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Schweizerischer Wissenschaftsrat SWR

Wirkungsprüfung des nationalen Förderprogramms SystemsX.ch

Bericht und Empfehlungen des Schweizerischen Wissenschaftsrates SWR
im Auftrag des Staatssekretariats für Bildung, Forschung und Innovation SBFI

Vom SWR verabschiedet am 5. Februar 2018 (rev. 3. September 2018)

INHALT

Executive Summary

Das Staatssekretariat für Bildung, Forschung und Innovation (SBFI) beauftragte den Schweizerischen Wissenschaftsrat (SWR) im September 2016 mit der Wirkungsprüfung von SystemsX.ch, dem Sonderprogramm zur Förderung der Systembiologie in der Schweiz, das der Bund 2008 bis 2016 mit 220 Mio. CHF unterstützte. Teil des Auftrags war es auch, die Auswirkungen des Programms Nano-Tera.ch zu untersuchen. Dieses wurde separat behandelt, der Schlussbericht ist auf der Webseite des SWR verfügbar.

Zur Wirkungsprüfung gehören gemäss Mandat eine Selbstevaluation durch das SystemsX.ch-Konsortium sowie eine Bewertung durch externe Experten. Als zentrale Wirkungsdimensionen bestimmte das SBFI die strukturelle Auswirkung auf die Partnerinstitutionen von SystemsX.ch, die interdisziplinäre und interinstitutionelle Zusammenarbeit, die Nachwuchsförderung und die wissenschaftliche Exzellenz. Der SWR ergänzte die Untersuchung der Wirkungsdimensionen mit einer systemischen Analyse. Die Selbstevaluation von SystemsX.ch, die Bewertung des Expertenpanels sowie eine vom SWR extern in Auftrag gegebene Analyse zur Dateninfrastruktur flossen in die Beurteilung des SWR mit ein; sie sind dem Bericht zusammen mit weiteren Dokumenten als Anhang beigefügt.

Der SWR kommt zum Schluss, dass die Förderung von SystemsX.ch zu qualitativ hochstehenden Forschungsergebnissen führte. Der Rat ist überzeugt, dass die Forschenden mit der aus der SystemsX.ch-Sonderförderung resultierten Forschung die Bekanntheit und die internationale Wettbewerbsfähigkeit der systembiologischen Forschungsgemeinschaft erheblich steigerten. Schweizer Forschende aus verschiedenen Institutionen sind heute an der Weltspitze mit dabei, was sich insgesamt positiv auf die Positionierung des schweizerischen BFI-Systems im Ausland auswirkt.

Gemäss dem internationalen Expertenpanel war SystemsX.ch für die rasche Etablierung der Systembiologie in der Schweiz bahnbrechend. Schweizer Akteure betonen die Wichtigkeit der zusätzlichen Fördermittel als Beschleuniger. Die fokussierte Sonderfinanzierung sei ein zentraler Faktor gewesen, lautet die übereinstimmende Einschätzung der Fachleute.

SystemsX.ch initiierte und förderte die interdisziplinäre und interinstitutionelle Zusammenarbeit; diese war von Beginn weg in den Ausschreibungen für die RTD-Forschungsprojekte (Research, Technology and Development) eingefordert worden. Nach Abschluss des Programmes sind ausserdem systembiologische Perspektiven in die Ausbildung integriert. Diese Auswirkungen lassen sich als nachhaltige Effekte von SystemsX.ch bezeichnen, wohingegen sich zum Zeitpunkt der Wirkungsprüfung, kurz nach Abschluss des Programms, die Langzeitwirkungen von SystemsX.ch-Kooperationen zwischen den Partnerinstitutionen sowie Änderungen bei der Förderung der interdisziplinären Karrierewege für junge Forschende nicht beurteilen lassen.

Weniger überzeugt haben den Rat der Einbezug der Wirtschaft; das Programm wie auch die meisten Fördergefässe (mit Ausnahme der Transfer Projects) verfügten über wenig konkrete, an die einzelnen Projekte angepasste Strategien für einen Wissens- und Technologietransfer.

Die epistemologische Neuorientierung der Forschung und somit das Ziel der Systembiologie, ein integrales und umfassendes Verständnis des quantitativen Verhaltens von biologischen Systemen zu erlangen, wurde aus der Sicht des Rates nur teilweise erreicht. SystemsX.ch hätte den Fokus stärker auf die quantitative Modellierung und auf datenzentrierte Analysen richten sollen.

