

**Commissioned Paper for the Human Genetics
Subcommittee of the Bioethics Advisory Committee**

Tissue Banking for Biomedical Research

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This document outlines procedures currently practised in Singapore for collecting and storing human biological materials* (HBM), surveys the range of biomedical research that use such materials and raises problematic areas encountered in tissue banking.

Preamble

Tissue banking as a means of providing material for medical research is not a new activity. The first known repository was initiated in 1847 by the eminent German pathologist Rudolf Virchow, who eventually amassed more than 23,000 human tissue specimens. Concurrent with the development of pathology (especially histopathology) as a specialised discipline essential for the diagnosis and prognosis of a large number of human diseases (principally cancer, inflammatory and degenerative conditions), pathology departments in hospitals and academic medical institutions have come to house large and near-permanent collections of preserved human tissues. Tissue specimens held in such archives, while originally obtained in the context of medical treatment (i.e. for clinical service), are increasingly recognised as invaluable research resources.

Tissue banking as an adjunct to biomedical research was not, until recently, a prominent activity of mainstream medicine but its backwater status has changed radically as human genetic and genomic research have gathered pace. With initial annotations of the draft human genome sequence at hand, it now appears highly probable that the complete but encrypted set of instructions that specify *Homo sapiens* may soon be comprehensible. Genome mapping and sequencing have also spawned technological advances that, for the first time, enable global surveys of genomes, transcripts and proteins as well as large-scale genotyping of individuals (e.g. by single nucleotide polymorphisms). The convergence of genome information with new techniques for high capacity molecular characterization is expected to yield a cornucopia of discoveries. New insights into human health and disease are clearly of keen interest to both academe and industry. These developments have consequently

* The terms 'tissue' and 'tissues' are used interchangeably with 'human biological materials' in this document since solid tissues are the predominant form of collection in tissue banks.

transformed tissue repositories from esoteric academic resources to invaluable materials with clear commercial value for genetic and genomic research. The emergence of commercial entities in recent years that procure and supply human tissues for the biotechnology and pharmaceutical industries is telling evidence, if any was needed, that human tissues have become coveted commodities.

Against the backdrop of recent accelerated landmark achievements in human genome research, a mood of confidence has predictably become pervasive in biomedical research today. Few, if any, research and technological goals in the field are now regarded as completely unattainable. This exhilarating wave of triumphalism is, however, accompanied by an undertow of disquiet that genetics and genomics possess unprecedented power over individual human health and happiness. Resurgent awareness of potential uses and abuses of medical, especially genetic, research has rightly served to focus attention on operational, bioethical and legal aspects of tissue banking – particularly as they pertain to the protection of human research subjects - and of the need to devise principled policies to govern academic-commercial collaborations.

Tissue Holdings in Singapore

Human biological materials used in research may take the form of solid tissues, body fluids (mainly blood and derivatives thereof) or cells. Such materials are harvested in different contexts, for a range of purposes, and are stored and used in variable ways.

Some HBM collections are initiated for the sole intention of providing material for research only. These tend to be collections of fresh frozen tissues (less commonly of cells or blood components) accumulated by particular investigators for specific research projects. Such project-based collections comprise the majority of tissue holdings in Singapore. They are often limited in scope (both in quantity and type of tissue stored) and generally not available to multiple users for other research projects i.e. they are closed ‘private’ collections.

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Multi-user tissue repositories differ from the foregoing in the antecedent intention to develop core research resources that serve, through formal application and oversight procedures, to provide HBM to investigators who may or may not have contributed to the actual process of tissue acquisition i.e. these operate as open 'public' collections, usually with long-term funding. Repositories of this type are uncommon in Singapore although clearly advantageous in accelerating disease-oriented research.

