

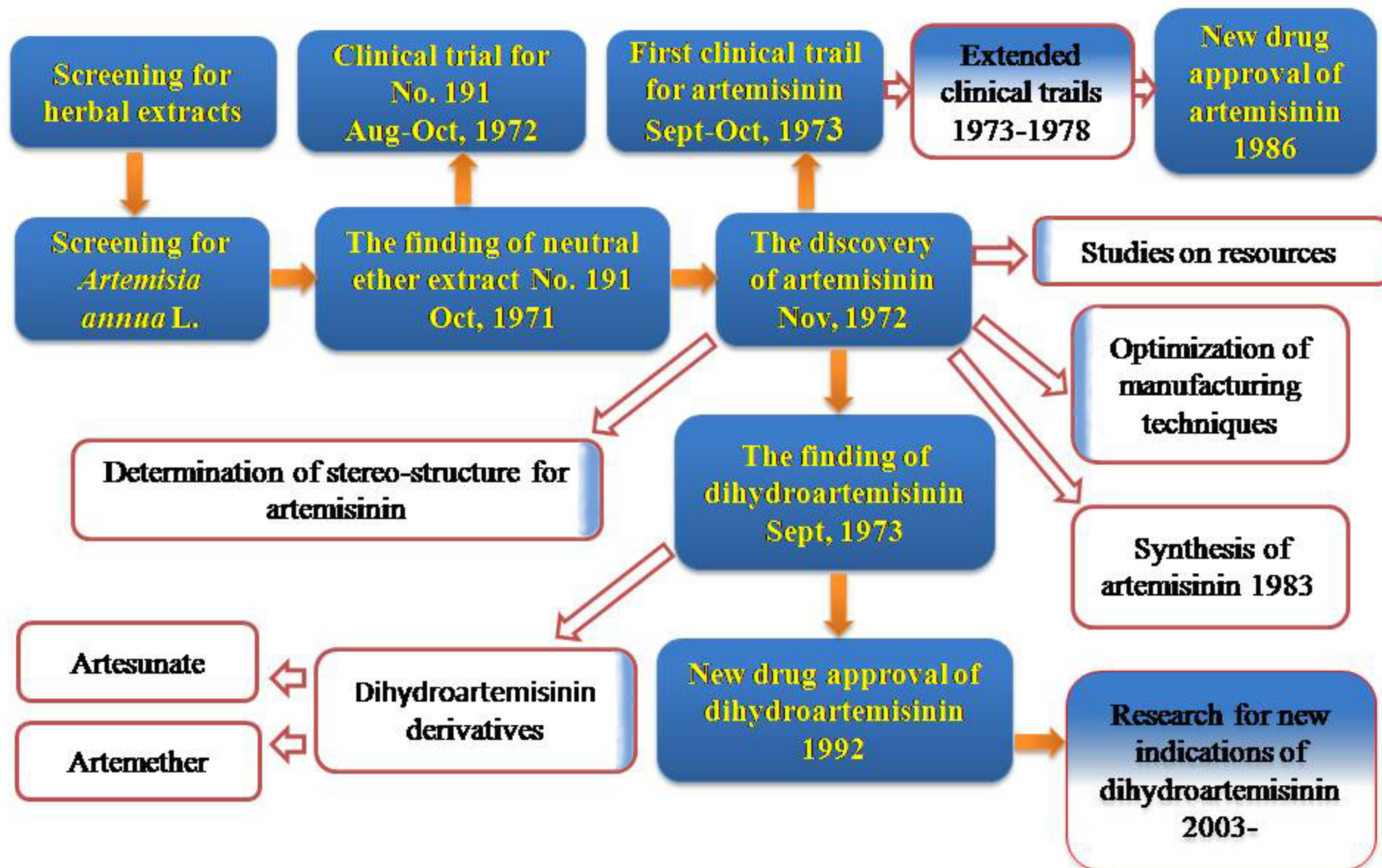
# **Artemisinin– A Gift from Traditional Chinese Medicine to the World**

**Tu Youyou**

**Institute of Chinese Materia Medica, China  
Academy of Chinese Medical Sciences,  
Beijing, 100700, China**

**Nobel Lecture, Dec 7, 2015  
Karolinska Institutet**

# Summary of the Work Completed by the Research Team in Academy of Traditional Chinese Medicine (Boxes in Blue Background)



# The Breakthrough in the Research of *Artemisia annua* L for Discovery of Artemisinin

186	185	→ 1:1	$\frac{0.5g}{0.3ml}$	"	"	1/5	540	590	640	602%	-30%
187	187 子 AEC+H <sub>2</sub> O 1:4	→ 1:2	$\frac{0.4g}{0.2ml}$	"	"	2/5	330	400	340	357%	22%
188	187	→ 1:1	$\frac{0.25g}{0.25ml}$	"	"	0/5	500	420	410 370 416	416%	9%
189	189 子 AEC+H <sub>2</sub> O 1:2.5		$\frac{0.5g}{0.2ml}$	"	"	0/5	480	420	400 600 228	426%	7%
190	189	→ 1:1.25	$\frac{0.31g}{0.25ml}$	"	"	0/5	550	460	290 600 400	120%	9%
✓ 191	青蒿 1:4		$\frac{0.8g}{0.2ml}$	"	"	4/5	0	(5/4 7/16)		100%	
192	191	→ 1:2	$\frac{0.6g}{0.3ml}$	"	"	2/5	0 (1-2/4)	205	0 (1-2/4)	68%	85%
193	青蒿 1:4		$\frac{1.2g}{0.3ml}$	"	"	1/5	293	0 (1/4)	132 0	106%	77%
194	193		$\frac{0.8g}{0.2ml}$	"	"	0/3	511	509	10	343%	26%
195	195 子 AEC+H <sub>2</sub> O 1:10	→ 1:2.5	$\frac{0.875g}{0.35ml}$	"	"	1/5	400	560	420 460	455%	1.3%
196	195	→ 1:2.5	$\frac{0.625g}{0.25ml}$	"	"	0/5	580	386	380 395 520	452%	2%



