

# Selenium Research

International Society for Selenium Research

Issue 5, Summer 2018

## *President's Remarks*

*Gary S. Bañuelos, President, ISSR*



Dear Members and Friends,

I am certain that we all still have fond memories of the 200th birthday of selenium, which was celebrated during August 13-16 in Stockholm, Sweden. Under the leadership of Professor Elias Arner, active participation of selenium research community worldwide, financial support from University of Science and Technology of China, and the hospitality of the city council of Stockholm, two selenium research conference series joined together to celebrate the discovery of selenium by Jöns Jacob Berzelius. Discovering the people-friendly and historic city of Stockholm and feeling its diverse cultural life and energy was a great “dessert” to our selenium conference. I hope that this jointly-celebrated conference provided a platform for new collaborative research opportunities to occur among the conference participants in the future years. Now it is time for us to think about the 6th International Conference on Selenium in the Environment and Human Health (ICSEHH) to be held in Yangling/ Xi’an, China in October 27-30, 2019. More detailed information can be found at the upcoming 2019 Se conference website: [icsehh2019.csp.escience.cn](http://icsehh2019.csp.escience.cn). Professor Dongli Liang of Northwest A&F University (NWAUFU) in China will be the lead organizer. Xi’an, located in the center of China, is an ancient capital of China, and has served as the capital city for 13 dynasties during its 3,100-year history. It was the center of the politics, economy, and culture of China for more than 1,000 years in Chinese history. Xi’an not only has a prominent place in Chinese history and culture, but also has re-emerged as an important agricultural, industrial, and educational center of the northwest region. Yangling is located 80 km west of Xi’an and is the birthplace of the Chinese agricultural civilization, where Houji taught

people how to grow and harvest millet and wheat some 4,000 years ago. The city was approved as the first national-level agriculture high-tech demonstration zone by the State Council in 1997. NWAUFU was established in 1934, and it is a national university with comprehensive academic programs in China. The conference facilities, including: opening day auditorium, our daily lecture hall, lunch and dining room, are excellent. Moreover, an excellent running track, walking paths, table tennis, badminton, and basketball and tennis courts are available for our use on this peaceful and environment-friendly campus. Beautiful excursion opportunities are ample in this ancient part of China.

The conference organization is actively in progress for the preparation of the 2019 Se Conference in Xi’an, China. I am very confident that this upcoming Se conference will be very successful and certainly enrich our international Se research community. Once again, the conference proceedings containing peer-reviewed accepted 2-page extended abstracts will be published by CRC Press. Our traditional “happy hours” have been also scheduled at the end of daily program. Please mark your calendars for October 27-30, 2019, and please also inform your colleagues and friends who might be interested. Our series of selenium conferences beginning in 2009 have continued to feed our passion and provide our bioenergy to reach out to the Se research community, as we strive to help share the multi-faceted nature of selenium at each of our conferences.

I encourage you to consider becoming a member of ISSR. The membership due of \$50 (for a regular member for two years), \$20 (for a student member for two years), or \$300 (for a lifelong membership) can be sent to Society Treasurer Professor Zhi-Qing Lin. More detailed payment information has been included in this newsletter. Membership dues have been used to maintain the society website and provide financial incentives for best graduate students presenting at our Se conferences. The anticipated success and growth of future selenium conferences are dependent upon the incorporation of our younger upcoming selenium researchers for tomorrow’s world.

As a kind reminder to all of you, we will be holding an election for our elected officer positions of the International Society for Selenium Research. According to our bylaw, only those who maintain their active membership status will have the right to elect and be elected. The general election

nomination and voting procedures will be provided to members later. The election results will be announced at the general society business meeting held during the conference in Yangling/Xi'an.

Lastly, if you are interested in organizing the next Se conference in 2021, please send a letter of intent to me

(gary.banuelos@ars.usda.gov) or Professor Zhi-Qing Lin (zhlin@)siue.edu) with a detailed description of your funding resources, tentative dates, and potential site facilities.