Less well recognised as *de facto* tissue banks are HBM collections, particularly those extant for a decade or longer, that did not originate from planned research efforts but whose continued existence in the genomic era makes them highly tempting to investigators. These are principally large archives of formalin-fixed human tissues stored as paraffin blocks in pathology departments, blood (or blood-derived) samples in blood banks, clinical chemistry and haematology laboratories and other more specialised collections e.g. gamete, cord blood and embryo banks. HBM stored in these locations are nearly always by-products from the provision of a range of clinical services during the course of standard health care i.e. they arose from medical services rather than from primary biomedical research.

Population-based studies such as population genetics, disease registries, clinical genetic services, neonatal and adult disease screening programs may all come to possess large collections of HBM (usually blood) linked to demographic and medical information. Such collections may also function as 'accidental' tissue banks for *post hoc* research objectives. This constitutes secondary use of human tissues. Furthermore, HBM such as lymphocytes obtained from identifiable subjects, families or other groups may be immortalized, thereby generating an unlimited supply of source material that obviates the need to return to the same subjects for more biological material. This has been a technically helpful expedient especially in clinical genetic services and in research on multi-generational families or siblings aimed at the identification of disease-causing genes or the transmission of familial mutations.

Recognising the value of genotypes in the identification of individuals, some countries have developed HBM collections of defence (e.g. military) personnel and of

penal populations. It is a reasonable prediction that such practices are likely to be more widely adopted by many more countries in the near future.

Tissue Banking Procedures in Singapore

A representative overview of tissue banking procedures in Singapore requires a reliable survey of its practitioners. Such information is not available to the author of this document. Nevertheless, tissue banking may be considered broadly as comprising a suite of interlinked processes, some of which are outlined below.

Bioethics procedures

- (a) Obtaining and documenting comprehension and consent of subjects to provide tissue(s), as well as any conditions that may accompany such decisions (e.g. the ability to specify type of research, duration of storage, provision for re-contact and to be informed of results of tissue analysis, family's status regarding disclosure of genetic data, profit sharing, posthumous use), and the benefits and risks of providing tissue for research
- (b) Clarifying 'ownership' of banked tissues and the nature of such tissues e.g. as waste products, outright donations or conditional gifts
- (c) Balancing the relative rights and responsibilities *vis-à-vis* human subjects whose tissues are banked, medical and research personnel who 'add value', the institution that performs tissue banking, governmental and other funding agencies (including commercial backers).
- (d) Rational and consistent application of policies on retaining and using or disposing of tissues harvested without prior documented consent and on the practice of obtaining retrospective consent
- (e) Establishing safeguards against inadvertent and improper disclosure of identifying and/or confidential information when data derived from tissue-based research are deemed to require correlative medical and/or personal data for enhanced interpretation

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Operational aspects

- (f) Harvesting tissues that are surplus to clinical care without compromise to the tissue donor
- (g) Storage of harvested tissues in conditions that are optimal for research
- (h) Developing an inventory system for tracking and retrieval of banked specimens
- (i) Implementing safeguards against physical loss or significant deterioration of tissues and/or associated records
- (j) Quality verification of banked tissues
 - histopathological diagnosis
 - pathogen status
 - integrity of biological macromolecules e.g. nucleic acids and proteins
- (k) Training repository personnel to high standards of safe laboratory practice, awareness of biosafety, meticulous inventory keeping, databasing and appropriate conduct regarding privacy and confidentiality.
- (l) Supporting the tissue bank with a database, having carefully considered:
 - mechanisms to prevent identification of donors to researchers
 - policies and practices that disallow direct access of researchers to donors, donor relatives and their medical/other records
 - defined categories of information to be extracted from the donor's medical/other records for the tissue bank database
 - security measures for controlled access to the tissue bank database
 - policies on sharing tissue bank resources (e.g. tissues, databases, processed experimental data) with academic (not-for-profit) institutions, commercial entities, foreign countries and governmental agencies.
- (m) Consider post-harvest processing for scarce tissues
- (n) Develop safe and acceptable disposal process(es) for culling tissues from the bank

Allocation of HBM resources for research

- (o) Define policies and procedures to evaluate and render decisions on requests from investigators to withdraw tissues from the bank
 - (p) Ensure compliance with conditions for use of banked materials (e.g. acknowledgement of source, indemnification against injury, non-warrantability, presumptions of safe laboratory practice, authorship/collaboration rights, transfer of materials to third parties, commercial use or otherwise)
 - (q) Establish priority of allocation, if necessary, when tissues are limiting
- A general impression of tissue banks in Singapore is that few, if any, operate to the foregoing undemanding standards. A Manual of Standard Operating Procedures of the National Cancer Centre's Tissue Repository is appended as an example of how tissue banking is practised in one institution in Singapore. It details the policies and operational practices of this multi-user resource that was established to facilitate cancer research.

