We were fortunate to be able to work together (NUS_Singapore_Sci & EPFL) to gain insights on the institutions and regulations present in Singapore and Switzerland involving genetic manipulation research, and at the same time to be able to understand another system. Thus, this literature review assesses the future legislative issues of international collaborative work that we should address for the future implementation of our projects. Here we present with joy our work, which, while it can be improved and enriched, nevertheless represents the first overview of a comparative study between our two countries on this subject.

1. Structure of our countries

1. Administrative structure (regional/national)

La Suisse possède 3 niveaux de politique : la Confédération (national), les Cantons (régional) et les Communes (villes). La Confédération regroupe le 26 cantons formant notre état, et possède un conseil, une assemblée et une cour fédérale qui assurent le pouvoir législatif, exécutif et judiciaire. Des institutions donnes des lignes directrices et définissent les lois pour les cantons, qui peuvent ensuite apporter des retouches lors de leur application, laissant ainsi une certaine marge de manoeuvre. Le conseil fédéral coordonne les procédures entre le niveau cantonale et fédéral. Deux comités épaulent la Confédéral dans ses décisions scientifiques : le comité d'expert, formulant les recommandations quant à la sécurité liée aux biotechnologies, et le comité d'Éthique pour le biotechnologies dans le domaine non-humain, chargé de définir les aspects éthiques à suivre dans la science et leur implications sociales. La variété d'opinion représentées garantit son objectivité. Des deux comités réfère au conseil fédéral de leur débats.

It is interesting to note that in Singapore, the ethical side is represented by a unique committee, called the **Bioethics Advisory Committee (BAC)**. It gives input and opinions on the matter with the **ultimate decision lying in the hands of the government**. This also requires the input of locals as well as the research and feedback usually collected by BAC. There are **no formal legislation to govern bioethics**. Instead, this comes in the form of guidelines that act as a moral guiding compass for all applications related to genetic engineering.

Singapore and Switzerland have **different administrative structures.** Singapore works with **guidelines**, which anchors on the concept of trust in each citizen to make their own decisions, with regulatory boards established to advice. Switzerland, on the other hand, has **official laws**, with different applications according to canton, but still clearly defined.

2. Religion

Singapore is a multicultural country, with diverse cultures and opinions, such as the roots of Confucius. The integration of culture plays an important role in policy making. There is a general legal "light touch" to Singapore's research practices, which is partly attributable to its emphasis on community harmony and cooperation, as opposed to the West's emphasis on individual rights. Before formalizing the guidelines, there will be **mandatory consultations with representatives of**

different religions. This helps the system to enable research when it instills the ideals that biomedical research is for the common good. This is very **different from Switzerland, where the state is neutral and has no official relationship with religious institutions.** However, due to religion playing a large role in the history of Switzerland, some churches are, according to cantonal choices, recognized as a Rights Corporation and can therefore have easier access to institutions such as schools and prisons. However, this does not give them an official status in decision-making in the state, and their influence in decision-making is more towards informing their community, especially on ethical issues.

Singapore therefore does not have a platform to listen to its religious communities in a more public manner as they are mainly done in private, while they take a more prominent place in public debates in Switzerland. The **code of ethics that motivates Institutional Biosafety Committee (IBC) in Singapore is conventional by international standards**, including the **acceptance of principles such as beneficence, autonomy, justice, sustainability and reciprocity.** The **IBC is consequentialist, by necessity**, because of Singapore's "position as a multi-religious and multicultural society". Its pragmatic approach to politics also stems from the survival instinct of a small nation competing in an international economy, its size being six times smaller than that of Switzerland. This is one of the reasons for the political and institutional divergence between the two countries.

II. Important Committees

As opposed to **Switzerland's legislation bodies** mentioned previously, Singapore has various **committees that share guidelines with the government** bodies.

