other at comparable time periods around the world? Looking at the early history of man iso-chronologically, that means by observing the development of human culture under the strict consideration of its absolute chronology, offers the possibility of relating completely different worldwide developments, which as a rule did not condition each other. Thus, a comprehensive global perspective of early world history emerges. By linking the various phenomena along a few selected timelines, the diversity of cultural developments in different regions of the world can be analysed. So, we do not only have to speak of an "axial age in the self-awareness of humanity" (Jaspers, 2018). Rather, we should also speak of different "factually-real axis times" in which people have independently developed new techniques of coping with the world (Parzinger, 2017).

So, in general, with few exceptions all the results on earliest history of the transfer of knowledge are little more than analogies—if certain animals, plants, products, etc. spread in a steadily progressing process, the assumption that a transfer of knowledge has taken place is justified. Who passed on this knowledge, when, under what circumstances and with which methods remains an open question. Overall, it can be assumed for the early period that the transfer of knowledge essentially extended to skills in the sense of everyday knowledge up to advanced manual knowledge. Knowledge in the sense of science or even second order science is, however, very strongly tied to multilingualism and texts—and thus to writing and, beyond writing, also to the production and dissemination of texts—e.g., the

Mesopotamian cuneiforms, the Egyptian papyrus, later Chinese paper and printing play a decisive role. A special role is played by religions, which always transported skills, the beginnings of scientific observation and world orientation—initially for religious reasons (e.g., holy days etc.)—reasons, which later could be marginalised during scientific developments. The scientific methods of textual analysis, textual criticism and scientific translation methods arose in Europe as well as in China from the observation that the traditional texts contained incompatible inconsistencies (for China see Li, 2019).

Ancient Europe and ancient China were highly developed cultures that knew about each other (Leslie & Gardiner, 1995, 1996; Lloyd, 2004; Mutschler & Mittag, 2008; Scheidel, 2005, 2009; Shankman & Durrant, 2000, 2002; Teggart, 1939). But they hardly ever came into direct contact at the official level and then only late in antiquity. Below this formal level, there has been a lively interchange through both trade by land and sea and by military campaigns. Both cultures have developed techniques and procedures—e.g., paper (China) or concrete (Rome)—that are still of world-historical significance today. How and through what channels did this interchange take place? Did the two cultures influence each other? The main hubs between East and West were the empires in Central Asia, e.g., the Parthians or the Sogdians. The Parthians attached some importance that their trading partners could not come into direct contact with each other (Isidore of Charax & Schoff, 1976). The trade routes over land and sea were mainly used for the exchange of luxury or prestige goods (Selbitschka, 2014, 2018). The necessities of life spread by biological dispersal or by imitation. Homogeneous dominions play a major role. For example, it can be assumed, that the elaborate qanat/kanat/kerez system of water supply was able to spread to the edges of the Persian empire and to the dominions of other countries—for example, in the then Chinese Taklamakan—in connection with the political expansion of the empire.

The routes between East and West by land and by sea each have specific geographical, technical, but also political prerequisites and limitations (Hansen, 2012a, 2012b; Ptak & Kauz, 2013; Schottenhammer, 2014). The two routes therefore alternated both in the goods transported and in historical circumstances of a respective period. Based on the results from historiography and archeology in the widest sense, can be assumed that there has been a lively exchange of materials, products, skills, and creatures—animals and humans—not only by land but also by sea silk roads. Due to advanced inventions in (shipbuilding) technology and knowledge and experience of seafarers as well the transports by sea seem to start later than overland. However, archaeological findings reveal that there was already early, probably since the 5th century BCE, a lively traffic over sea. In terms of time, it is mainly due to (a) political decisions (e.g., sea politics of the early Ming period (Ptak, 1992, 2007); the closed border between East and West by the empire of the Ottomans),

(b) to the spread of religions and finally to (c) the worldwide expansion (Portuguese, Spaniards, Dutch, French, English) that the importance of the land and the sea silk road for international trade alternated. The loads transported by sea are larger and/or heavier than those transported by land. The Sea Silk Road played a major role not only in the exchange of goods, knowledge, and cultures including religion, but also in the spread of diseases.