SystemsX.ch zeitigte in den Partnerinstitutionen unterschiedliche strukturelle Veränderungen. Gemeinsame Strategien zur Umsetzung und zum Aufbau der dazu notwendigen Forschungsgruppen, Professuren und auch technologischen Infrastrukturen fehlten weitgehend. Diese Resultate sind für den SWR mit dem Entstehungsprozess und der Governance des Programms verknüpft. In diesem Sinn schöpfte SystemsX.ch sein gesamtschweizerisches Potenzial nicht vollumfänglich aus.

Aufgrund dieser Ergebnisse empfiehlt der SWR dem SBFI erstens, dass künftig explizit festgehalten wird, was ein gesamtschweizerisches Forschungsförderungsprogramm wie SystemsX.ch erreichen soll. Dabei ist sowohl die notwendige Infrastrukturentwicklung mit zu bedenken als auch, ob genügend qualifizierte Forschende in den gewünschten Disziplinen mobilisiert werden können.

Zweitens ist der Rat der Meinung, dass „nationale Förderinitiativen im Bereich von Forschung und Innovation“ im Sinne von Art. 41 Abs. 5 des Bundesgesetzes über die Förderung der Forschung und der Innovation[1] sehr selten bleiben sollten. Zudem ist es für die langfristige internationale Wettbewerbsfähigkeit das Beste, wenn die Auswahl wissenschaftliche, aber auch nationale Gegebenheiten berücksichtigt, insbesondere durch die Identifizierung strategischer Nischen. Das Auswahlverfahren für eine nationale Förderinitiative sollte systematisch alle BFI-Akteure konsultieren; ausserdem sollte der Mehrwert der Initiative sowie des Verhältnisses zu und der Auswirkungen auf die gängige Forschungs- und Innovationsförderung geklärt werden. Es müsste eine transparente Organisation mit klaren Entscheidungsstrukturen etabliert werden, die sowohl die nationale Orientierung als auch die Bedürfnisse der Forschenden und Innovierenden vertritt. Falls Public Private Partnerships angestrebt werden, ist eine Strategie unter Einbezug der Wirtschaft zu erarbeiten, zum Beispiel mit der Unterstützung eines wissenschaftlich-wirtschaftlichen Beirats. Das Monitoring müsste den Standards der etablierten Förderinstitutionen entsprechen.

Abschliessend empfiehlt der SWR zu prüfen, inwieweit die aktuellen Gesetzesbestimmungen (Art. 41 Abs. 5+6 FIFG) die Einhaltung klarer Grundsätze betreffend Formulierung, Wahl und interner Organisation der zu diesem Zweck finanzierten Initiativen sicherstellen.

[1] Bundesgesetz vom 14. Dezember 2012 über die Förderung der Forschung und der Innovation (FIFG), SR 420.1, in Kraft getreten am 1. Januar 2014.

Résumé

En septembre 2016, le Secrétariat d'Etat à la formation, à la recherche et à l'innovation (SEFRI) a mandaté le Conseil suisse de la science (CSS) de procéder à une appréciation de l'impact de SystemsX.ch, le programme spécial pour l'encouragement de la biologie des systèmes, que la Confédération a soutenu de 2008 à 2016 à hauteur de 220 millions de francs. Le mandat comportait également un volet consacré à l'appréciation des effets du programme Nano-Tera.ch, qui a été traité séparément; le rapport final est disponible sur le site internet du CSS.

Conformément au mandat, l'appréciation de l'impact se compose d'une auto-évaluation effectuée par le consortium SystemsX.ch ainsi que d'une appréciation par un groupe d'experts externes. Le SEFRI a déterminé les principales dimensions fondamentales sous revue, à savoir: l'impact structurel sur les institutions partenaires de SystemsX.ch, la coopération interdisciplinaire et interinstitutionnelle, l'encouragement de la relève et l'excellence scientifique. Le CSS a complété l'étude de ces dimensions fondamentales par une analyse systémique. L'auto-évaluation de SystemsX.ch, l'appréciation par le groupe d'experts ainsi qu'une analyse de l'infrastructure de données, confiée par le CSS à un mandataire externe, ont nourri l'appréciation du CSS; ces éléments figurent, avec d'autres documents, en annexe du rapport.