In Singapore, the Bioethics Advisory Committee (BAC) and Genetic Modification Advisory Committee (GMAC) are key non-regulatory advisory committees, **without legal identity** or statutory powers. Although Singapore does not have legally-binding clauses specific for the regulation of genetic engineering, there is a **joint-effort by multiple regulatory agencies** to **implement these guidelines**.

BAC is made up of **professionals from different entities**, for example, lawyers, medical boards, research institutes and religious councils. The purpose of BAC is to **examine legal, ethical and social issues** that arise from research on human biology. BAC also examines the **behaviour of the people and suitability of the policies,** so as to develop and recommend policies on legal, ethical and social issues. The council aims to protect the rights and welfare of individuals, while not compromising on biomedical Science advancements so as as to reap more beneficial research for the society. BAC makes **scientific and ethical recommendations to the Singapore Government**. Thereafter, they actively gather opinions from international and local community to evaluate the guidelines proposed and adopt them to suit the local context.

GMAC is a committee that specially handles Genetically Modified Organisms (GMOs). They **advise and recommend for approval the research, development, use and handling of GMOs**. Also, they practice environmental protection by monitoring the control of release of GMOs. Furthermore, they carry out public engagement to inform the public planned release of GMOs and raise awareness on GMO-related issues.

1. **Genetic engineering**
    1. **Use**

In both our countries, the use of genetic manipulation must **under no circumstances constitute a danger to humans, animals or plants.** It must respect biodiversity, ecosystems and protected organisms, and must not represent any risk of extinction of species and long-term disruption of an environmental balance (soil in particular). **A rigorous assessment of the possible risks and side effects of a new technique is also required** to assess the impact on the surrounding ecosystem.

In Switzerland, the **principle of confinement for research must be respected** in order to avoid uncontrolled spread. In Singapore, the guideline on the safe import, release and use of animals (fish/invertebrates), plants, microorganisms and vaccines used in cultivation, breeding, etc. was defined in 1999, and it helps to **assess the risks of these GMOs to humans and to the environment**. This is done to maintain a standard approval mechanism for the release of these GMOs. The same applies to Switzerland, where the **spread is strictly regulated through a law** [814.91], particularly with regards to antibiotic resistance in humans and animals.

In addition, **in Switzerland, the duties of scientists and industrialists handling GMOs are clearly defined.** Examples include the obligation to inform the buyer of the key concerns for the protection of humans, animals and the environment of the product of interest. Another example is the strict adherence to the sorting of GMO and non-GMO elements, both in transport and in waste. Also, the nature of GMOs must be clearly mentioned when they are released on shelves to guarantee free consumer choice and prevent fraud of products. The Federal Council sets the threshold (for mixtures/containers) above which the mention of the nature of GMOs is mandatory, regardless of the concerns of the importer or manufacturer.

In addition, the import or possession of GMOs, unrelated to human health, is regulated by section 9 of the Animal and Birds Act (Chapter 7) and Part IV of the Vector and Pesticide Control Act (Chapter 59). The import or supply of biological agents and specific toxins that may cause death, disease or dysfunction in humans, such as those specified in the first, second, fourth and fifth schedules, is regulated by the Law on Biological Agents and Toxins (Law 36 of 2005).

Our two countries therefore have an **almost similar policy on the protection of the environment, humans and animals with regard to the risk of spread and research on genome modification, with differences being in the actual "guidelines" and laws.**

As for the biological information policy **in Singapore, GMAC maintains the confidentiality of information that the sponsor requires to be kept confidential.** It is the responsibility of the promoter to patent intellectual property protection. The sponsor is responsible for meeting the GMAC safety requirements and must continuously collect data for post-release monitoring. They must assess any potential risks from the time of the release of the GMOs. In Switzerland, after consultation with stakeholders, **a publication by the authorities of the acquired information (recordings/controls) is allowed if it is of general interest,** and communication abroad is also authorised with the information kept confidential from the public. **The two policies are therefore also similar in that they both aim to protect professional secrecy and intellectual property.**

b. Research (respect of integrity)