The comparison between Western and Eastern medicine is an important example of questionable similarities and equally questionable interactions. At first glance, ancient European medicine and ancient Chinese medicine seem quite similar. But despite these similarities, e.g. in pulse measurement, on closer examination they were not at all similar (see, for example, the more than questionable comparison of (Kuriyama, 1999)): with comparable technology, Chinese doctors saw something different from European doctors. Also the living conditions of doctors and consequent structures of thinking and acting were different (Lloyd, 2006; Lloyd & Sivin, 2002; Needham et al., 2004; Unschuld & Jinsheng, 2012). Contacts could have existed via the Hellenistic Greco-Bactrian empires (3rd century BC–2nd century AD), via Buddhist medicine or via Islam (Yunani or Unani medicine (Urdu: tibb yūnānī; i.e. "Yonian medicine"—meaning: ancient Greek medicine)). For the founding period of classical Chinese medicine, as e.g., Paul U. Unschuld sees it, only the second and first century before the turn of time would come into question. So are there possible encounters, is there an exchange of knowledge between Eastern and Western medicine in the period in question? If so, in what ways? How can this be empirically proven? But these assumptions are so far only an interesting and challenging idea for future research.

In Europe, the Middle Ages—the "Medium Aevum" in Latin—is the time between Antiquity and the Renaissance/Early Modern Age, roughly between 600 and 1400 CE. This term expresses the fact that in Renaissance—Latin for: Time of Re-Birth—people oriented themselves towards antiquity and understood themselves differently than the people of the centuries "in between", thus the "Middle Ages". What is the essence of these "Middle Ages"? What does this mean for knowledge and knowledge transfer and exchange? And what does "Middle Ages" mean in Asia, especially in China? Chinese history is usually arranged by dynasties. Were there these "in-between times" among very old-antiquity—and very new times—precisely a "Chinese Renaissance"? Was there the idea of unity, disintegration, and the re-birth of something new, which nevertheless followed on from the old? Can the Chinese Renaissance of Neo-Confucianism be compared with the European Renaissance? Regarding the question of the production, dissemination, and the transfer and exchange of knowledge, the role of religion is particularly important in this context.

For the question of knowledge and knowledge exchange, it is important that in Europe and China in the period from the 3rd to the 7th century CE, entire cultures and

with them entire bodies of knowledge were overlaid by the cultures and bodies of knowledge of immigrant peoples—pushed to the margins or lost for all time. In Europe, for example, this applies to all schools of philosophy which were not compatible with Christianity—not to mention the great administrative and technical achievements of antiquity. These superimpositions themselves led to new forms of knowledge. However, these processes resulted in the problem of what made cultures survive recognisably, but ultimately in a considerably altered form. In Europe, Christianity comes into question as the unifying bond for the subsequent periods up to date—not only as a faith but also as an institution with its functionaries: for the Christian Church gradually migrated not only into the religious but also in mundane functions of the former Roman Empire in late antiquity or the early Middle Ages (Labisch, 2013). What is the enduring feature of China that provided the basis for the survival of Chinese culture over millennia? The fundamental philosophies—Confucianism, closely linked to legalism until the "Chinese Renaissance", Daoism, later Buddhism too? Who were the institutional carriers, outstanding personalities? The power-conscious scholars and functional positions? Was it the high-level language and writing that gradually spread throughout East Asia as quasi obligatory form? What role do space and ethnic groups play in the center of China? Or should we not better assume that the Europe of antiquity, the China of antiquity has little to do with what we perceive today as Europe or China? That our image of antiquity in the East and in the West is formed from the circumstances of our own time?

When it comes to the exchange of knowledge between East and West, the "intermediate countries" are seriously underrated in Western historiography (why? language barriers?). Graeco-Bactria, the Seleucids, Kushan empire, empires from steppe peoples like the Xiongnu, Sogdana, later Turk tribes, the Abbasid Caliphates, Tibetans, and many others can be named. Especially Persia and northern India have always been areas of exchange between East and West. At the same time, these areas have contributed significantly to the production and transfer of knowledge from their own culture. The region of Persia—its historical predecessors and followers—is one of the cradles of knowledge for millennia—from calculating to writing, astronomy/astrology, geometry, arts asf. This is also true for antique India. Today widely underrated or even forgotten, is India's contribution to science in general and mathematics in special (Liu, 1988; Liu & Shaffer, 2007).