中国医学科学院药物研究所

分析化学室

微量有机元素分析报告

样品原编号: 青蒿素(IV)

分析编号:

送样人: 中药研究所陈明之

工作领导人签字:

样品干燥情况: 已干燥

样品主要性质:

样品含有元素:

要求分析项目: C, H, O

要求分析元素的百分比范围

或化合物的可能结构式:

$C_{15}H_{22}O_5$

送样日期: 73年4月24日

感光: \_\_\_\_\_; 吸水: \_\_\_\_\_; 挥发性: \_\_\_\_\_; 爆炸性: \_\_\_\_\_

沸点: \_\_\_\_\_; 熔点: \_\_\_\_\_; 其他: \_\_\_\_\_

(分析结果见)

The elements analysis by the collaborative institution, Institute of Materia Medica, Chinese Academy of Medical Sciences, on April 27<sup>th</sup>, 1973.  
(Front side)



(Back side)

分析结果:

样品在分析前的处理:

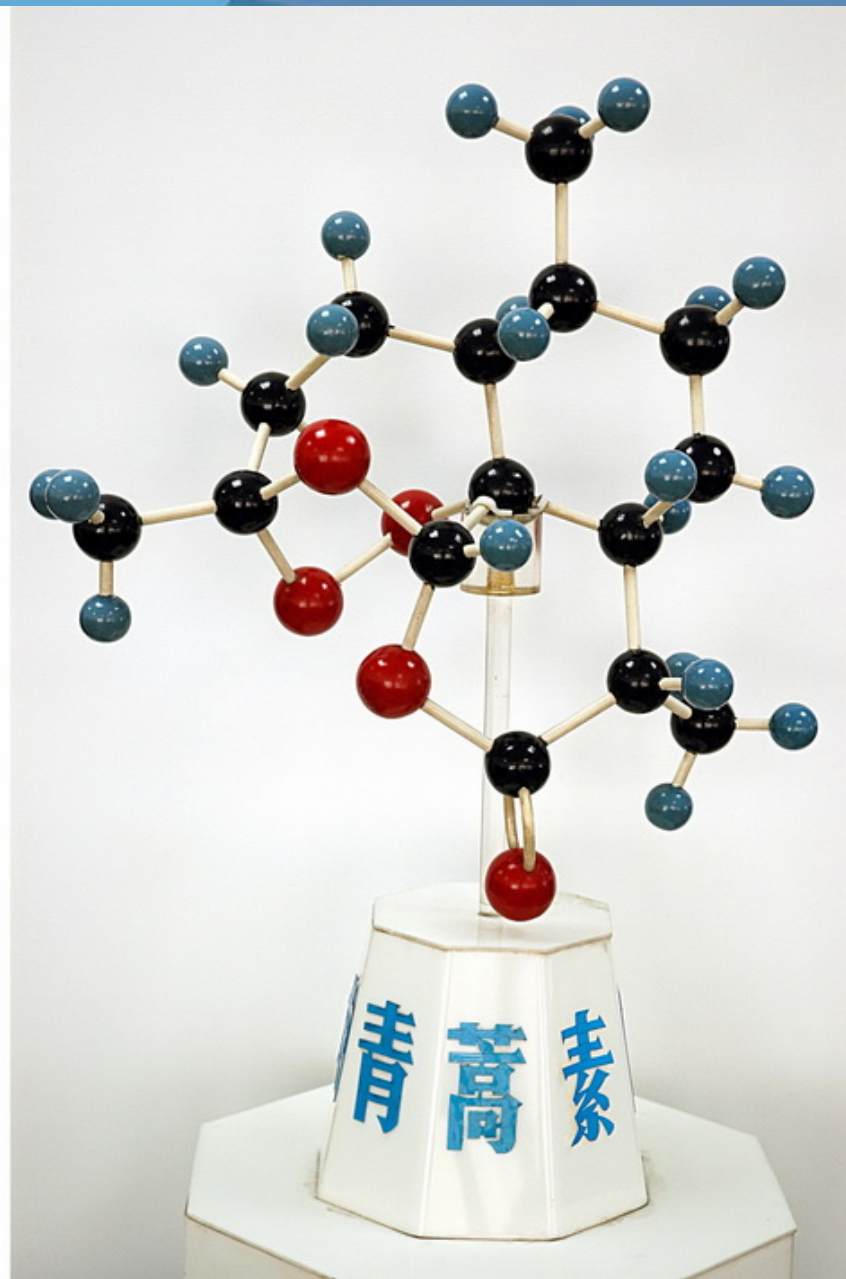
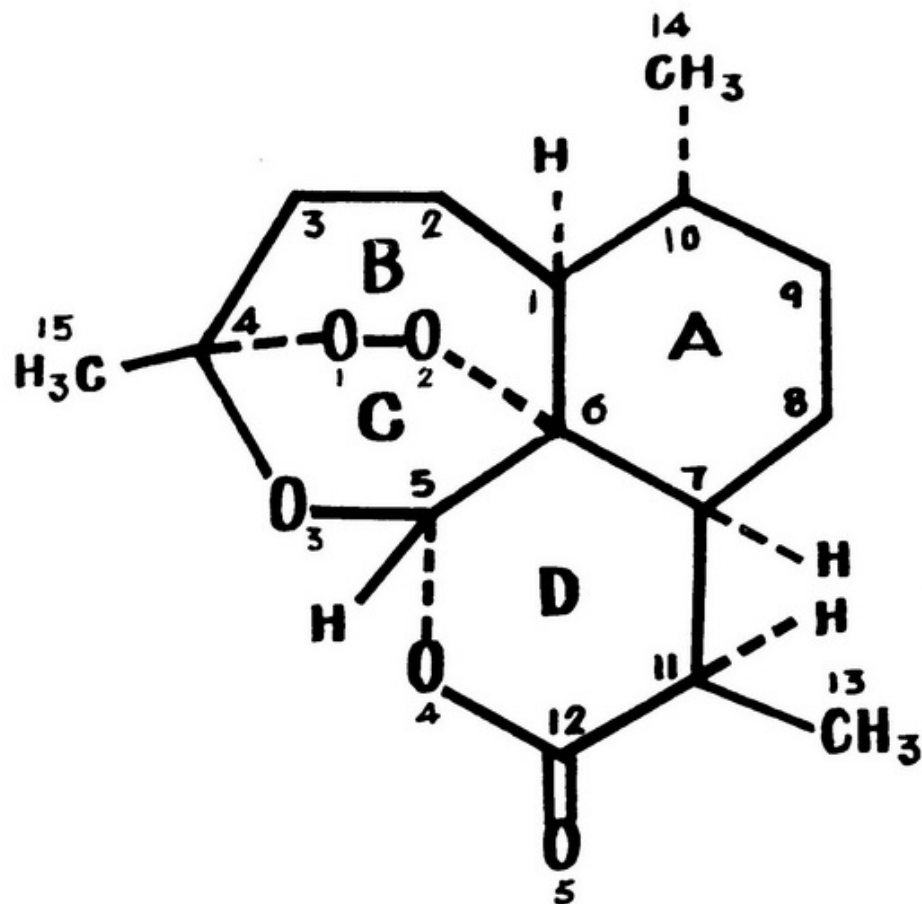
样品重(Mg)	CO <sub>2</sub> 重(Mg)	H <sub>2</sub> O重(Mg)	%C	%H	註
2.531	5.923	1.928	63.86	8.54	
3.173	7.411	2.422	63.59	8.54	
样品重(Mg)	温度(°C)	压力(MM/Hg)	氮气体积(Ml)	%N	
样品重(Mg)	( )沉淀重(Mg)	Ml	N	%	