The Case for Informed Choice of Human Subjects

Possibly the most egregious feature of current tissue banking practice in Singapore is common neglect of the informed consent process - not from ignorance but rather from the desire not to inconvenience investigators or impede the pace of research.

Obtaining the consent of human subjects has not always been considered as important as it is today. More stringent standards of conduct have evolved mainly as a consequence of major innovations in genetic and genomic analysis coupled with a perception that genetic information has unique properties not shared by other forms of biological information. In essence, genetic information

- (i) reveals an individual's past and present
- (ii) possibly predicts a person's future
- (iii) is informative of families
- (iv) may be informative of ethnic groups

- (v) is obtainable without consent
- (vi) may be accessible indefinitely
- (vii) has potential commercial value.

These far-reaching implications of engaging in genetic/genomic analysis of human subjects call for substantially higher levels of bioethics sensitivity than is currently prevalent in Singapore. The foundational reasons for operating, whenever feasible, within the bounds of informed choice freely given by competent subjects are:

- (i) respect for individual autonomy, rights and privacy
- (ii) protection of research subjects against exploitation and abuse
- (iii) protection against discrimination
- (iv) protection against stigmatization
- (v) fostering trust and
- (vi) winning public support for biomedical research

By virtue of its personal, familial and societal nature, genetic information is justifiably regarded as being more susceptible to misuse.

Research Involving Human Biological Materials

Although research using human tissues antedates the genome era, recent advances have greatly increased its demand. Research for which HBM is essential may be considered in three partially overlapping domains. (Certain uses have matured into standard methods employed in clinical care.)

Human genetics Diagnosis of genetic diseases through mutation analysis, prenatal diagnosis (including embryos obtained by *in vitro* fertilisation), carrier detection, reproductive counseling, risk assessment (e.g. of cancer, Alzheimer's disease), predicting responses to pharmacological agents (pharmacogenetics) and discovery of disease-causing genes (e.g. by positional analysis) cannot be performed without recourse to human tissues.

Global molecular analyses Techniques for simultaneous analysis of large numbers (typically thousands) of macromolecules e.g. genomic DNA, messenger RNA, proteins and metabolites on relatively small, compact and high density or high throughput physical platforms are increasingly characteristic of technology employed in biomedical research. This feature distinguishes the newly emergent ‘-omic’ disciplines from their precursors e.g. ‘genomics’ and ‘transcriptomics’ from genetics, ‘proteomics’ from protein chemistry and ‘metabolomics’ from classical metabolic studies. Global surveys (or profiling) of cells and tissues are likely to be more effective and efficient at identifying biological networks and circuits than traditional gene-by-gene or protein-by-protein approaches.

A few examples will suffice to illustrate how tissue-based global surveys are poised to expand, deepen and transform current knowledge of human biology. Correct classification of diseases and accurate diagnosis are the foundation of treatment. While disease taxonomy has long relied principally on tissue and cellular morphology, certain clinical observations point persistently to biological heterogeneity within apparently homogeneous categories. Resolution of this conundrum is emerging from the capacity to generate transcript profiles (‘molecular signatures or portraits’) of tissues taken from subjects bearing the same clinical and histopathological diagnosis. That molecular signatures constitute a biologically relevant and robust basis for refining disease taxonomy has already been demonstrated for several human cancers in the past two years – and will undoubtedly be extended to many more disease states. This in turn is likely to lead to new diagnostic methods having superior precision and sensitivity. Refining taxonomy *per se* would not, in itself, be of general interest were it not for the fact that more precise diagnosis has also been shown, for certain diseases, to predict response to treatment and survival to a degree that current taxonomy does not.