In the 8th century the expansion of Islam from Spain in the far west to China in the far East played a role in the transfer, spread and creation of new knowledge that can hardly be overestimated. Islam represented a unified cultural space—despite different dominions. The peculiarities of the peoples, their culture and traditions of thought were not touched but largely preserved. During this time, knowledge gradually detached itself from religion. The Islamic world therefore connected equally with the ancient knowledge traditions of the West and the East. This process

of appropriation was at the same time a process of transformation of knowledge and an invention of new knowledge. We can therefore speak of a first phase of the globalisation of knowledge, albeit not an enduring one. Much of the ancient knowledge that had been largely lost in the European Middle Ages could now be rediscovered in the West, leading to the Renaissance—which finally led to "modern science".

The Mongol Empire of the 13th/14th century CE created a space of interaction that stretched from Central Europe to East Asia and brought about a horizon of thought and action that extended across the whole of Eurasia. It made possible the meeting of knowledge traditions that had until then been largely separated from each other, such as the Hellenistic-Islamic and the Chinese astronomical traditions. Knowledge and personnel were exchanged, but the different intellectual traditions were not integrated into a larger system of knowledge. Nevertheless, great empires like the Mongol Empire not only created favorable conditions for long-distance travel. Rather, they also created an awareness of global political and religious constellations. These also offered global exchange and intervention perspectives to people who were not directly politically engaged, such as merchants, missionaries, adventurers and even intellectuals. However, it should not be forgotten that the Mongols wiped out ancient cultures once and for all – such as the cradle of science in Mesopotamia with its many high times of scientific culture till 1258 CE.

From the Early to the late Middle Ages, many technical achievements found their way from the East to the West: gunpowder—known in China since 1040 CE, magnetic compass—used on Chinas ships since the 11th century CE, woodblock printing—familiar in China since the 7th century CE. There is archaeological evidence that paper already existed in China before the turn to Christian times, the first process regulations have been published in China in the 2nd century CE. Paper printing probably became first known in the West through Chinese printed playing cards—mediated through the silk roads. Other technical achievements were the sternpost rudder, the segmental arch bridge, the canal lock gate, and the wheelbarrow. The Indian stirrup came from the East, as did the violin bow and the traction trebuchet, a feared siege engine. Silk and porcelain found many imitators and replicas. The culture of making silk gradually spread from the East to the West—and led to many new intermediate products. The many attempts to make porcelain also led to new ceramic products—such as the famous Delft tiles. But it was not until the early 18th century that Europe succeeded in producing porcelain of Chinese quality. Of great importance for Western science was the Hindu-Arabic mathematics of the twelfth and thirteenth centuries. However, it reached Europe through the translation of Arab scientists. We can therefore conclude that until the fifteenth century of our era, many new scientific impulses did not find their way to the East from the West—as is the usual assumption in the West – but came to the West from the East.

So, finally to summarize our results to date, in the East and the West the end of antiquity is marked by different paths. Europe created a new world in the Middle Ages that built on antiquity but was characterised by an all-embracing interpretation of life in terms of Christianity. From religious thinking new approaches to knowledge were formed (Fried, 2001). China's path was marked by almost constant disintegration and re-integration, which meant centuries of greatest misery, but led also to the highest cultural flowering of the country during Tang and Song dynasty. Significant new impulses for thought came from the sciences transported via Buddhism in the East and Islam in the West. The "pax mongolica" created a large space for free exchange of people, goods, and ways of thinking.

So we can conclude, that up to 15th century many new scientific impulses came not from the West to the East but from the East to the West. In Europe, the Renaissance opened anew the diverse world of ancient knowledge and science. In China, the early Ming period saw the establishment of a power that operated throughout the eastern hemisphere. These are issues that need forthcoming attention.

3 Knowledge Exchange: What, Who, Where, When, How

After this brief and largely superficial excursion into the history of knowledge exchange from prehistoric times to the end of the—European—Middle Ages, we can now sharpen our initial questions about what knowledge is and how it is transferred. The results will be arranged according to the following questions: what, who, where, when, and how?