Pour le CSS, l'encouragement de SystemsX.ch a produit des résultats de recherche de très haut niveau. Le Conseil est convaincu que l'encouragement spécifique dont les chercheurs ont bénéficié a sensiblement accru la notoriété et la compétitivité internationales de la communauté de recherche en biologie des systèmes. Des chercheurs suisses rattachés à différentes institutions comptent désormais parmi l'élite mondiale, ce qui a amélioré le positionnement du système FRI suisse à l'étranger.

De l'avis du panel d'experts internationaux, SystemsX.ch a été déterminant pour l'établissement rapide de la biologie des systèmes en Suisse. L'importance du soutien complémentaire a été soulignée par plusieurs acteurs suisses en tant qu'accélérateur du processus. De l'avis unanime des spécialistes consultés par le CSS, le financement spécial a été un facteur central.

SystemsX.ch a initié et encouragé la collaboration interdisciplinaire et interinstitutionnelle; celle-ci était exigée dès le début dans les appels à projet de recherche RTD (Research, Technology and Development). De nouvelles perspectives sur la biologie des systèmes ont été intégrées dans la formation après la fin du programme. De tels résultats sont à considérer comme des effets durables de SystemsX.ch. Cela dit, la présente appréciation des effets ayant lieu peu après la fin du programme, il n'est pas possible d'évaluer les effets de SystemsX.ch à long terme en matière de coopération entre les institutions partenaires, de même que dans l'encouragement des carrières interdisciplinaires chez les jeunes chercheurs.

L'intégration de l'économie dans SystemsX.ch a par contre moins convaincu le Conseil. En effet, tant le programme que les différents modes d'encouragement (à l'exception des Transfer Projects) ne disposaient, en matière de transfert de connaissances et de technologies, de stratégies concrètes et adaptées aux différents projets soutenus.

La contribution de SystemsX.ch à la réorientation épistémologique de la recherche, et donc à l'objectif d'établir une biologie des systèmes qui favorise une compréhension holistique du comportement quantitatif des systèmes biologiques, n'est, de l'avis du Conseil, que partiellement avérée. SystemsX.ch aurait ainsi du davantage mettre l'accent sur la modélisation quantitative et sur les analyses de données.

SystemsX.ch a entraîné différents changements structurels au sein des institutions partenaires. Toutefois, la mise en œuvre des groupes de recherche, des chaires et des infrastructures technologiques y relatives n'a pas fait l'objet de stratégies préalables communes. Ce manque est, de l'avis du CSS, à mettre en rapport avec le processus de création et la gouvernance du programme. Dans ce sens, SystemsX.ch n'est pas parvenu à épuiser l'ensemble de son potentiel de programme national.

Se fondant sur ces résultats, le CSS recommande en premier lieu au SEFRI d'établir de manière explicite et avant son lancement quels sont les objectifs d'un programme national d'encouragement de la recherche tel que SystemsX.ch. Il s'agirait également dans ce contexte de prendre en compte les développements nécessaires quant aux infrastructures ainsi que la question de la disponibilité d'un nombre suffisant de spécialistes qualifiés.

En deuxième lieu, le CSS se prononce de manière générale sur les „projets d'encouragement nationaux dans le domaine de la recherche et de l'innovation" au sens de l'art. 41, al. 5, de la Loi fédérale sur l'encouragement de la recherche et de l'innovation[2]. De tels projets doivent, de l'avis du CSS, rester très rares. De plus, la réponse optimale en termes de compétitivité à long terme sur le plan international devrait résider dans une sélection qui tiendrait compte des configurations à la fois scientifiques et nationales, en particulier par l'identification de niches stratégiques. La procédure de sélection des projets d'encouragement nationaux devrait reposer sur la consultation systématique de tous les acteurs du système FRI. En outre, il convient aussi de clarifier au préalable quelle est la valeur ajoutée attendue d'un tel projet d'encouragement national, en particulier son rapport avec et son impact sur l'encouragement ordinaire de la recherche et de l'innovation. Il faut veiller à mettre en place une organisation transparente dotée de structures décisionnelles claires, capables d'intégrer à la fois l'orientation nationale du projet et les besoins des chercheurs et des acteurs de l'innovation. Si des partenariats public-privé sont envisagés, les milieux économiques devront être associés à l'élaboration de la stratégie, par exemple avec le soutien d'un comité consultatif scientifique et économique. Le monitorage devrait correspondre aux standards des institutions d'encouragement.