分析室意见:

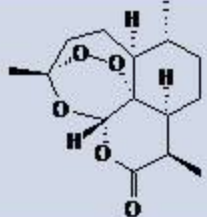
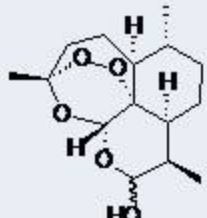
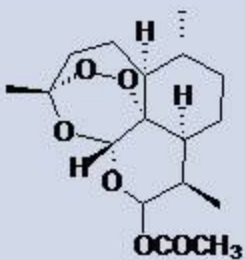
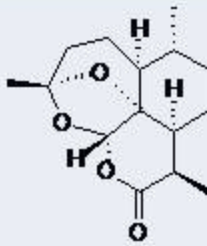
分析人: 李秀兰

分析日期: 73 年 4 月 27 日

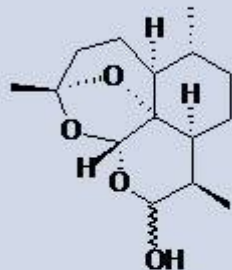
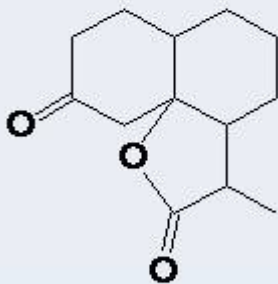
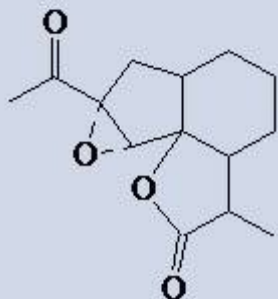
# The Molecular Structure and the Stereo-structure of Artemisinin