In Switzerland, it is an obligation to respect the integrity (wholeness) of the living being: **respect in the modification of the genetic heritage**. For example, there should be no serious damage to the characteristic properties, functions or morals of a species if the objectives are not justified and predominant. The **degrees of damage caused to animals and plants are assessed according to a series of guidelines** deemed worth of protection: human and animal health, reduction of environmental damage, conservation and improvement of ecological conditions, important economic, social and ecological benefits to society, improvement of knowledge. A public inquiry is conducted within 30 days of the request for authorization. Appeals [not by persons of adequate status - Federal Law of 20 December 1968] to the authority issuing the authorisation is possible. It is important to note that any person who has not expressed an objection is excluded from the rest of the procedure. Also, **regular re-evaluation of hazards is available**.

The same is true in Singapore, where **animal testing is also very controlled**. AVA (Agri-Food and Veterinary Authority) has established guidelines for the care and use of animals for scientific purposes to **promote humane and responsible animal care and use**. In line with the principles of **Replacement** (by other models, such as mathematical models and in vitro statistics), **Reduction and Refinement** in the care and use of animals for scientific purposes, this policy, also shared by Switzerland, has **led to a considerable reduction in animal model tests in recent years**.

The National Advisory Committee For Laboratory Animal Research (NACLAR) has also developed **a set of guidelines in Singapore on the** care and use of animals for scientific purposes, drawing inspiration from other countries, including Australia and the USA. For example, the use in education, field tests, product tests are covered, as well as the responsibility of institutions and researchers, staff and other persons involved in the care and use of animals.

In Switzerland, an exemption from authorisation procedures is possible in cases where recent work or expert opinions show that the process does not endanger man and his environment and that it has scientific/therapeutic/detection purposes. In addition, if the institute or company is not subject to the authorisation system, it must "self-check" while remaining controlled by the Federal Council.

The policies of our two countries therefore meet in respect for the integrity of the organizations used, both aimed at maximum protection while allowing for the improvement of the common good. Of course, the compromises made then depend on the context, and the research topics precisely addressed, between the two countries but also within both countries.

c.Responsibility

In **Switzerland, the responsibility is largely assumed by the person who obtained the authorization.** If damage is caused to users after the authorised release of GMOs, the holder of the authorisation shall be the only person liable for it if these organisms are contained in or derived from agricultural or forestry means of production and defective. It also responds to the lack of scientific and technical knowledge that did not allow this problem to be detected at the time of dissemination. Any **person held liable must then bear the costs of restoring the elements of the original environment**. In the event that these elements do not have a precise legal status, it is the responsibility of the local authorities to do so, and proof of the problem is provided by the person claiming compensation.

On the other hand, **in Singapore, each institution or company must set up an IPC to monitor and supervise genetic manipulation work.** IBC will evaluate proposals, conduct a risk assessment to categorize risk levels and advise on risk management protocols. In addition, they will ensure the qualification of members and the adequacy of containment facilities. However, unlike Switzerland, **Singapore does not have specific legislation to regulate genetically modified technology and products.** The GMAC is a non-regulatory advisory committee that provides **non-legally binding guidelines**. These guidelines are implemented and monitored by the competent authorities.

Responsibility is therefore more clearly defined and standardized in Switzerland than in Singapore, where it depends on the framework and institution in which the scientific experiments and studies were conducted.

B. RISKS OF SPREAD (Distribution)

a. Official transportation/distribution laws

Both countries have **guidelines/laws governing distribution**, however the extent of coverage for GMO-related applications have different focuses.