Finalement, le CSS recommande d'examiner dans quelle mesure les dispositions légales actuelles (art. 41 al. 5+6 LERI) garantissent le respect de principes clairs en matière de formulation, de sélection et d'organisation interne des initiatives financées à ce titre.

[2] Loi fédérale du 14 décembre 2012 sur l'encouragement de la recherche et de l'innovation (LERI), RS 420.1, entrée en vigueur le 1er janvier 2014.

Empfehlungen des SWR

Die Empfehlungen des Schweizerischen Wissenschaftsrates (SWR, bis 31. Dezember 2017 Schweizerischer Wissenschafts- und Innovationsrat SWIR) beruhen auf den im Rahmen der Wirkungsprüfung von SystemsX.ch erarbeiteten Analysen sowie weiteren Arbeiten des Rates.

Die Forschenden steigerten mit der aus der SystemsX.ch-Sonderförderung resultierten Spitzenforschung die Bekanntheit und die internationale Wettbewerbsfähigkeit der systembiologischen Forschungsgemeinschaft erheblich, was sich positiv auf die Positionierung des schweizerischen BFI-Systems auswirkte. Gleichzeitig wurden die interdisziplinäre und interinstitutionelle Zusammenarbeit gestärkt und neue Blickwinkel in die Ausbildung integriert. Hingegen wurden aus der Sicht des SWR die Ziele in den Bereichen der epistemologischen Umorientierung hin zur Modellierung von biologischen Prozessen, des Einbezugs der Wirtschaft und der strukturellen Auswirkungen des Programms, beispielsweise die Installierung von Lehrstühlen oder von Dateninfrastrukturen, nur teilweise erreicht. Die mangelhafte Entwicklung dieser Bereiche ist für den SWR mit dem Entstehungsprozess und der Governance des Programms verknüpft und bildet eine wichtige Grundlage für die Empfehlungen an den Mandatgeber, das Staatssekretariat für Bildung, Forschung und Innovation (SBFI).

Nachfolgend formuliert der SWR auf der Grundlage der Analyse des Programms SystemsX.ch Empfehlungen zur Sonderforschungsförderung. Danach geht der Rat generell auf „nationale Förderinitiativen im Bereich von Forschung und Innovation“ im Sinne von Art. 41 Abs. 5 des Bundesgesetzes über die Förderung der Forschung und der Innovation[3] ein.

Der SWR empfiehlt,

- dass im Rahmen einer Vereinbarung explizit festgehalten wird, was eine gesamtschweizerische Forschungsförderung wie das Programm SystemsX.ch erreichen soll. Die anzustrebende Anwendungsorientierung und die Rolle der Technologieförderung sind ebenso zu klären wie die Langzeitwirkungen (Outcomes, Impact);

- dass dabei sowohl die notwendige Infrastrukturentwicklung mitbedacht wird als auch, ob genügend qualifizierte Forschende in den gewünschten Disziplinen mobilisiert werden können.

Planung und Organisation nationaler Förderinitiativen

Generell empfiehlt der SWR,

- dass der Bund im Auswahlverfahren für eine nationale Förderinitiative systematisch alle BFI-Akteure, inklusive die Forschungs- und/oder Innovationsförderorganisationen, konsultiert; dieser vorbereitende Bottom-up-Prozess im Sinne eines Ideenwettbewerbs unterstützt den wissenschaftspolitischen Entscheid;

- dass von Beginn weg darauf geachtet wird, dass die Strategien, ihre Umsetzung und Governance den wissenschaftlichen, sozioökonomischen und strukturellen Zielen der nationalen Initiative entsprechen;

- dass die Strategie unter Einbezug der Wirtschaft erarbeitet wird, falls Public Private Partnerships angestrebt werden. Zusätzlich zur kritischen wissenschaftlichen Unterstützung ist die Begleitung durch Fachleute aus der Wirtschaft unabdingbar (wissenschaftlich-wirtschaftlicher Beirat);

- dass der Mehrwert einer nationalen Förderinitiative geklärt wird; das umfasst insbesondere das Verhältnis zu der und die Auswirkungen auf die gängige Forschungs- und Innovationsförderung;

[3] Bundesgesetz vom 14. Dezember 2012 über die Förderung der Forschung und der Innovation (FIFG), SR 420.1, in Kraft getreten am 1. Januar 2014.

