Microbiol. Cult. Coll. June 2006. p. 15-19 Vol. 22, No. 1

Economic value of microbial resources

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Undiscovered biological and genetic resources, in particular microbial resources, preserved in natural habitats, are potentially valuable sources for future innovation of pharmaceutical and other industrial products. However, there is no established method for evaluating the economic value of microbial resources collected from natural habitats. This is one of the reasons why a benefit-sharing agreement on microbial resources in the context of implementing the Convention on Biological Diversity (CBD) is difficult to conclude.

This study examined the economic value of microbial resources used as screening materials for developing new pharmaceuticals. The economic value, which was estimated based on the sum of an initial charge and expected royalties obtained from pharmaceutical companies, resulted in US$2-60/strain, depending on their quality and value-added information attached to the strains.

In order for source countries to gain a greater share of the benefits from microbial resources, they should, for example, build human and technological capabilities to isolate, preserve and characterize microorganisms and provide users with more value-added resources. For this purpose, emphasis should be placed on non-monetary benefit-sharing rather than monetary benefit-sharing in negotiating an access and benefit-sharing agreement with resource users in the context of the CBD.

Key words: microorganism, value, biodiversity, CBD, pharmaceuticals

INTRODUCTION

Biodiversity helps to maintain the ecosystem functions that support life and human activity on earth. In recent decades, the global economic activities of humans have been rapidly eroding natural ecosystems, threatening the existence of many species and destroying biodiversity.

Responding to global concerns about the rapid loss of biodiversity, the Convention on Biological Diversity (CBD) was adopted in 1992 and came into force in 1993. Under the CBD, fair and equitable sharing of benefits from the use of genetic resources is expected to provide financial incentives for source countries to preserve their biodiversity.

Currently, the number of validly described microorganisms is less than 5% of the estimated number of microorganisms that are presumed to exist on earth (Schleifer, 2004). Undiscovered microbial resources preserved in natural habitats are potentially valuable sources for future innovation in pharmaceutical and other industrial products. Such commercial use would bring significant social and economic benefits to humans.

However, there is no established method to calculate the economic value of microbial resources to be collected from natural habitats.[1] This is one of the reasons why an access and benefit-sharing (ABS) agreement on microbial resources in the context of implementing the CBD is difficult to conclude.

This study aims to estimate the economic value of *ex situ* microbial resources collected from natural habitats.

Since pharmaceuticals represent one of the biggest potential markets for microbial resources, this study examines the economic value of microbial resources used as screening materials for developing new pharmaceuticals.

EVALUATION METHODS

There is a market for *ex situ* microbes. Microbial cultures in major culture collections are traded in the range of US$40-190/strain (Fig. 1). These microbial strains are mainly used as references for identifying new taxa or standards for microbial test-

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Accepted: March 24, 2006

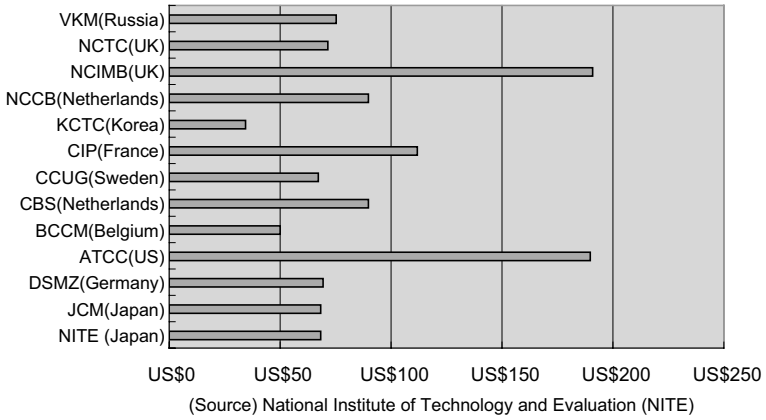

Fig. 1 Market prices of microorganisms provided by major culture collections

ing, not as screening materials for pharmaceutical research.

Several previous studies presented models on the economic value of plants used as screening materials for plant-based pharmaceuticals (Pearce & Moran, 1994; Simpson *et al*., 1996; Rausser & Small, 2000). However, there has been no study to present a model on the economic value of microbial resources collected from natural habitats.

Research and development (R&D) of new pharmaceuticals takes 9–17 years and needs investment of more than US$800 million (Japan Bioindustry Association (JBA), 2005). Fig. 2 shows a typical R&D process, its timeframe, costs, and survival rate of lead chemicals for developing a new pharmaceutical product. Pharmaceutical companies develop a screening assay, and then screen a huge number of biological and/or chemical materials in order to find lead compounds. For this purpose, they collect resources by conducting bioprospecting activities or obtain resources from outside providers through contracts.