Parlier, California

## 6<sup>th</sup> International Conference on Selenium in the Environment and Human Health

October 27-30, 2019, Northwest A&F University, Yangling/Xian, China

The 6<sup>th</sup> International Conference on Selenium in the Environment and Human Health will be organized by Northwest A&F University (NWAUFU) in Yangling, China. The NWAUFU was established in 1934 as former National Northwest Senior College of Agriculture, and now it is one of the most prestigious national universities in China. NWAUFU is located approximately 80 km west of Xi'an in central China.



Xi'an was home to the Zhou, Qin, Han and Tang dynasties' ruling houses. There are numerous historical sites in Xi'an's surrounding plains, including the famed Terra Cotta Army. Xi'an has many allures for tourists, and is often hailed as the birthplace of Chinese civilization. At the top of the list is Mount Huashan, one of the five sacred Taoist mountains in China. Featuring five distinctive peaks, Mount Huashan offers a thrilling hike and breathtaking views. For updated conference information, please visit the conference website: <http://icsehh2019.csp.escience.cn>



**Professor Dr. Dongli Liang**  
Conference Chair  
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### Conference Registration

On-line registration will be open soon. For regular delegates, the registration fee will be \$450 (or \$550 after June 30, 2019). For students, the registration fee will be \$300 (or \$350). Each accompany person will need to pay \$150 (or \$200). The registration fee will include welcome reception, tea breaks, happy hours, lunch and dinners, conference banquet, and a hardcopy of the proceedings book.

### Confirmed Keynote Speakers

(As of July 31, 2018, in alphabetical order)

- Gary Bañuelos, USDA-ARS, Parlier, California, USA  
*Selenium biofortification: Accomplishments and research needs*
- Ulrich Schweizer, University of Bonn, Bonn, Germany  
*Molecular biology and pathophysiology of inborn errors of selenoprotein biosynthesis*

### Confirmed Invited Speakers

(As of July 31, 2018, in alphabetical order)

- Martin Broadley, University of Nottingham Leicestershire, UK  
*The geography of selenium nutrition in sub-Saharan Africa*
- Joel Caton, North Dakota State University, North Dakota, USA  
*Maternal dietary selenium supply and offspring developmental outcomes*
- Luiz Roberto Guimaraes Guilherme, Universidade Federal de Lavras, Lavras, Brazil  
*Selenium biofortification in rice and common beans in Brazil*
- Jean Hall, Oregon State University, Corvallis, USA  
*Selenium supplementation strategies for livestock, with focus on agronomic biofortification*
- Zhen Huang, Georgia State University, Atlanta, USA  
*Selenium nucleic acids for biotechnology and biomedicine*
- Gijss Du Laing, Ghent University, Ghent, Belgium  
*Selenium bioaccessibility and bioavailability in Se-enriched food and feed products*

- Huafen Li, China Agriculture University, Beijing, China  
*Effect of Se on the uptake and translocation of heavy metals in plants*
- Li Li, USDA-ARS, Ithaca, NY, USA  
*To be determined (TBD)*
- Dongli Liang, Northwest A&F University, Xi'an, China  
*Selenium bioavailability in soil-plant system and influential factors*
- Zhi-Qing Lin, Southern Illinois University-Edwardsville, Illinois, USA  
*Biotransformation and volatilization of nanoscale elemental selenium*
- Kunli Luo, Chinese Academy of Sciences, Beijing, China  
*Selenium distribution characteristics in Chinese soil and geological influential factors*
- Graham Lyons, University of Adelaide, Adelaide, Australia  
*The potential of Se-biofortified herbs as antiviral agents*
- Milton Ferreira de Moraes, Federal University of Mato Grosso, Brazil  
*Accumulation and distribution of selenium in Brazil nut tree and its regulation by soil selenium availability*
- N.Tejo Prakash, Thapar Institute of Engineering and Technology, Patiala, India  
*TBD*
- Nicholas Ralston, University of North Dakota, USA  
*In a world contaminated with cadmium, mercury, and other soft electrophiles, we need dietary selenium to protect us*
- Andre de Reis, São Paulo State University, Brazil  
*Current knowledge on bioaccessibility of selenium enriched crops and its relations to nutritional quality*
- Michela Schiavon, University of Padova, Legnaro, Italy  
*Unravelling the complex trait of plant selenium hyperaccumulation: Advances in research on potential candidate genes involved*
- Lutz Schomburg, Charité- Medical University Berlin, Germany  
*Biomarkers of Se status*
- Roger A. Sunde, University of Wisconsin-Madison, WI, USA  
*Impact of high dietary Se on the selenoprotein transcriptome, selenoproteome, and selenometabolites in animals*
- Jian'an Tan, Chinese Academy of Sciences, Beijing, China  
*Achievements and prospects of environmental selenium and human health research in China*
- Shuxin Tu, Huazhong Agriculture University, Wuhan, China