- dass das Monitoring einer solchen Sonderinitiative den Standards der etablierten Förderinstitutionen entspricht;

- dass das SBFI angesichts der rechtlichen Änderung durch das FIFG vorab prüft, inwieweit die aktuellen Gesetzesbestimmungen (Art. 41 Abs. 5+6 FIFG) die Einhaltung klarer Grundsätze betreffend Formulierung, Wahl und interner Organisation der zu diesem Zweck finanzierten Initiativen sicherstellen.

Grundsätzlich ist der SWR überzeugt,

- dass nationale Förderinitiativen die schweizerische BFI-Landschaft bereichern, dass sie aber als Ausnahme gelten sollten. Von einer Routine ist abzusehen, und Pfadabhängigkeiten im Hinblick auf künftige Förderinitiativen sind zu vermeiden;

- dass nationale Förderinitiativen die Voraussetzung schaffen, um wissenschaftliche und sozioökonomische Ziele zu erreichen, die einen entsprechenden Einsatz von wissenschaftlichem Personal und institutionellen Ressourcen erfordern. Im Zusammenhang damit kann die Identifizierung strategischer Nischen nützlich sein, um eine profilierte Positionierung der schweizerischen Forschung und Innovation im internationalen Kontext zu ermöglichen.

1 Einleitung

1.1 Die Ausgangslage

SystemsX.ch wurde im Rahmen der Botschaft über die Förderung von Bildung, Forschung und Innovation (BFI-Botschaft) 2008–2011[4] als nationale Initiative lanciert. Das Programm sollte „die Schweiz in der Systembiologie an die Weltspitze zu bringen“[5]. Das Hauptziel war gemäss Botschaft, „im übergeordneten Interesse des Wissenschafts- und Technologiestandorts Schweiz eine umfassende Initiative zur Entwicklung der Systembiologie in der Schweiz zu lancieren und damit eine weitere Grundlage für das Zusammenwirken der Forschungsförderung des Bundes mit der Privatwirtschaft zu schaffen (Public Private Partnership). Dieses Ziel übersteigt die Möglichkeiten einzelner Hochschulen und kann nur als nationale Verbundaufgabe erfolgreich umgesetzt werden.“[6]

Nach dem Übergangsjahr 2012 wurde die Initiative mit der BFI-Botschaft 2013–2016[7] bis Ende 2016 verlängert. Die Finanzierung führte weder in der ersten noch in der zweiten Förderperiode zu Diskussionen in National- oder Ständerat. Während der 9-jährigen Laufzeit 2008–2016 unterstützte der Bund SystemsX.ch mit insgesamt 220 Mio. CHF.[8] Das Programm zur Förderung der Systembiologie ist gemäss Angaben von SystemsX.ch die „bislang grösste öffentliche Forschungsinitiative in der Schweiz, die auf einen bestimmten Bereich in der Grundlagenforschung fokussiert“.[9]

1.2 Das Mandat des SBFI

Das Staatssekretariat für Bildung, Forschung und Innovation (SBFI) beauftragte den SWR im September 2016 mit der Wirkungsprüfung der beiden nationalen Programme SystemsX.ch und Nano-Tera.ch.[10] Das übergeordnete Ziel, „unter programmspezifisch relevanten Aspekten die Wirkungen umfassend festzustellen und aus übergeordneter Sicht zu bewerten“[11], sowie das Vorgehen waren bei beiden Aufträgen identisch. Sie unterschieden sich jedoch insbesondere bezüglich der vom SBFI als relevant bewerteten Wirkungsdimensionen und des Zeitplans[12].

Ziele, Vorgehen und Gegenstand der Wirkungsprüfung von SystemsX.ch stellte das SBFI im dem Mandat beigefügten Konzeptdokument detailliert dar. Die erste Etappe bestand aus einer internen Beurteilung in Form eines Selbstevaluationsberichts des SystemsX.ch-Konsortiums, gefolgt von einer externen Begutachtung, die aus einem Bericht eines internationalen Expertenpanels sowie der Analyse des SWR bestand. Gemäss dem Auftrag sollte der SWR nicht nur vier Wirkungsdimensionen bewerten,[13] sondern auch eine Gesamtbeurteilung aus einem „broader view“[14] abgeben. Die Koordination der gesamten Wirkungsprüfung von SystemsX.ch oblag dem SWR. Bei der Erarbeitung des

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4 Botschaft vom 24. Januar 2007 über die Förderung von Bildung, Forschung und Innovation in den Jahren 2008–2011 (BFI-Botschaft 2008–2011), BBl 2007 1223ff, https://www.admin.ch/opc/de/federal-gazette/2007/1223.pdf Konsultation aller Links am 9. Januar 2018.