Many pharmaceutical companies, when they obtain microbial resources from resource providers, often offer royalties for such microorganisms after the product launch in addition to an initial charge. Therefore, by using the following model, the economic value of microbial resources can be estimated based on the sum of an initial charge and expected royalties obtained from pharmaceutical companies:

$$Ve = c + \sum_{i=n}^{m} \frac{p \cdot r \cdot Si}{(1+d)^i} \quad (1)$$

Ve: economic value of microbial resources *ex situ* (per strain)
c: initial charge (per strain)
p: expected probability of success in developing a new pharmaceutical product
Si: expected pharmaceutical sales in the *i*th year (per drug)
r: royalty (rate on pharmaceutical sales)
d: discount rate
n: the year when pharmaceutical sales will start
m: the year when pharmaceutical sales will end

ESTIMATION OF THE ECONOMIC VALUE OF MICROBIAL RESOURCES COLLECTED FROM NATURAL HABITATS

It is not possible to estimate the value of microbial resources with any precision on the basis of currently available methods. However, it is possible to obtain an idea as to their magnitude by using some data from pharmaceutical industries. On this assumption, this study collected various data from different sources and calculated the economic value of microbial resources *ex situ* by using the model (1) given above.

Initial charge (*c*)

The author's interviews with industry experts revealed that the current initial charge of microbial

[1] Only a small percentage of microscopically detectable microorganisms *in situ* can be cultivated and therefore isolated as *ex situ* microbial resources, which can be used for research on new pharmaceutical and other industrial products.

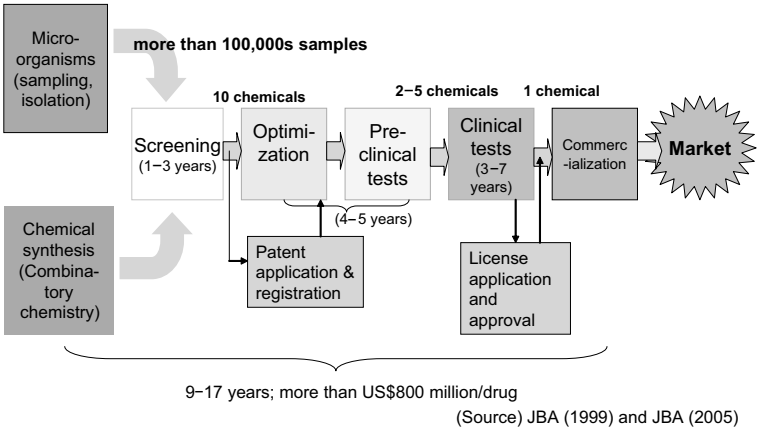

Fig. 2 R&D process for developing new pharmaceuticals

resources used as screening materials for developing new pharmaceuticals was US$1–30/strain, depending on their quality and value-added information attached to the strains.

Expected probability of success (*p*)

The probability of success in developing new pharmaceuticals from microbial resources may depend on their characteristics, diversity, quality, value-added information, etc., and it is very difficult to ascertain its exact range.

There are several reports on the probability of success of biological/chemical resources for new pharmaceutical development, although there is a wide divergence in numbers among those various reports. For example, ten Kate & Laird (1999) quoted the figure of one out of 5,000 to 10,000 chemical compounds.[2] The JBA (1999) reported that the probability of success from microbial samples would be less than 1/100,000s.

Those numbers were obtained from past experience of screening in the pharmaceutical industry, but the future situation is difficult to forecast, since the probability of success by pharmaceutical companies will be influenced by progress in science and technology. Therefore, based on the estimate of the JBA (1999) and the author's interviews with experts on biological screening in the pharmaceutical industry, this study assumed that the expected probability of success from microbial strains would be between 1/100,000 and 1/1,000,000.

Expected pharmaceutical sales (*Si*)

The average annual sales based on 62 major pharmaceutical products offered by the top four pharmaceutical companies in Japan were US$153 million/year/drug in 2003 (Annual reports of Takeda, Sankyo, Yamanouchi & Daiichi, 2003). This study assumed that pharmaceutical R&D would take an average of 15 years, and pharmaceutical sales would start from the 16th year and end in the 28th year based on the assumption that a patent would be filed in the third year and sales would continue until such a patent expired 25 years later (25 years is the maximum patent period for pharmaceuticals, compared with 20 years for other products).

Royalty (*r*)

ten Kate & Laird (1999) reported that the average range of royalties for genetic resources of 'raw' materials or early research was 0.5–2.0% of annual sales. Inquiries with Japanese pharmaceutical companies revealed that the current royalty rate for microbial resources in the pharmaceutical industry is 1% at the maximum. Therefore, this study assumed the royalty rate as 0.5–1.0%.