A brief remark at the outset: primarily in figurative representations of knowledge, every day or craft knowledge is usually set as the basis to then narrow step by step towards the highest wisdom as the pinnacle of possible knowledge. The actual basis of knowledge is information and data, which must be processed into knowledge in the first place. A hierarchy of knowledge—from everyday life to science of science—is not implied in what follows: we are dealing with different forms of practice. And as far as wisdom is concerned: I am probably not the only one who knows people in my environment whom I would describe as wise, but who have never attended more than primary school—and occasionally not even that. Wisdom is only conditionally bound to knowledge! This assertion is left as a question.

What is knowledge?

The range of forms of knowledge with different degrees of reflexivity includes the following, strongly overlapping and by no means comprehensive categories:

- symbolically represented knowledge (religion, culture, power (cf. rites))
- second and higher-order knowledge—knowledge, history and theory of knowledge, meta-analysis of knowledge systems, critique of knowledge systems
- scientific knowledge—a special way to test hypothesis and formulate general rules/theories
- technological knowledge—bound to/aiming at/applying scientific findings
- scientifically based knowledge
- skilled knowledge—e.g., complicated handicraft (e.g., porcelain, metalwork)
- practitioners' knowledge (lay and experts; intuitive knowledge; invisible hands; implicit and/or explicit knowledge including implicit knowledge of theoretical scientists and researchers)
- knowledge (purposeful/"zweckrational" (Max Weber), "cooked" information and data)
- basics: information and data

Who has, who might transfer knowledge?
- symbolically represented knowledge: priests, monks, philosophers etc.
- second and higher-order knowledge: scientists, philosophers, logicians, mathematicians, historians, scientific translators etc.
- scientific knowledge: scientists, philosophers
- technological knowledge: experimenting priests, monks, philosophers, scientists etc.
- scientifically based knowledge: scientifically advised/supervised craftsmen
- skilled knowledge: skilled and trained people
- practitioners' knowledge: lay people and experts
- knowledge: everyone
- basics: everyone

Where, when, and how knowledge is transported:
Where, when, how? In peace and ordinary life:
- symbolically represented knowledge (religion, culture, power (cf. rites)): churches, monasteries, missions and missionaries etc.
- second and higher-order knowledge—knowledge, history and theory of knowledge, meta-analysis of knowledge systems, critique of knowledge systems often outside of traditional schools, academies, or universities
- scientific knowledge—churches, schools, academies, libraries, universities

- technological knowledge—traders, seafarers, soldiers, travellers (e.g. astrolabes, metalwork, gunpowder, agricultural tools, musical instruments etc.)
- scientifically based knowledge: highly specialised crafts (for example: metal-working, porcelain painting, silk painting) mostly secret tradition
- skilled knowledge: Craft traditions, (closed) workshops/ateliers, apprentices, journeymen, masters
- practitioners' knowledge: traditional knowledge transmitted through everyday life, farming, household, encounters, markets, goods, food, animals etc.
- knowledge: everywhere at any time
- basics: everywhere at any time

Where, when, how? In people migration, mass exodus, turmoil, war etc.:
- symbolically represented knowledge
- second and higher-order knowledge

Survival and/or transfer is highly dependent on the cultural environment (evtl. pushed to periphery, underground, migration, or complete extermination).
- scientific and technological knowledge
- scientifically based knowledge
- skilled knowledge
- practitioners' knowledge

Survival and/or transfer depends on the respective assessed usefulness: e.g. astronomy, weaponry asf. In the worst case: total extinction
- knowledge and basics: every where

What should we be aware of while talking about knowledge transfer, knowledge network, and globalization of knowledge?
- Social, cultural, religious basis of societies: environment and context
- Stimuli from within: Social change, uprisings, revolts, new ruling houses, bureaucrats, scholars, intellectuals
- Stimuli from outside: Mass migration, campaigns of conquest, overlapping and mixing of old and new cultures—from every day to high culture, from every day to second-order knowledge, (complete) eradication of previous cultures
- Free trade and transport routes, border regions: indirect and fragile chain of transmission
- large dominions overlapping old cultures
- expansion of empires and spread of religions

- knowledge as fellow traveler in these processes, participating in their dynamics without controlling them, the results of transmission are often precarious.
- Processes of "travelling knowledge" either by products or by people were dependent on the possibility of free transport and travel, so that individuals or groups could gain a significant role in the transfer of knowledge.