# Structure - Activity Relationship of Compounds from Artemisinin

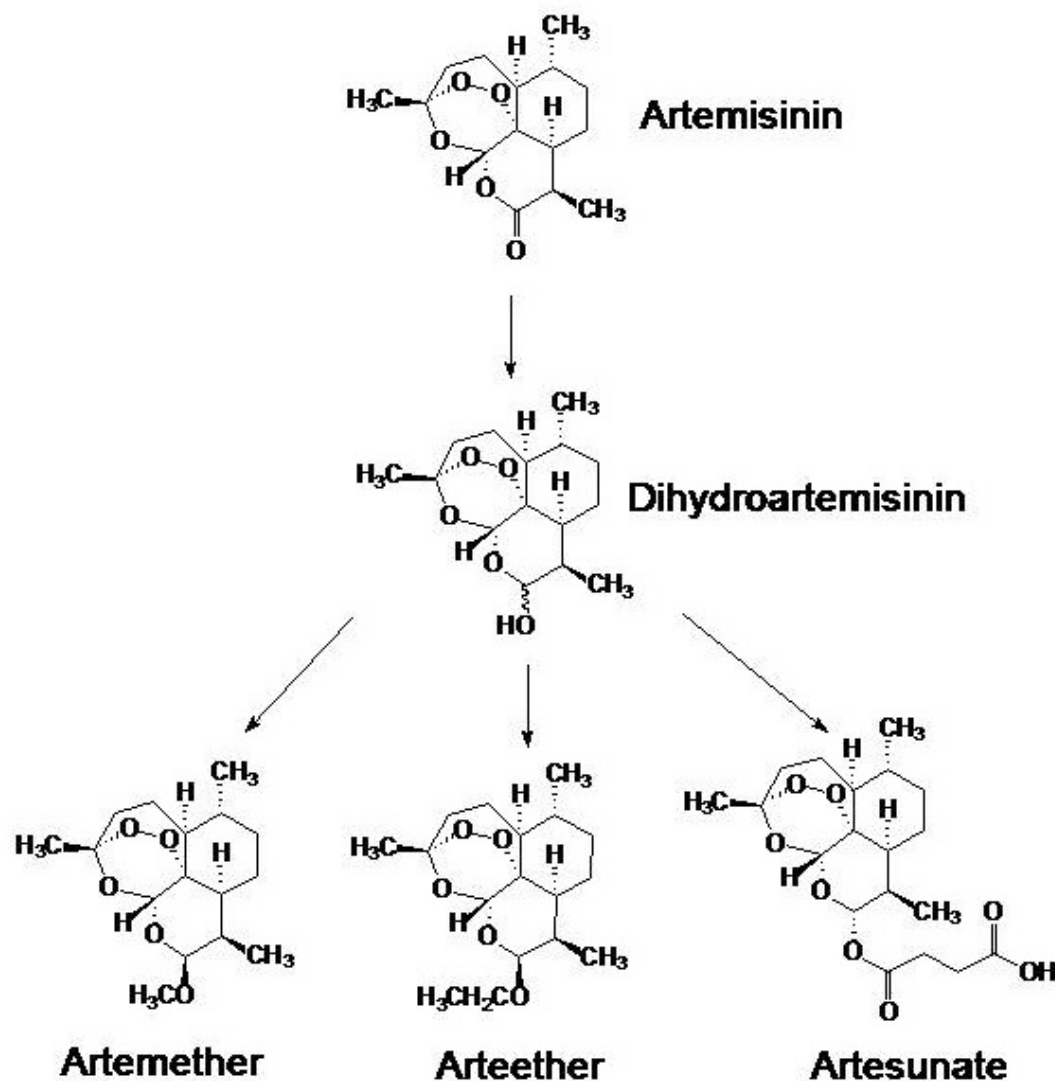
Compound	Graph of chemical structures	Dose mg/kg/day $\times$ 3	Clearance of parasites
Artemisinin		50-100	Yes
Dihydroartemisinin		12.5	Yes
Acetate of dihydroartemisinin		6	Yes
Deoxyartemisinin		100	No

# Structure - Activity Relationship of Compounds from Artemisinin (continued)

Compound	Graph of chemical structures	Dose mg/kg/day $\times$ 3	Clearance of parasites
Dihydrodeoxyartemisinin		100	No
Acid treatment product of artemisinin		100	No
Base treatment product of artemisinin		100	No



# Molecular Structures of Artemisinin and its Derivatives







New drug certificate of artemisinin issued by the Ministry of Health (1986) (left)