5 BFI-Botschaft 2008–2011, S. 1269.

6 Ebenda, S. 1354.

7 Botschaft vom 22. Februar 2012 über die Förderung von Bildung, Forschung und Innovation in den Jahren 2013–2016 (BFI-Botschaft 2013–2016), BBl 2012 3099ff, https://www.admin.ch/opc/de/federal-gazette/2012/3099.pdf.

8 Gemäss den Angaben des Konzeptdokuments „Framework of the impact evaluation for the national funding program ‚SystemsX.ch‘“, das das Mandat des SBFI an den SWR präzisierte, siehe Anhang A.

9 SystemsX.ch (2014), *SystemsX.ch: Die Schweizer Initiative in Systembiologie*, Zürich: SystemsX.ch, S. 2, http://www.systemsx.ch/fileadmin/redaktion/Communication/Brochure/Web_SystemsX_ch_Brochure_2014_D.pdf. Weitere Erläuterungen zu SystemX.ch, insbesondere zum rechtlichen und finanziellen Rahmen, siehe Kapitel 2.

10 Das Mandat des SBFI für die Wirkungsprüfung beider Programme sowie das präzisierende Konzeptdokument „Framework of the impact evaluation for the national funding program ‚SystemsX.ch‘“ sind dem Anhang A beigefügt.

11 Ebenda, S. 2.

12 Der Nano-Tera.ch-Schlussbericht des SWR wurde dem SBFI Ende Juni 2018 übergeben. Schweizerischer Wissenschaftsrat SWR (2018), *Appréciation de l’impact du programme national d’encouragement Nano-Tera.ch*, Bern: SWR, https://www.wissenschaftsrat.ch/images/stories/pdf/fr/20180830_Nano-Tera_SSCreport_Final_publ_FR.pdf.

13 Die Wirkungsdimensionen waren: structural changes, networking and partnerships, promoting young talents, excellence in science. Details dazu, inklusive der entsprechenden Key Statements, sind im „Framework of the impact evaluation for the national funding program ‚SystemsX.ch‘“ (Anhang A) zu finden. Die Key Statements sind zudem im Kapitel 3.2 jeweils zu Beginn aufgeführt.

14 Siehe „Framework of the impact evaluation for the national funding program ‚SystemsX.ch‘“, S. 5 (Anhang A).

SWR-Schlussberichts wurden die Berichte des SystemsX.ch-Konsortiums und des Expertenpanels mitberücksichtigt.

1.3 Die Projektorganisation

Die Recherche- und Analysearbeiten wurden von einer Ratsarbeitsgruppe durchgeführt (unterstützt von der SWR-Geschäftsstelle). Der Arbeitsgruppe gehörten an:

- Prof. Dr. Hans-Joachim Böhm;
- Prof. Dr. Gerd Folkers;
- Prof. Dr. Wolf Linder.

Der SWR erhielt die Selbstevaluation des SystemsX.ch-Konsortiums Ende März 2017. Die Selbstevaluation (inklusive Appendizes) ist dem Anhang B des vorliegenden Berichtes beigefügt.

Wie im Mandat vorgesehen, beauftragte der SWR in Absprache mit dem SystemsX.ch-Konsortium externe Experten, welche einen unabhängigen Panelbericht verfassten. Der Bericht des Expertenpanels basiert auf Fragen des SWR, dem Mandat des SBFI, der Selbstevaluation des SystemsX.ch-Konsortiums, ausführlichen Diskussionen mit Vertretern des SystemsX.ch-Konsortiums und des Schweizerischen Nationalfonds zur Förderung der wissenschaftlichen Forschung (SNF) am 14./15. Juni 2017 in Zürich sowie den Kenntnissen und Erfahrungen der Panelmitglieder. Dem externen Expertenpanel gehörten an:

- Prof. Dr. Luis Serrano, Centre for Genomic Regulation, Barcelona, Spanien;
- Prof. Dr. Martin Vingron, Max-Planck-Institut für Molekulare Genetik, Berlin, Deutschland.[15]

Der Bericht des Expertenpanels ist (zusammen mit einer Stellungnahme des SystemsX.ch-Konsortiums) dem Anhang C beigefügt.