*The role and mechanisms of selenium in plant heavy metal detoxification*

- Yongmin Xiong, Xi'an Jiaotong University, Xi'an, China  
*The mechanism of selenium and selenoproteins in Kaschin-Beck disease*
- Xuebin Yin, University of Science and Technology of China, Suzhou, China  
*Industrialization development models of functional agriculture in China*
- Linxi Yuan, Jiangsu Bio-engineering Research Centre on Selenium, Suzhou, China  
*Effective and safe utilization on natural selenium resources in China*
- Zhaohui Wang, Northwest A&F University, Yangling, China  
*Selenium in wheat grain of China and its biofortification*
- David J. Waters, Purdue University, IN, USA  
*How U-shaped thinking informs future research on selenium and cancer prevention*
- Philip White, Scotland, UK  
*The genetics of selenium accumulation by plants*
- Lenny Winkel, Swiss Federal Institute of Aquatic Science and Technology & Swiss Federal Institute of Technology (ETH), Zurich, Switzerland  
*Marine biogenic emissions as a source of terrestrial selenium*

## **Post-Conference Tour in Xi'an** **ON OCTOBER 31, 2019**

The post-conference cultural tour is scheduled on October 31, 2019, from 8:00am to 10:00pm. The tour will be organized by a local tour company. Participants will need to register for the tour via the conference website. This tour will include three locations, including *Terra Cotta Warriors Museum*, *Xi'an City Wall*, *the Big Wild Goose Pagoda*, and *the Dumpling Banquet with Tang Dynasty Show*. The fee is estimated for \$100/per person (with subsidy from the conference organizer), including roundtrip bus transportation, entry tickets, English tour guide, lunch, and the dinner banquet with the show. The show will end at 9:30pm, and the return bus will arrive in Yangling around 11:00pm.

### ***Terra Cotta Warriors Museum***

The museum is located in Lintong, about 35 km east of Xi'an. It is on the list of the UNESCO World Heritage. The 14260 m<sup>2</sup> pit of the Terra Cotta Warriors and Horses was buried for the first Qin Emperor over 2200 years ago, which makes it one of the most important archaeological excavations of the 20th century. So far more than 8000 full-sized warriors and horses and 100 chariots have been excavated. More information can be found at:

<https://whc.unesco.org/en/list/441>





### ***Xian City Wall***

Xi'an City Wall is one of the best-preserved largest ancient city walls in China. The 14 km wall was built in the Ming Dynasty (1368-1644) with ancient defense systems. More information can be obtained at:

[https://en.wikipedia.org/wiki/Fortifications\\_of\\_Xi'an](https://en.wikipedia.org/wiki/Fortifications_of_Xi'an)



### ***Big Wild Goose Pagoda***

Big Wild Goose Pagoda was built at the Ci En Temple in the south of Chang'an City (now Xi'an) in 652 BC in the Tang Dynasty (618-907). It was designed and built to consecrate and store the Sankrit Classics and Buddhist statues and relics by the eminent monk, Xuan Zang, who brought them from ancient India. This brick-built 7-story pagoda is 64-m high. You may learn more about this attraction at:

[https://en.wikipedia.org/wiki/giant\\_wild\\_goose\\_pagoda](https://en.wikipedia.org/wiki/giant_wild_goose_pagoda)



### ***Banquet with Tang Dynasty Show***

Experience an enchanting night with the region's unique cuisine of dumplings and enjoy the Tang Dynasty Music and Dance Show.