Another application of high throughput analytical techniques is the study of genetic and genomic variations (polymorphisms) among individuals of similar ethnicity and between ethnic groups. Intense efforts, particularly by the

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pharmaceutical industry, to map and investigate genetic polymorphisms for possible correlations with phenotypes of interest is premised on the likelihood that some will prove to be predictive of future events e.g. response to environmental and exogenous influences including drugs and disease occurrence, in addition to forming, at least in part, the substrate for behavioural traits and cognitive functions e.g. learning and social skills.

Molecular profiling of tissues under defined conditions is also thought to be a powerful approach to mining the genome for new drug targets against which entirely novel therapeutic agents could be developed. This prospect is especially alluring when the number of current drug targets (fewer than 500 gene products) is far below even the tentative gene content of the human genome (estimated by both major genome groups to be approximately 30,000).

Large-scale genotyping and molecular karyotyping are other variants of the same technological principles that are being applied to dissecting the genetic contributors of complex diseases (e.g. obesity, diabetes, hypertension, asthma, neuropsychiatric disorders and many others) and to delineate detailed pathways of disease causation.

Cell and tissue engineering Although most banked tissues are unviable when withdrawn for use, specialty banks exist for long-term storage of viable cells and embryos. Such banked resources and freshly harvested tissues are used in research aimed at regenerating differentiated cells (with or without additional genetic modifications) having therapeutically desirable properties e.g. neurons, blood-forming cells, insulin-secreting cells, skin, cartilage, that would be useful in cell-based treatment of a wide range of human disorders.

Problems and Issues

Notwithstanding its relatively long history, contemporary tissue banking poses questions and problems that are troubling, contentious, potentially litigious and probably insoluble by imposing universal standards of policy and practice. What

follows is an outline of some of the more pressing dilemmas that the writer has encountered in Singapore.

(a) Informed consent

The most serious and common flaw is the wilful or unintended failure to even consider the need to obtain consent from human subjects before their tissues are banked. The omission is usually justified on the grounds that patients will be 'confused' if consent is sought and/or that obtaining consent is intolerably cumbersome and obstructs research. In certain collections, human subjects are not even informed that their cells will be immortalized, with all the implications thereof. Harvesting tissues from children, mentally impaired (incompetent) and posthumous sources requires special consideration.

Tissue archives that pathology departments retain for many years may raise problems when used for research. Such tissue blocks were nearly always obtained during the course of standard medical care (i.e. they accrued as an integral part of clinical service rather than research), yet often come to be recognised as highly valuable resources for (retrospective) research. The possibility that it might be proper to seek consent before using paraffin-embedded tissues for research seldom surfaces among investigators (perhaps because it is suppressed and ignored), nor is much effort given to devising ethically and socially acceptable alternatives if consent has not been obtained for research use. Similar considerations apply also to research use of blood specimens or blood derivatives that remain from clinical chemistry and blood banking services, or from population studies.

(b) Overreliance on quasi-legal procedures

Informed consent policies that are developed after extensive review of the recent bioethics literature are likely to be excessively reliant on legal procedures for a veneer of propriety. When tissue banks act under compulsion to adopt informed consent practice without a corresponding understanding of