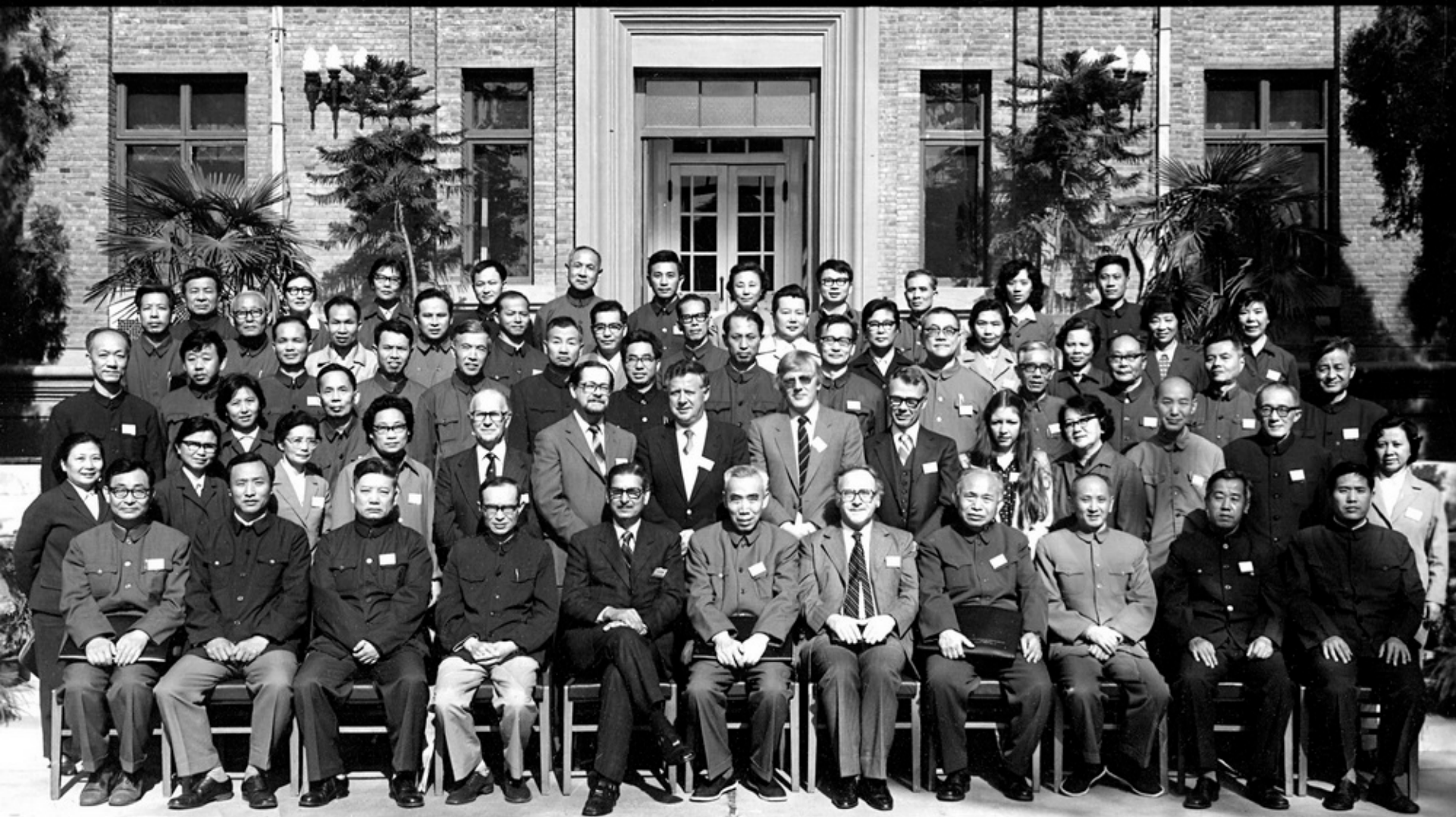
New drug certificate of dihydroartemisinin issued by the Ministry of Health (1992) (Right)