This excursion combines an entertaining show and dumpling banquet that will indulge all of your senses. The dumpling banquet comes with approx. 20 varieties of dumplings including pork, chicken, mushroom, and duck with leeks, carrots, lotus roots, and more. The dumpling banquet starts around 7:00 pm and after dinner you will enjoy the Tang Dynasty Music and Dance Show. More detailed information can be found by visiting the website at:

<https://xiantangdynastyshow.com/>

## RESEARCH HIGHLIGHTS



### **Selenium Research in Africa**

### **Selenium Research in Ethiopia and Malawi**

There have been several exciting selenium research developments in Ethiopia and Malawi, since our presentations by several of our Se society network at the Selenium 2017 Conference last August. Ms. Ivy Ligowe will shortly begin her fourth year of PhD study at Lilongwe University of Agriculture and Natural Resources (LUANAR) in Malawi. Ivy's PhD studies are providing us with a greater understanding on the mechanisms of selenium dynamics in tropical soils and crops under different soil management schemes.

Ivy's work has included the use of stable isotopes of selenium to understand the dynamics of movement in soil-

crop systems, when fertiliser forms of selenium are applied to crops. She has shown that there is a narrow window of selenium uptake by plant roots. Most of the added selenium seems to become fixed as anionic/oxyanionic selenium species into inert humus-bound forms and/or inorganic colloids (e.g. Fe/Al hydrous oxides). There are additional small losses of selenium from the system, by leaching and/or volatilization, although these are not being measured directly. Ivy has also found that incorporating crop residues into the soil over longer time-frames can improve the selenium quality of crops.



*Ivy Ligowe (Lilongwe University of Agriculture and Natural Resources), flying a drone above her field plots of maize at Chitedze Research Station, near Lilongwe, Malawi*

Ivy's studies are being funded by the UK Department for International Development and the Royal Society as part of a doctoral training program and wider capacity strengthening initiative, called the Africa Capacity Building Initiative (ACBI). Ivy is working alongside other PhD projects registered at University of Zambia and University of

Zimbabwe. The outputs of all of these students is expected to be used by agricultural policy makers. Previous work in Malawi, beginning with the studies of Allan Chilimba, showed that selenium deficiency is likely to be one of the most pressing micronutrient deficiency (MND) risks in the country (Hurst et al. 2013; Joy et al. 2015). Allan showed that this could feasibly be solved by use of selenium fertilisers, as used for >30 years in Finland (Chilimba et al. 2012a,b). However, any future policy decisions on fertiliser use in Malawi can only be taken at national levels, once the evidence of a public health issue is sufficient, and once the cost-benefit of intervention have been established.

Tasked with improving the evidence base of the selenium status of the Malawi population, Felix Phiri began his PhD studies in late 2015. Felix's project was designed to augment a nationally representative survey of the micronutrient status of the Malawi population in 2015-2016 and include selenium analyses of blood plasma and urine samples. His studies have directly shown that there is widespread Se deficiency in Malawi, as described in a paper that is currently under review. Working with the National Statistics Office of Malawi, and using plasma selenium analysis of a nationally representative sample of >2,700 individuals, the studies show that that 65% and 30% of women of reproductive age (WRA) had plasma selenium concentrations below the thresholds for the optimal activity of the selenoproteins glutathione peroxidase 3 (GPx3, <86.9 ng/mL) and iodothyronine deiodinase (IDI, <64.8 ng/mL), respectively. Using geostatistical modelling, we can see that selenium deficiency risks are influenced by soil type, as predicted by Allan Chilimba's work (Chilimba et al. 2011),

and also by proximity to Lake Malawi where more fish are consumed, as predicted by Edward Joy and Diriba Kumssa's study based on household survey data (Joy et al. 2015). Given the marginal cost of monitoring selenium status in national micronutrient surveillance programmes, we would advocate that selenium status should be quantified routinely during micronutrient surveys in sub Saharan Africa, to further extend the evidence base.



*Felix Phiri, University of Nottingham, presenting an overview of his work to GeoNutrition project team in Lilongwe, January 2018*

A final exciting development to report is a new project, funded by the Bill & Melinda Gates Foundation, called *GeoNutrition*. The work is based in Ethiopia and Malawi. The aim of *GeoNutrition* is to provide new evidence to support policy makers in the agriculture and public health sectors of Ethiopia, Malawi, and the wider region. This will include new, spatially-informed evidence on the prevalence and causes of MNDs, with selenium as a major focus. The team will also study the potential effectiveness of biofortification strategies to contribute to alleviating Se and Zn deficiencies through application of micronutrient-containing fertilisers. Food system interventions that act through agriculture are likely to play an important role in improving nutrition, especially among rural and marginalised groups.