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and commitment to the true purpose of the informed consent process, human subjects remain equally unprotected against exploitation. There is a pressing need for investigators to act on the clear understanding that one of several key elements that should underpin informed choice is information of appropriate quantity and complexity that could be comprehended by subjects from whom tissues are sought. Merely procuring a subject's signature on a consent document unaccompanied by the subject's comprehension of what is being done violates the purpose of seeking informed consent – although it might simulate rectitude. Assessment of how much information should be presented for subjects to sufficiently comprehend what is being asked of them, and thus to enable consent to be freely given or withheld must be firmly emplaced within the cultural, socioeconomic, religious and educational context of particular societies. Too little or too much information militates against understanding. Thus, the manner in which informed consent is obtained may well change with time in societies whose levels of literacy and social development are evolving. An unhelpful opinion especially prevalent among the *literati* holds that policies and practices espoused by North American bioethicists should *de facto* become the 'gold standard' to which tissue banks in all countries must operate or be found wanting. Such an unthinking embrace of standards that even North American tissue banks do not uniformly adopt or practise reflects an unhealthy preoccupation with external appearances of propriety rather than a sincere purpose of protecting human subjects and building public trust in biomedical research.

(c) Disposition of unconsented tissues and the practice of retrospective consent

Careful consideration should be given to deal with the ethical, legal and social impasse when scientifically persuasive reasons are advanced for secondary and retrospective use of HBM collections unconsented for research e.g. tissue blocks in pathology departments, stored blood samples, embryos and progenitor cells. A related question is the propriety (feasibility aside) of seeking retrospective consent.

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(d) Status of banked tissues

It may be helpful for each tissue bank to clarify what it regards to be the status of banked tissues, as this may modulate the approach to informed consent. Surplus tissues that are harvested for research may be considered waste products in which the subject of origin has no interest and perhaps no rights (e.g. placentas). Banked tissues may be considered instead to be outright donations from subjects who, in consenting to donate, also renounce their interests and rights in such materials. An intermediate position regards banked tissues as conditional gifts for which donors may specify terms of use. It would appear that all three designations could be justified and implemented. However, tissue banks rarely articulate the category in which they operate, although widespread neglect of the informed consent process suggests that most have seized the implicit prerogative of treating surplus tissues as waste.

(e) Ensuring uncompromised medical care

Tissues that are banked for research must be surplus to the requirements for making accurate and complete diagnoses. Overzealous harvesting, especially of cancerous tissues, puts the patient at clear risk of incomplete or even wrong diagnosis, leading to sub-optimal treatment or worse, to no treatment if excessive tissue had been removed for research. For example, advanced cancer may be diagnosed wrongly as early cancer, or the diagnosis of cancer may be missed entirely if the cancerous portion of a tissue specimen had been completely removed for research, leaving behind only normal tissue for diagnostic evaluation. There is an urgent need for tissue banks to operate under guidelines to ensure that patients' interests are not made subservient to research.

(f) Quality of banking

Tissue banks have a clear responsibility to operate competently to preserve the physical integrity of stored tissues for biomedical research, if such tissues are not considered waste products but rather donations or gifts from individuals who freely chose to contribute to biomedical research. The corollary of this

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position is that soliciting tissue donations without the operational competence to properly store tissues is unethical.

(g) Assessing research requests

An axiom that remains cogent is that ‘bad science is bad ethics’. Tissue banking is not limited to establishing and maintaining competence of physical operations but should function in tandem with impartial and scientifically credible procedures that evaluate the merit of research projects for which tissues are requested.

(h) Secondary use

HBM that was originally obtained for a specified research purpose may sometimes be useful for other types of research. Whether such secondary use requires fresh consent from the subjects whose tissues/blood are diverted to other research projects is a contentious and unresolved problem.

(i) Ownership

Tissue banks need clear and consistent policies on ownership. Competing claims to partial or complete ownership of HBM emanate from several sources i.e. subjects whose tissues are collected, clinicians who perform tissue harvesting, institutions that provide physical and other support, sources that finance tissue banks, investigators and others who add value to the tissue collection. The question of ownership applies not only to the physical forms of HBM but equally to derivatives - whether in the form of data, discoveries or biological products.

(j) Confidentiality and privacy

It is generally agreed that permanently and completely unidentifiable HBM is of limited research value. Such material could be used in prevalence studies but little else. HBM released to investigators should not bear any information that could identify the subject from which it was obtained but could be linked, with appropriate safeguards, to clinical (though not personal) information about the subject that may be relevant to the research objective(s) and that would enhance interpretation of research data.