# Worldwide Attention to Artemisinin

**The 4th Meeting of The SWG-Chemal "Qinghaosu"  
Beijing · China      october · 1981**



## Commitment to the Clearly Defined Goal





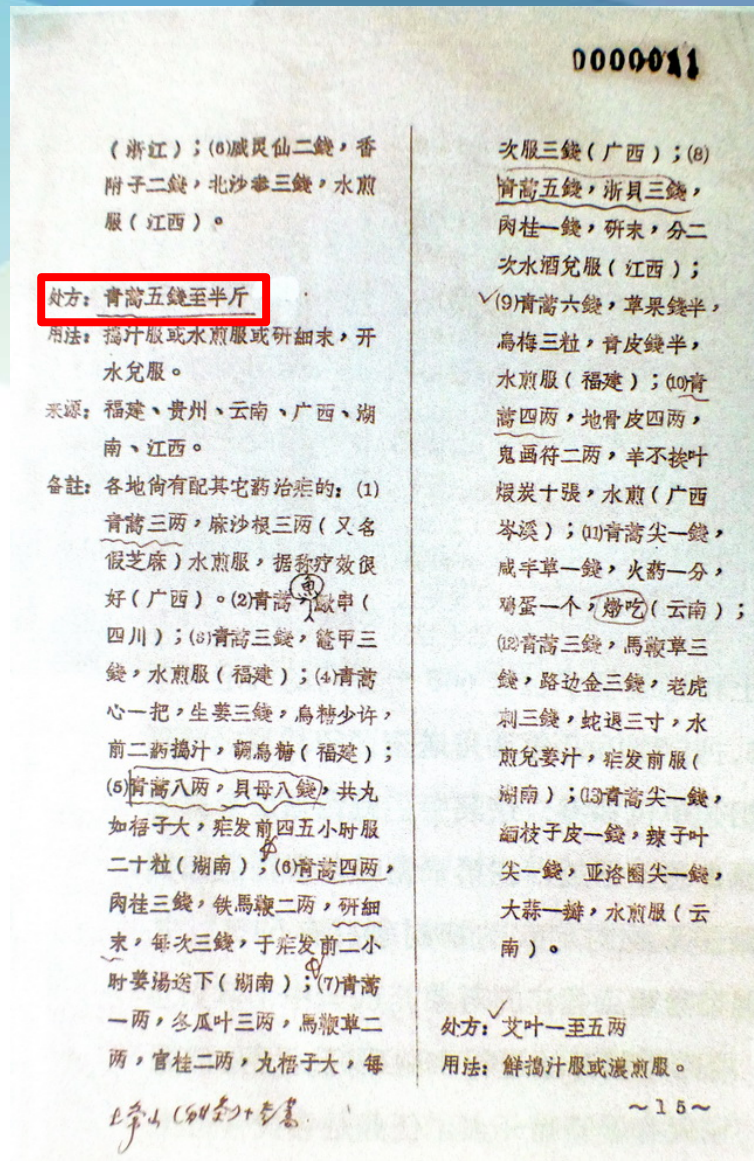
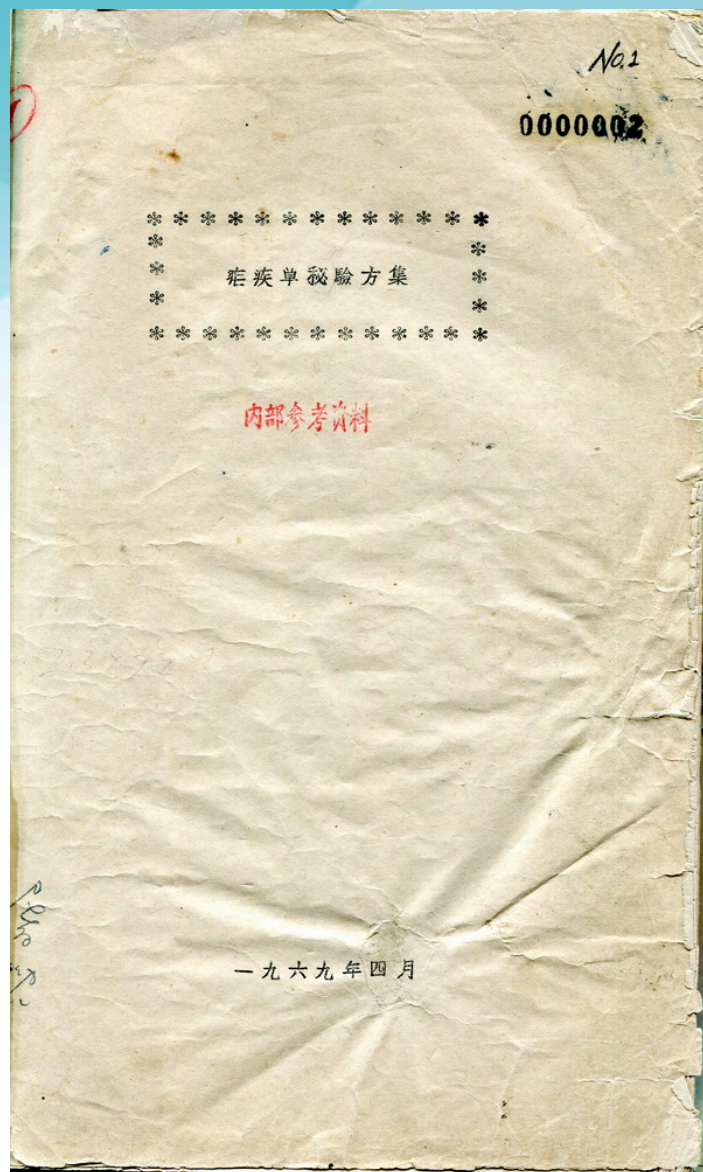
# Knowledge is Prologue in Discovery





# Antimalarial Collections of Recipes and Prescriptions

## April, 1969





# A Handbook of Prescriptions for Emergencies



葛仙翁肘後備急方卷之三  
治寒熱諸瘧方第十六  
治瘧病方鼠婦豆豉二七枚合搗令相和未發時服  
二丸欲發時服一丸  
又方青蒿一握以水二升漬絞取汁盡服之  
又方用獨父蒜於白炭上燒之末服方寸匕  
又方五月五日蒜一片去皮中破之刀割令容巴豆  
一枚去心皮內蒜中令合以竹挾以火炙之可  
熱搗爲三丸未發前服一丸不止復與一丸  
又方取蜘蛛一枚蘆管中密塞管中以縮頸過發時



# Qinghao Has a Long History of Clinical Application

图版拾貳

马王堆三号汉墓出土的帛书



《五十二病方》(部分)





# Simple Resarech Facilities in the 1970s





# Invention Certificate for Progress in Anti-malarial Research Issued by National Congress of Science and Technology, 1978



# The World Is Continuing to Make Impressive Progress in Reducing Malaria Cases and Deaths.

Dr. Margaret Chan, 2014

## Since the year 2000

Average malaria infection prevalence declined **46%** in children aged 2–10, from 26% to 14% in 2013.

The number of malaria infections at any one time dropped **26%**, from 173 million to 128 million in 2013.