In Switzerland, the Federal Council established the Ordinance on the Transboundary Movement of GMOs. Under the duty of care, any party that exports or imports GMOs or are responsible for their transit, must ensure that their **handling, packaging, labelling and transportation takes account of national and international norms**. This includes but is not limited to, a clear indication of the identity of GMOs, clear instructions on safe handling, storage and transport. Furthermore, there is also a need for **caution on the production pipelines, to ensure products are GMO-free**. This ensures there is **no infringement of free choice of individual consumption**. Currently, production and release of GMOs are authorized only for therapeutic, scientific, medical and veterinary diagnostic purposes.

Different from Switzerland, Singapore **does not have federal rules but instead guidelines** that serve the same function. GMAC released Singapore Biosafety Guidelines for Research on GMOs in 2006 to **ensure the safe containment, handling and transportation of GMOs** (microorganisms, animals, arthropods, plants). This is the only biosafety standards for GM-related laboratories. All proposed work have to be approved by the Institutional Biosafety committee (IBC) of the investigator before seeking approval by the GMAC. Transport of GMOs have to **pose minimal risk to the society by the usage of sealed and proper packaging, as well as labelling of relevant biohazard symbols**. Complete documentation is required for all transports. The receiving storage facility has to be able to contain GMOs of equal risk levels. On the topic of distribution, Singapore has extended guidelines for release of Agriculture-related GMOs but not for other purposes. There is **more focus on the safety of distribution of GMO products into the commercial market**.

b. Mitigation of Risks

Both countries have an extensive process for risk assessment to identify potential risks arising from GMOs, monitor and manage these safety issues.

In **Switzerland, third parties have no right to release GMOs into the environment or to conduct experiments related to GMOs.** The containment measures have to comply to the ratification of the Federal Council, based on hearing experts, financial coverage of the measures necessary to identify and prevent potential hazards, management of risks and information to the public. In addition, there is an **obligation to implement an environmental monitoring system** to detect potential negative effects of GMOs on the environment and biological diversity. This is accompanied with an **impact study** to gauge the impact of GMOs implement the necessary environmental protection measures to reduce or prevent the negative impact. Results from this study will be communicated to the public.

In Singapore, we do not have our own national legislation, instead we **share a common framework with other ASEAN countries on ensuring risk assessment associated to transboundary movements of agriculture-related GMOs for the environment.** The GMO release party will have to go through a panel of scientific experts to evaluate potential risks at any stage of release, and then evaluated based on the **concept of substantial equivalence** (assessing the safety of GM food by comparing with similar traditional food that has been proven

safe). The IBC for the institute in charge of the GMO is responsible for reviewing and controlling the proposed GMO-related activity to mitigate risks.

C. Genetic Testing

Genetic testing is the usage of tests for the **purpose of diagnosis, carrier testing and genetic screening**.

1. Respect for the welfare, safety, religious and cultural perspectives and traditions of individuals

All patients should be **well-informed of the possibility of their information being used for research**. Due to the multi-racial and multi-religious nature of Singapore, respect and sensitivity essential. Certain cultures may not be open to having certain diseases, it is the responsibility of the person handling the information to respect these cultures and not communicate confidential information that might be used for research purposes. not communicate the disease to any individuals.

2. Free and informed consent

Both countries need to **follow guidelines for the use of patient information**. In Switzerland, **swissethics** is a set guidelines that is followed for its consideration for use in any research project. Some components taken into consideration include: medical risks and the benefits of the public. There will be a need to understand how much of the patient data is required for the research; **longer and shorter processing time corresponds to the risk of the project**. For example, longer time is required if the research involves major alterations that may interfere with the participant's daily activity.

Unlike Switzerland, there is **no definite agency or body that the research group needs to get past to be able to carry out their research in Singapore**. There is a need for the participants who are sharing their information or undergoing any research to be fully informed by the research group and for them to make an informed decision on any research or test screenings they are participating in. However, it is important to note that though there are **guidelines protecting the rights of the individuals, there are also exceptions to permissions given**.