As it were, as a counter-voice as well as a supplement to the question what knowledge is and in which complexity knowledge transfer and exchange is to be seen, the already mentioned sociologist Frank Blacker with his "Images of Knowledge" should be quoted (Blackler, 1995, pp. 1023–1026):

- Embrained knowledge is dependent on conceptual skills and cognitive abilities—meaning practical, high-level knowledge, including tacit knowledge, even though it is mainly subconscious.
- Embodied knowledge is action oriented and consists of contextual practices which are likely to be only partly explicit. It is rooted in specific contexts and depends on how people interact with new technologies.
- Encultured knowledge refers to the process of achieving shared understandings through socialization and acculturation. Texts, language, discourse, and negotiation are means of transport and exchange.
- Embedded knowledge is tacit and resides within systematic routines. It relates to the relationships between roles, technologies, formal procedures, and emergent routines within complex systems.
- Encoded knowledge is information that is written down and, where appropriate, expressed in formulas and symbols (catechisms, manuals, textbooks, databases, etc.) and ultimately conveys rules of conduct.

It is evident that these "images of knowledge" encompass in ideal-typical way forms of knowledge and knowledge transfer that follow from the historical analysis presented here.

- Embrained knowledge—technological and scientifically based knowledge.
- Embodied knowledge—skilled and practitioners' knowledge.
- Encultured knowledge—symbolically represented knowledge.
- Embedded knowledge—every day and skilled knowledge.
- Encoded knowledge—scientific, second and higher order and symbolically represented knowledge.

It is to be hoped that these historically and sociologically derived types of knowledge and the transfer and exchange of knowledge offer sufficient approaches to operationalise them for empirical studies.

4 Forthcoming Problems and Questions—an Outlook

We have now reached an intermediate methodological step and an historical turning point. Methodologically, different types of knowledge and different ways of exchanging knowledge can now be better described from the outset and used as questions or patterns for further research. A historical turning point has been reached by China's becoming part of Eurasia by the Yuan Dynasty.

With the beginning of "European expansion" in early modern times, China finally entered the world community out of East and Middle Asia. The Jesuit mission can be seen as the beginning of a systematic, thoroughly intentional exchange of knowledge from West to East: the Jesuit mission was designed to convert China from the head, as it were, through the consent of the emperor and the elites. And the way was not preaching, but European science (for an overview of the discussion and critical appraisal of the quite ambivalent aftermath of the Jesuit mission in China, see (Zurndorfer, 2009)). At the same time, many learning processes among East and West took place outside of the official channels (Elman, 2005; Li, 2021; Reynolds, 1991; Xiong, 1994, 2013a, 2013b, 2013c). As we have already seen, it is one of the prejudices of ordinary European historiography that China was, in a sense, the subordinate recipient with whom open scientific exchange began. But European science in the early modern period was largely beholden to medieval scholasticism and was caught in the categories of physico-theology and later physico-teleology until the 19th century. In contrast, modern science and technology from the late 18th century onwards is—methodologically inadmissibly—used as a yardstick in retrospect. But technology and science in China should be seen and studied "on their own terms"—as the title of Benjamin A. Elman's famous book indicates (Elman, 2005). China was centuries ahead of Europe in many areas of science, technology, administration, education, agriculture, and everyday techniques in the early modern period. Dagmar Schäfer, for example, has elucidated the empire-wide organisation of craft labour in the Ming period, which brought the importance of labour to the attention and instruction of the literati; she has also shed light on the scientifically consistent understanding of theory and practice, using the famous 'tian gong kai wu' as example (Schäfer, 2010, 2011, 2012). Probably best known, however, are China's ships, fleets, and navigation techniques—as shown by the Mongols' attempts to conquer Japan, the voyages of Zheng He or the conquest of Taiwan—which were far superior to those of Europe. This raises the question of why the Europeans, with unchallenged self-confidence, swarmed out in all directions to conquer the world and shape it according to their own criteria?