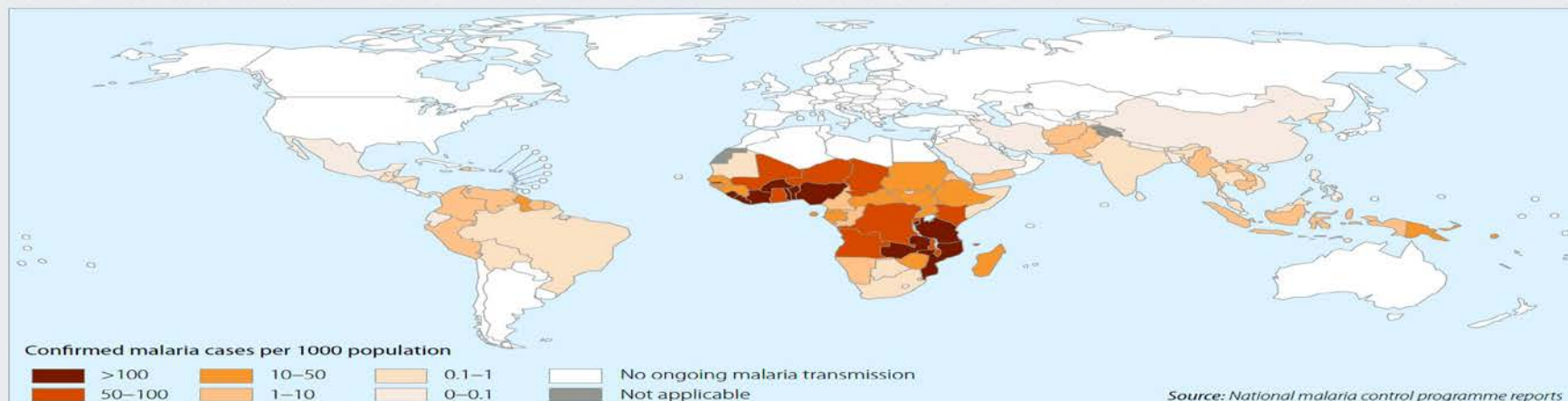
Malaria mortality rates have decreased by **47%** worldwide and by **54%** in the WHO Africa Region.

## By 2015

If the annual rate of decrease over the past 13 years is maintained, malaria mortality rates are projected to decrease by **55%** globally and by **62%** in the WHO Africa Region.

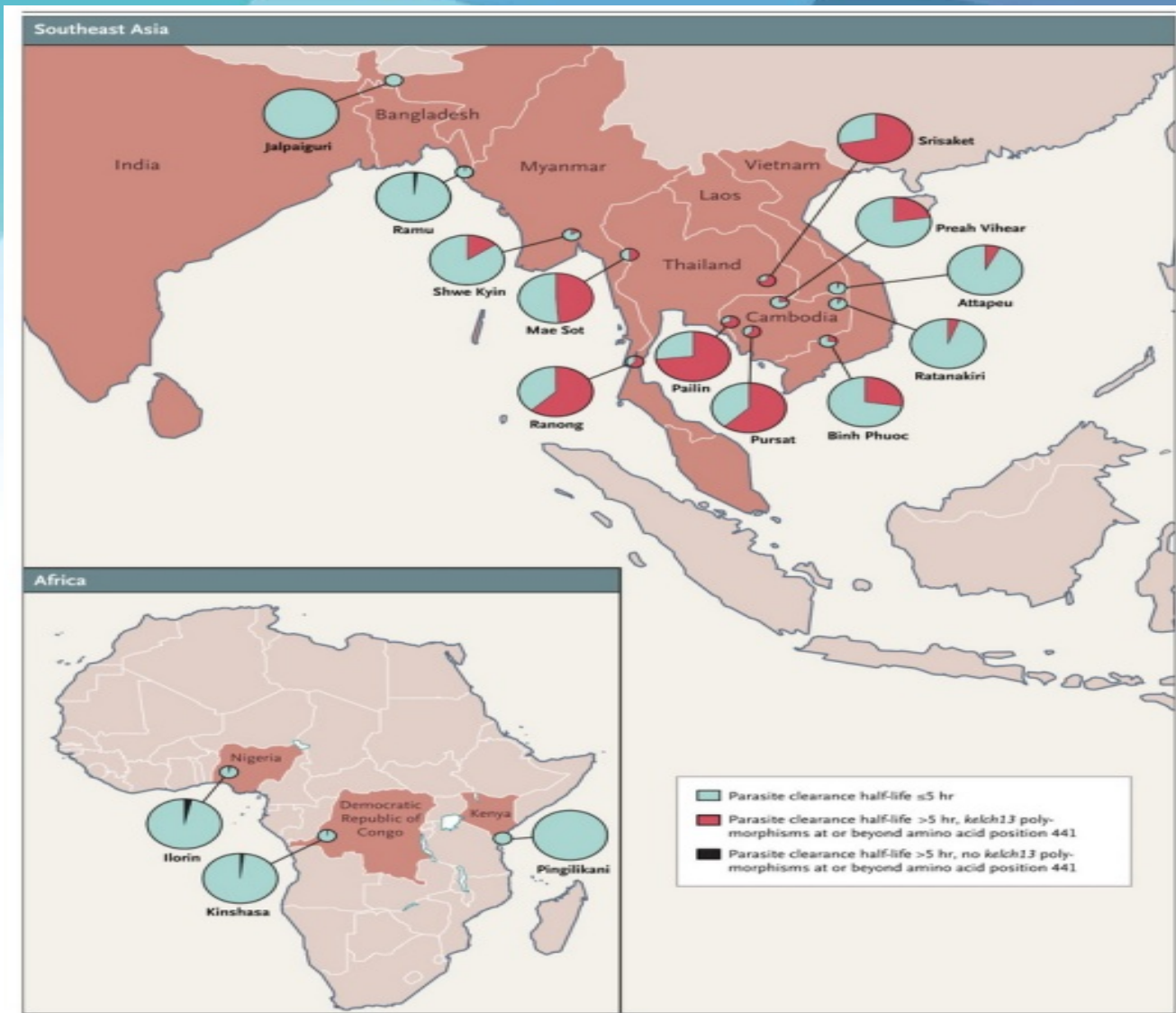
Malaria mortality rates in children aged under 5 years are projected to decrease by **61%** globally and **67%** in the WHO Africa Region.