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Tissue banking operations therefore frequently encompass databases of varying depth and quality to provide regulated access to linked information of correlative value. Biomedical communities that are new to tissue banking are often uninformed of the need to protect the confidentiality and privacy of medical and personal information. Moreover, little consideration is given to how access to medical records could be allowed, if at all, to individuals outside the clinical care team. At an even more rudimentary level, HBM may not always be provided in coded manner to investigators. The assignment of a unique National Registration Identification (NRIC) number to each Singapore citizen and permanent resident and its ubiquitous use makes this single identifier a key that could turn many locks in national and institutional databases.

(k) A dichotomy of standards

While the power of genetic information has rapidly come to be appreciated by societies at large, it is also narrowly perceived that only analyses involving nucleic acids (i.e. DNA and RNA) yield genetic information. The fact that superficially ‘non-genetic’ analyses e.g. of proteins, hormones, metabolites, and even radiologic imaging may, in certain situations, be equally informative as genotyping appears to have escaped many. This may explain the invidious tendency to handle what is wrongly perceived to be ‘non-genetic’ medical information with much less care and attention to bioethics concerns than overtly ‘genetic’ information. This common and unacknowledged dichotomy of standards is not only irrational but, given the relatively large corpus of medical information not derived from DNA and/or RNA analysis, continues to place numerous human subjects at risk of breached confidentiality and privacy.

(l) Disclosure of data and re-contact

Tissue banks differ significantly in their policies on whether results from tissue or blood analysis, especially if considered to have potential medical implications, are disclosed to the subject and/or relatives. Some offer subjects

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the choice of receiving information about analysis of their tissues/blood.

Other operations do not disclose such information on the grounds that observations gleaned in a research project are of uncertain clinical significance until reproduced and rigorously validated by other investigators. A related issue arises when re-testing is judged to be in the subject's interest for clinical management. In such instances, re-testing should optimally be performed in a facility accredited for provision of clinical laboratory service.

(m) Commercial access to tissues and data; sharing profits and benefits

Keen and aggressive commercial interest in human tissues, medical information and data derived therefrom is a development whose ramifications are as inescapable as they will be enduring. The large financial investments required to develop new pharmaceutical agents, diagnostic tests, novel treatments and devices for clinical use compel collaboration of not-for-profit research institutions with the biotechnology and pharmaceutical industries. This economic reality of medical progress urges reflection on how research integrity and just treatment of human subjects can be upheld when conjoined with overtly commercial interests. The manner in which profits and/or benefits reach individuals and communities should garner public support by winning society's trust. Points to consider in this regard are informing patients in advance of possible commercial interest in and exploitation of research performed on HBM, whether profits will be shared with patients, and how material and non-material benefits of applied research might reach the community.

Recommended Policies

1. Increase awareness and practice of bioethical tissue banking

Prevailing awareness of bioethics among biomedical researchers in Singapore is disturbingly low and not consonant with Singapore's aspiration to excel in medical care and research. Clinical and other investigators need to become far more knowledgeable about bioethics of the genome era, to be aware of clearly

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proscribed actions and controversial issues.

2. Encourage basic standards for all tissue banks

All tissue collections in Singapore should be urged to function to basic standards of bioethics and operational competence. Departments and institutions that possess service collections of tissues, blood and other HBM should use (or allow the use) of such materials for retrospective research only with rigorous ethics oversight and approval.

3. Mandate involvement of pathologists in tissue banking

Tissue harvesting, particularly of surgically excised and biopsied samples, should always be performed under the guidance of trained surgical pathologists. This optimizes harvesting of surplus tissues for research while ensuring that complete and correct diagnosis is not compromised. Operating in an adversarial relationship between tissue bankers and pathologists is liable to undermine the reputation of tissue banking and expose clinicians to medico-legal risks.

4. Tissue audits

Regular audits of tissues that were also harvested for banking could be performed to ascertain the frequency, if at all, of compromised tissue evaluation and diagnosis by inappropriate harvesting.