*GeoNutrition soil and crop sampling in a teff field in Amhara, November 2017*

The Ethiopian academic lead on the project is Dawd Gashu, a human nutritionist at Addis Ababa University. Dawd's previous work showed that there was evidence of widespread selenium deficiency in the Amhara Region but that this was under strong spatial control, as seen in Malawi (Gashu et al. 2016). The Malawi academic lead on the project is Patson Nalivata, a soil scientist, and Ivy's lead supervisor at LUANAR.

The research project is highly multidisciplinary, spanning agriculture, nutrition, socio-economics, geography, and ethics. The team includes nutritionists and clinical trial experts from the London School of Hygiene & Tropical Medicine (LSHTM). Other partners are The International Maize and Wheat Improvement Centre (CIMMYT) and the



International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Ethiopia; CIMMYT and the World Agroforestry Centre (ICRAF) in Kenya; and Rothamsted Research and British Geological Survey in the UK. We look forward to updating the selenium community on all of these activities (and more) in 2019.



*Dawd Gashu (Addis Ababa University), sampling teff in Amhara, November 2017*

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*(This article was contributed by Martin Broadley, University of Nottingham & Edward Joy, London School of Hygiene and Tropical Medicine, June 2018)*

## Selenium Status Assessment and Agronomic Biofortification Trials in Central Kenya Highlands

*Peter Biu Ngigi, Gijs Du Laing, Carl Lachat & Peter Wafula Masinde*

Micronutrient deficiencies continue to contribute to morbidity and mortality concerns in Kenya, with over 50% of morbidity and mortality cases among children attributed to vitamin A, zinc, iodine, and iron deficiencies (Fanzo 2012; Ministry of Health, Republic of Kenya 2011). Selenium (Se) has however not been studied nor considered as important at a public health standpoint in Kenya. Dietary mineral supplies mapping in Africa estimated the mean risk of Se deficiency in the East African region at 52%. Kenya had the lowest dietary Se supply (23-35 µg/capita/d) and highest risk of dietary Se deficiency (91-100%) in the region (Joy et al. 2014). The country has also the lowest dietary Se availability and hence, high risk of dietary Se inadequacy in the region (Hurst et al. 2013). Low dietary Se intake is cited as a causal factor of rapid diffusion of HIV-1 in Sub-Saharan African countries including Kenya, where soil Se deficiency is common and AIDS is a chief cause of mortality (Foster 2003). Selenium deficiency has also been observed to increase the infectiousness of women with HIV-1 in the coastal region of Kenya (Baeten et al. 2001). These past studies make it more apparent that Se deficiency is wide spread in Kenya and should therefore be considered as an important public health issue that requires research attention aimed at assessing the prevalence and regional variation of dietary Se deficiency risk, and most important, develop national/regional intervention measures to address the deficiency.

A survey was conducted to assess Se status in agro-climatic zones in the highlands; home for 74% of Kenya's population with the highest volume of staple food production, ethnic diversity, and the largest proportion of severely malnourished children. Major soils used for agriculture and locally consumed foodstuffs were analysed for Se concentration. This was complemented with a dietary intake assessment for actual food intake. Total soil Se concentration results ranged from 0.215 to 0.703 mg/kg and extractable soil Se from 0.005 to 0.009 mg/kg. Very low mean daily dietary Se intake of 7.61 µg/d among children under 5-year old and 14.40 µg/d among women aged between 19 to 39 years were observed, and varied among the study areas (Fig. 1). Overall, 97% of women had their daily dietary Se intake below the Estimated Average Requirements (EARs) of 45 µg/d while 81% of children were below the EARs of 17-23 µg/d. Out of the eight study areas in central Kenya highlands, 100% of women and >90% of children in the five study areas had mean dietary Se intake below the EARs. These results reflect what was previously reported by Joy et al. (2014).