3. Respect for vulnerable persons

Both countries are similar in their guidelines for **vulnerable individuals, such as children, adolescents and the mentally impaire**d. These individuals may **need the consent of their parents/guardian** when making decisions and it should be taken note that there are no definitive ages at which parental/guardian intervention should extend till it is mainly attributed to a case-by-case basis, and this shows the **flexibility of the guideline** when there is a grey area in collecting consent in participants in both countries.

4. Privacy and confidentiality

Switzerland and Singapore has general laws that state any medical records are considered strictly confidential with the genetic information obtained to be treated with utmost confidentiality like regular medical records. These information obtained during patient management is solely used during the treatment of the patient. Exceptions are present when the results of the treatment or any information from patient are able to benefit any additional parties in the community. In such cases, patient consent in overwritten.

D. Data Management

1. Nagoya Ordinance

Data management in Switzerland follows a policy of **due diligence**. The user of the data must, amongst other roles, record, store and transmit the following information: internationally recognised certificate of conformity (and right of use and transmission) and, in the absence of a certificate: name/address of the user, description of the genetic resource, its use, date of access to the resource, source, name/address of the person from whom the data were acquired, if the same is transmitted, certificate of knowledge (prior consent).All such information must be kept for ten years from the end of the use and as long as the genetic resource or product based on the use of a genetic resource is preserved; on request, it may be made available to the enforcement authorities.However, in an internationally or nationally recognized emergency situation threatening human, animal or plant health or the environment, it is sufficient, in the case of the use of genetic resources that constitute pathogenic or harmful organisms, that the duty of care is fully respected when marketing products whose development is based on the use of such genetic resources. The use of the data and its type must also be mentioned in marketing procedures.

Singapore, for its part, adopted the **Personal Data Protection Act** in 2012. An organization that collects and depersonalizes personal data for processing and storage purposes is always considered to hold personal data if it retains the ability to re-identify them. Thus, when re-identifying reversibly depersonalized data, the key management of any code or encryption can and should generally be separated from the data management.

Our two countries are therefore aware of the importance of data and the critical position they hold in individual and collective security.

b. Access to genetic resources

While Singapore and Switzerland are both putting in place guidelines for secure usage of information from the public, it can be agreed upon that both countries agreed that the **general rule of having to gather consent for the usage of personal information, albeit protects the rights of individuals, limit public health research and brings about more need for additional**

actions when using. However, disclosure of information is prevented by a personal information protection regime.

Singapore's **public awareness of personal information used in biomedical research is low**. In Switzerland, some individuals are trying to move towards a **more open concept of voluntary sharing of records**. Switzerland is effective in creating a system where users should record where they use their data, such as the address and description of the resource. The Federal Office of the environment, FOEN, an organisation in Switzerland, aids in the access for and sharing of information that is compliant to the duty of care, with an agreement that whatever information used in the research needs to be told to FOEN.

In conclusion, even though **both countries are scientifically advanced**, there exist **prominent differences in our administrative structures** and the **extent of control over GM-related technology**. However, we reconcile our differences and appreciate that fundamentally, both countries places utmost importance in the various aspects of GM-technology, from use, research, distribution to data management. The **differences can be accounted to the need to contextualize laws to the local context and the alignment to the regional intergovernmental associations.** Through this case-study done across Singapore and Switzerland, we have **definitely gained valuable insights**. It was interesting to work closely to **consider the perspectives from another country** and we are certainly **grateful for iGEM to be a platform for such intellectual exchange**.

- https://www.bafu.admin.ch/bafu/fr/home/themes/biotechnologie/droit/lois-ordonnances.html
- https://www.admin.ch/opc/fr/classified-compilation/19996136/index.html
- https://fr.wikipedia.org/wiki/Politique_en_Suisse
- http://www.migraweb.ch/themen/religion/staat-und-religion/
- http://www.ekr.admin.ch/pdf/staat_religion_gesamt_def-f30ef.pdf
- https://www.swissethics.ch/doc/leitfaden_pos/Bedenkzeit_final_f.pdf