Figure 1.1 Countries with ongoing transmission of malaria, 2013



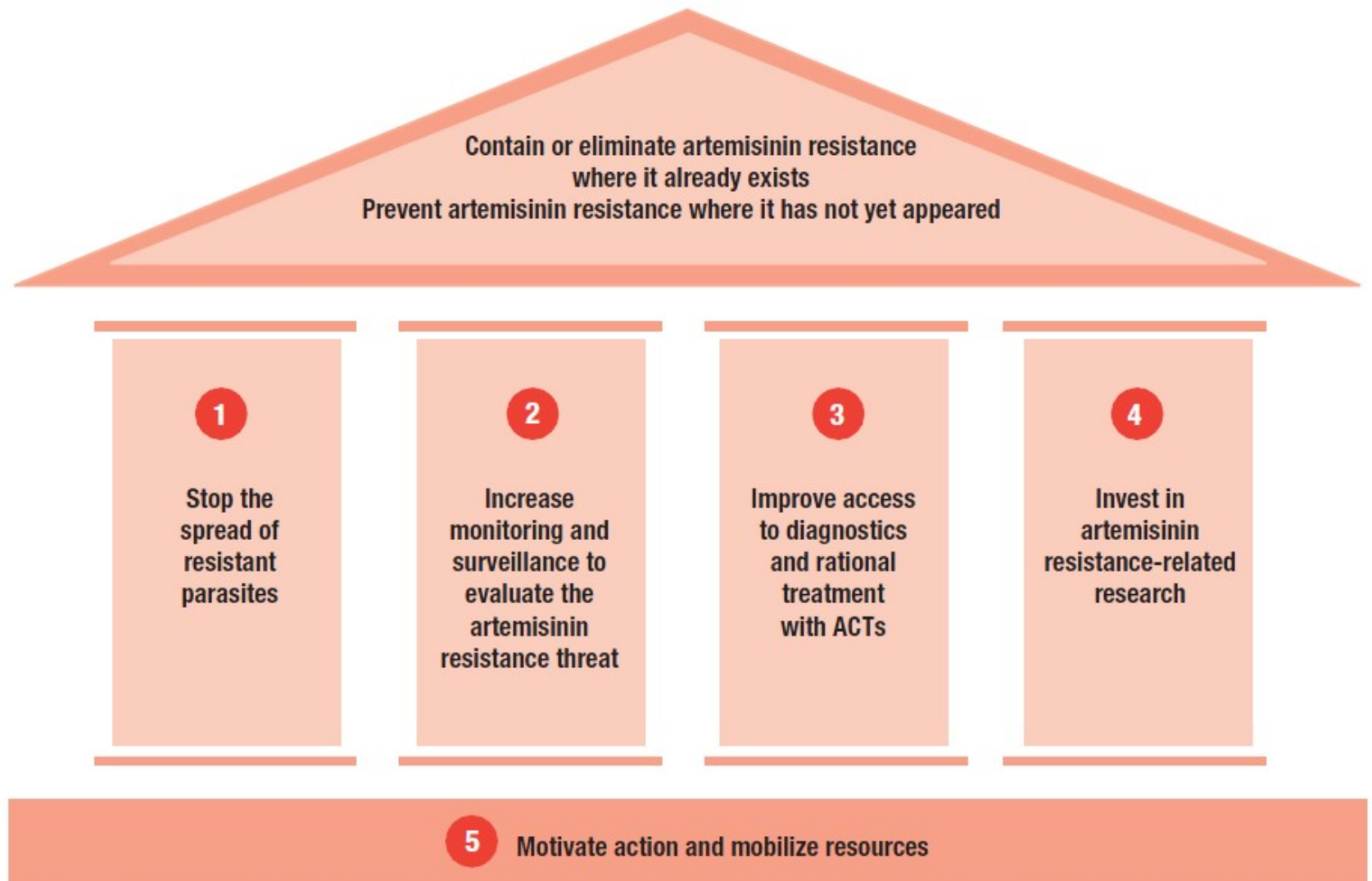


# Spread of *P. falciparum* Resistance to Artemisinin



Ashley E A et al, Spread of Artemisinin Resistance in *Plasmodium falciparum*  
*Malaria N Engl J Med.* 2014, 371(5): 411–423

# WHO Global Plan for Artemisinin Resistant Containment (GPARC) Goals and Recommendations





中國醫學是  
一個偉大的寶庫，  
應當努力發掘，加  
以提高。  
毛澤東

Chinese medicine and pharmacology are a great treasure-house.  
We should explore them and raise them to a higher level

Hand writing by Mao Zedong



白日依山尽，

The sun along the mountain bows,



黄河入海流，

The Yellow River seawards flows,



欲穷千里目，更上一层楼。

**You will enjoy a grander sight,  
By climbing to a greater height.**

On the stork tower,  
Wang Zhihuan (Tang dynasty)

# Acknowledgements

Finally, I would like to acknowledge all colleagues in both China and overseas for their contributions in the discovery, research and clinical application of artemisinin.

I am grateful for all my family members for their continuous understanding and support.

I sincerely appreciate your kind attention.

Thanks you all!