Maize was selected as the most suitable crop for agronomic biofortification trials since it's the main staple food in the



region and contributed the most to daily dietary Se intake among the target study population. Biofortification trials were set up in study areas with the highest risk of dietary Se deficiency. The field trials tested crop response to soil and foliar Se fertilizer application in the form of sodium selenate ( $\text{Na}_2\text{SeO}_4$ ) at the application rates of 5, 10, and 20 g Se/ha. Post biofortification trial

results showed that maize crops responded better to foliar application (when the crops were knee high) than soil application (during sowing). The foliar application doses increased Se concentrations in maize grains by a mean of 1.8, 2.4, and 5.7 folds, respectively. This means that in regions with the highest dietary Se deficiency risk, Se biofortification would increase the daily dietary Se intake by 1.3, 1.4, and 2 folds respectively, for both children and women (Table 1).

It should, however, be noted that the climate change being experienced globally and more so in the tropics, affected the weather pattern during the biofortification trials. The crops

had inadequate rainfall and conducive conditions for foliar fertilizer application on a sunny day was not achieved. During more favorable weather conditions, Se concentration in maize grains and overall impact on daily dietary Se intake is expected to be higher.

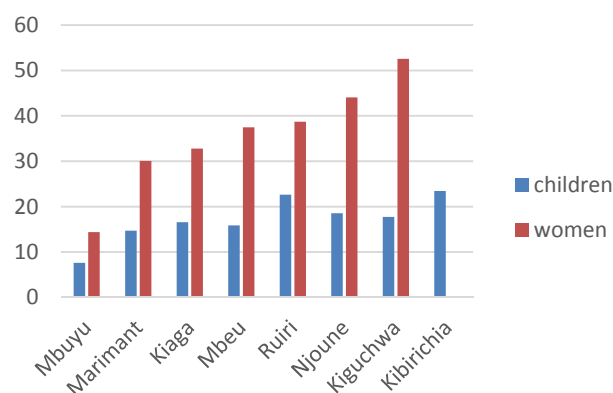


Figure 1. Regional variation in dietary Se intake.

Table 1. Impact of Se biofortification on dietary Se intake in Mbuyu region of Central Kenya highlands

	Children				Women			
	Fertilizer dosage (g Se/ha)				Fertilizer dosage (g Se/ha)			
	Control	5	10	20	Control	5	10	20
Maize Se Conc. (mg/kg)	0.031	0.055	0.074	0.177	0.031	0.055	0.074	0.177
Maize Se supply (µg/d)	0.43	2.56	3.49	8.31	1.61	5.52	7.51	17.91
Daily Se intake (µg/p/d)*	7.61	9.74	10.67	15.50	14.40	18.30	20.29	30.69
Increase in Se intake (folds)		1.3	1.4	2.0		1.3	1.4	2.1

\*Daily Se intake (µg/p/d) is the total Se intake from all foods consumed in a day.

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## **INTERNATIONAL SOCIETY FOR SELENIUM RESEARCH**

### **How to Become a Member?**

Membership is open to all who are interested in fostering the expansion of communication and scientific exchange of new and emerging concepts centered within the multi-disciplines associated with current and future worldwide selenium research efforts. The membership will include regular, student and honorary members. A regular member has the right to elect, or to be elected, as an officer of the ISSR. To join the ISSR, individuals will need to complete the membership application form. The membership due for a regular member is \$50 (USD) for a two-year membership, and \$20 (USD) for a student member. For a lifelong membership the membership due is \$300 (USD).

The current list of members can be found at the Society's webpage: [www.seleniumresearch.org/](http://www.seleniumresearch.org/)

### **How to Pay Your Membership Fee?**

The membership due of \$50 (for a regular member for two years), \$20 (for a student member for two years), or \$300 (for lifelong membership) can be paid via the following approaches: (1) The payment can be made in cash at the selenium conference; (2) The fund can be transferred through Western Union or other companies with money transfer service; (3) Remitting the payment in the form of a cashier's check, certified check, or money order payable to *International Society for Selenium Research*. A personal check in US currency will also be acceptable. Please send your check or fund transfer notice to: Dr. Zhi-Qing Lin, Department of Environmental Sciences, 2165 Science West, Southern Illinois University, Edwardsville, Illinois 62026-1099, USA; Tel.: 1-618-650-2650; Email: [zhlin@siue.edu](mailto:zhlin@siue.edu)

### **Current Elected Officers**

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*Gary Bañuelos, U.S. Department of Agriculture-ARS,  
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