5. Develop institutional standards of basic tissue banking procedures

Academic and medical centres that engage in tissue banking could be encouraged to accelerate development of acceptable standards by providing their faculty/staff with standard institutional procedures that meet basic standards of tissue banking. The availability of such 'template' operational procedures could be modified for specific purposes but would nonetheless be time-saving for individual efforts.

6. Train tissue bankers

There is a dearth of structured training for personnel at all levels who are employed to bank tissues for research. That tissue banking is still a relatively

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small activity makes formal training courses even rarer. Nonetheless, some effort should be made to identify training courses in better developed countries or to consider initiating some form of regional training.

7. Develop appropriate informed consent

Deliberately collecting tissues from human subjects without their prior informed consent would be regarded, by current standards, to be akin to rogue behaviour. There is a pressing need in Singapore to develop contextually appropriate processes for research subjects to make informed choices without adopting *en masse* practices espoused in more litigious and literate societies that are likely to seriously impede research (and all the societal benefits that derive therefrom), while not concurrently affording real protection to research subjects in Singapore. In this regard, North American hegemony in the bioethics literature badly needs to be balanced by bioethics models from other cultures and societies. The establishment of an Asian Centre for Bioethics could well be valuable in bringing other views to bear on this growing field.

8. Records and audit of informed consent

Tissue banks could be encouraged to retain documentation of the informed consent of all research subjects and to perform periodic audits to ascertain compliance with and quality of the informed consent process as practised in their host institution.

9. Resolving the dilemma of unconsented HBM

Notwithstanding the problems presented by retrospective use of HBM that were collected when bioethics standards were far less stringent, it may still be possible to develop acceptable mechanisms and safeguards to enable release of these valuable resources for research. A multidisciplinary coalition, including lay representation, could be entrusted to examine the issues and propose recommendations.

10. Security of medical and other information

More carefully regulated access to medical records and clinical databases is needed. It is at present neither difficult nor unusual for individuals outside the

clinical care team to obtain such records and information. Chart reviews have been assigned to individuals who may not be fully cognizant of the need to maintain confidentiality.

Conclusion: Achieving Balance

The landscape of biomedical research has changed irrevocably and the genomic sciences have thrown up new issues in bioethics that cannot be ignored. The way forward is neither through overprotection of research subjects nor overprotection of research interests, whether academic or commercial. Asian biomedical research centres need to develop confidence to work out the dilemmas presented by the genomic sciences in their own cultures, and to develop codes of conduct that uphold the protection of individuals while not denying society the benefits of research.

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Privacy of medical records

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30. Roche PA & Annas GJ. Protecting genetic privacy. Nat Rev Genet 2: 392-396 (2001).

Commercialization and benefit-sharing

31. Gray N, Womack C & Jack SJ. Supplying commercial biomedical companies from a human tissue bank in an NHS hospital – a view from personal experience. J Clin Pathol 52: 254-256 (1999).
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36. Chadwick R & Berg K. Solidarity and equity: new ethical frameworks for genetic databases. Nat Rev Genet 2: 318-321 (2001)

Useful web resources

37. National Human Genome Research Institute (USA)
<http://www.nhgri.nih.gov/ELSI/>
38. National Bioethics Advisory Commission (USA) Publications and Reports
<http://bioethics.georgetown.edu/nbac/pubs.html>
39. National Reference Center for Bioethics Literature, Georgetown University (USA)
<http://www.georgetown.edu/research/nrcbl/>
40. University of Montreal, Canada
GenConnect is a compendium of more than 300 governmental and non-governmental organizations formulating policies
<http://www.humgen.umontreal.ca/en/>

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41. Nuffield Council on Bioethics (UK) – publication on ‘Human Tissues: Ethical and Legal Issues’
<http://www.nuffieldfoundation.org/bioethics/publication/pub0000000308.html>
42. Karolinska Institutet Library (Sweden) – Ethics in Biomedicine
A compilation of links to other web resources
<http://www.mic.ki.se/Diseases/k1.316.html>