Anyway, since the early modern era, personal contacts, and the exchange of goods between East and West increased constantly. For the West, this was a particular challenge. Admittedly, the West's path to a scientific and technological world was mapped out after the scientific revolution of the late 17th and early 18th centuries (Cohen, 2010; Graham, 2010; Huff, 1993, 2005). But it was not until the end of 18th century that there were first signs of a self-propelling industrialisation process based on scientific-technical progress. China was by far the leading economic region in the world until well into the 19th century. When the Qianlong emperor rejected Lord Macartney's gifts in 1793, it was not an act of arrogance: everything George Macartney offered, the Chinese already knew and had (Cranmer-Byng & Levere, 1981/2006; Elman, 2005; Waley-Cohen, 1993). But—as the Yi Jing teaches—those who have reached their peak are threatened with decline. Only a few 50 years later, the first Opium War marked the first turning point—not through superior scientific and engineered products, but through steam-powered violence and narcotics that could be imported "contractually/legally" into China. After the Second Opium War and esp. after the Taiping rebellion, it was clear to China's leaders that something had to be changed. This was also true because more and more foreign goods were pouring into the country and because through the transfer of knowledge, sometimes also through knowledge theft—as e.g., with tea—classic Chinese export products became prone to competition on the world market. The transformation of the world in the 19th century gradually extended to China: China was more and more included in global networks (Osterhammel, 1989, 2009).

However, compared to former historical eras the situation has changed completely since the middle of the 19th century. This is true for China and the world itself as well as for the research situation. China is being pushed into the new world order by western imperial world powers and must face the situation—first defensively, then half-heartedly with great inner strife and irreconcilable discord. According to our category system, the so called "self-strengthening movement" was an externally imposed and thus forced transfer of foreign knowledge. This knowledge should be strictly limited to the purely technical levels of scientific-technical knowledge and science-based skills: "zhong xue wei ti, xi xue wei yong". As the brief excursions into the protagonist institutions and selected persons reveal, this precept was not adhered to. On the contrary, knowledge requires a certain social basis. With the transfer of knowledge, these social roles are transported along and culturally appropriated—they thus differ from the place of origin, but they also differ from the environments into which they are planted—something new emerges.

Like the literature on the self-strengthening movement, there is also a wealth of literature on the transfer of knowledge that, beginning in this period, continued into the 20th century. Finally, here Joseph Needham and his school have to be emphasised (Finlay, 2000; Hart, 1999; Nakayama & Sivin, 1973; Needham & al,

1954–present; Sivin, 1975). Of course, the history of the exchange of knowledge between East and West has gone beyond these immense pioneering works in terms of content and method. The only ones mentioned here are the older works of Toby E. Huff, oriented socially towards the environmental situation of the scholars, and the works of Benjamin A. Elman, oriented historically towards the Chinese sources and their interpretation (Elman, 2005, 2006; Ho, 2015; Huff, 1993, 2011; Tsu & Elman, 2014)—a discussion between the eagle eye of the sociologist and the connoisseur's eye of the archive mole, a discussion that can hardly be solved. In Germany, many topics and publications on knowledge transfer have been elaborated in recent decades, dealing with specific topics such as particular subjects and procedures, with fundamental issues such as terminology and grammar, and subsequently with overarching issues such as the cultural preconditions and impact of knowledge exchange (except the already mentioned authors to name but a few see at a first glance collected volumes, e.g. (Lackner et al., 2001; Lackner & Vittinghoff, 2004)).

This is not the place to give a detailed overview of worldwide recent research on our topic. But it should be clear that research in the field of knowledge transfer and exchange between China and Europe has reached a completely different stage for the times since the beginning of the Jesuit mission. For our research question, the task thus arises of finding a path in these rich studies, which are largely supported by comprehensive source work. How to come up with relevant problems and questions, which are new both in terms of content and method? From this perspective, it will be inevitable to focus on certain questions, topics, and methods. At present, it seems to me that the influence of religions (Buddhism, Islam, Christianity), the pragmatic but also theoretical exchange of different varieties of medicine and the question of translation are of special importance (on the question of language in "Global History of Knowledge" cf. recently the special issue of *History of Science and Humanities* 46.1, 2023 (Nickelsen, 2023)). And this having said, it immediately raises the counter-question: what about any skills and techniques that spread across Eurasia without any written preconditions or remains?

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