Discount rate (*d*)

This study assumed the discount rate as 10%.

Based on the above assumption using the model (1) given above, the economic value of microbial resources was estimated to be US$2–60/strain. This value is relatively low compared with microbial

[2] It does not mean that screening 5,000 to 10,000 chemicals will lead to a successful drug development.

strains distributed by culture collections, which are taxonomically identified and have established practical value as reference strains.

DISCUSSION

Resource providers may assert higher economic value of *in situ* microorganisms when they negotiate an ABS agreement with resource users. However, as long as useful characteristics of *in situ* microorganisms and their genetic diversity are not made known to resource users when negotiating an ABS agreement, it will be difficult to resolve the mismatch of expectations, because there are a huge number of undiscovered microorganisms ubiquitously occurring in nature, except for microorganisms living in exceptionally unique environments.

Simpson (1997) argued that pharmaceutical researchers were not willing to pay much to preserve natural habitats even in some regions that are highly imperiled but rich in biodiversity. When the economic value of microorganisms from culture collections was calculated, no value was assumed for an *in situ* microorganism and value was only acquired through the transition from *in situ* to *ex situ* by intensive scientific activities (although accepting that there was always an intrinsic value to *in situ* microorganisms) (the World Federation for Culture Collections, 1998). ten Kate & Laird (1999) reported that a higher royalty rate was applied for genetic resources with more value-added data.

Therefore, more realistic measures for resource providers would include building human and technological capabilities to isolate, preserve and characterize microorganisms (e.g., primary screening, chemical and/or biological analysis) so that resource providers could produce more value-added information on their microbial resources. Joint research on microbial resources with companies of developed countries may be an example of such a measure. For example, the National Center for Genetic Engineering and Biotechnology (BIOTEC) in Thailand has been isolating microorganisms and preserving them in its culture collection, and has been conducting joint research on them with Novartis (drug discovery) and Shiseido (cosmetics research).[3]

For this purpose, non-monetary benefit-sharing[4] should be focused on rather than monetary benefit-sharing in negotiating an ABS agreement in the context of implementing the CBD.

CONCLUSION

The estimation on the economic value of *ex situ* microbial resources collected from natural habitats for screening materials for developing new pharmaceuticals resulted in a relatively low value (US$2–60/strain).

In order for source countries to gain a greater share of the benefits from microbial resources, they should, for example, build human and technological capabilities to isolate, preserve and characterize microorganisms and provide users with more value-added resources. This could be realized through conducting scientific and technological education and training, scientific research, and technology transfer, as provided for in the relevant articles of the CBD. For this purpose, priority should be put on non-monetary benefit-sharing rather than monetary benefit-sharing in negotiating an ABS agreement with resource users in the context of implementing the CBD.

ACKNOWLEDGEMENTS

I am grateful to Drs. Yuko Harayama, Mikihiko Watanabe, Katsumi Isono, Shigeaki Harayama, Katsuhiko Ando, Shinji Miyado and Manabu Suto for their kindness in providing valuable comments and/or suggestions on my draft. I also would like to express my appreciation to anonymous referees for their comments.

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[3] The author's interview with BIOTEC officials.
[4] See the Bonn Guidelines on Access to Genetic Resources and Fair and Equitable Sharing of the Benefits Arising out of their Utilization.
[5] Translated by the author.

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微生物資源の経済価値

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生物多様性が豊かな生態系には，新規の医薬品，化学品等の開発につながる未知の微生物が存在している可能性がある．しかし，このような微生物資源の経済価値の評価方法が確立していないため，1993 年に発効した生物多様性条約（CBD）を実施する文脈において，微生物資源へのアクセスと利益配分に関する合意形成が容易ではない原因の一つとなっている．

本研究では，微生物資源を対象とし，その利用については規模が大きい医薬品の開発に焦点を当て，微生物資源を医薬品探索スクリーニング材料として用いる場合の経済価値の評価を試みた．それによると，製薬企業から得る初期の支払額に医薬品の開発に成功した場合に期待されるロイヤリティ収入を加えた 1 株あたりの微生物の経済価値は，その質と付加情報によるが US$2–60 と算出された．

以上の結果，原産国が微生物資源の利用からより多くの利益配分を得るためには，例えば原産国において微生物資源を解析し付加価値情報を付ける能力を高めることが有効と考えられ，CBD に基づく生物遺伝資源利用者との利益配分の契約においては，これを可能とする能力構築等の非金銭的な利益配分を重視すべきであると結論した．