Um die Rolle von SystemsX.ch bei den Entwicklungen nachhaltiger Dateninfrastruktur im Bereich der schweizerischen systembiologischen Forschung zu erhellen, beauftragte der SWR Prof. Dr. Fritz Sager, Kompetenzzentrum für Public Management (kpm) der Universität Bern, und sein Team mit einer zusätzlichen Analyse.[16] Sie sollten die Entwicklung der SystemsX.ch-Dateninfrastruktur im Zeitraum 2007–2017 anhand je einer Momentaufnahme des Anfangs- und Endzeitpunkts sowie anhand einer vertieften Betrachtung der Strukturen, Akteure und Prozesse untersuchen. Die Analyse findet sich ebenfalls im Anhang des vorliegenden SWR-Berichts (Anhang D).

[15] Gemäss der Planung und Vereinbarung mit SystemsX.ch hätte als drittes Panelmitglied Prof. Dr. Jeffrey Bethony von der George Washington University School of Medicine and Health Sciences, Washington DC, USA, im Expertenpanel mitarbeiten sollen. Er musste sich jedoch im Juni 2017 kurzfristig zurückziehen.

[16] Fritz Sager, David Kaufmann und Johanna Künzler (2017), *Wirkungsprüfung SystemsX.ch – Bericht zum Mandat „SystemsX.ch und die Dateninfrastruktur“*, Bern: Kompetenzzentrum für Public Management. Der Bericht ist dem Anhang D beigefügt.

1.4 Projektablauf und Vorgehen

Zentrale Meilensteine des Auftrags wurden im Mandat des SBFI festgelegt. Ausgehend davon definierte der SWR im Einvernehmen mit dem SystemsX.ch-Konsortium im November 2016 folgenden Ablauf:

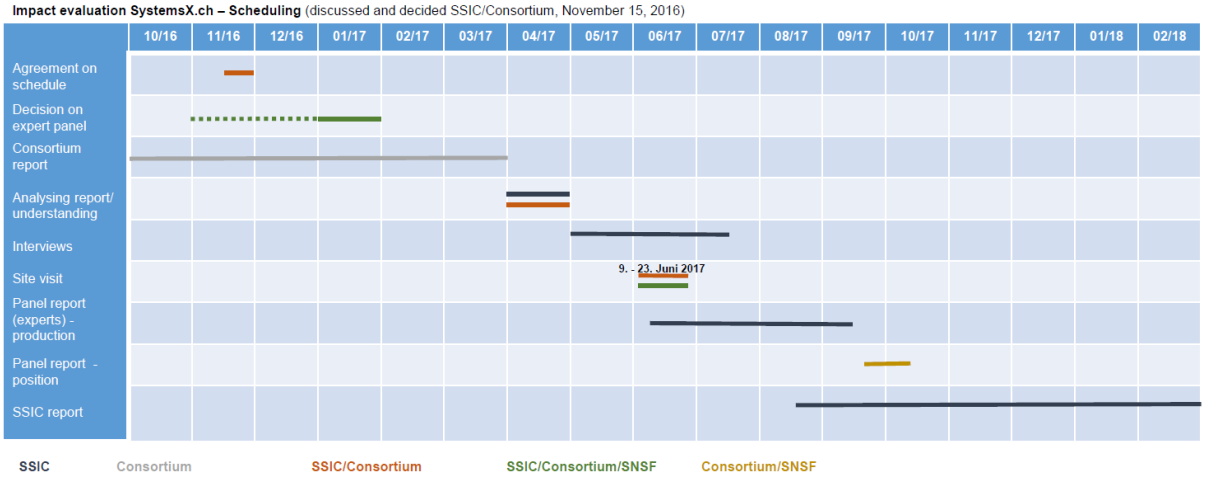

Abbildung 1: Ablauf der Wirkungsprüfung, vereinbart mit dem SystemsX.ch-Konsortium im November 2016 (Quelle: SWR)

Die SWR-Arbeitsgruppe informierte das Plenum im Verlauf des Prozesses mehrfach über den Stand der Arbeiten und stellte im November 2017 vorläufige Schlussfolgerungen zur Diskussion. Der gesamte Bericht und die SWR-Empfehlungen wurden ebenfalls im Ratsplenum diskutiert und am 5. Februar 2018 verabschiedet.

Der SWR-Präsident informierte das Plenum am 24. April 2018 über die Rückmeldung des SBFI auf den Bericht, die zentralen Punkte sind in einer internen Aktennotiz vom SBFI an den SWR vom 18. April festgehalten. Unterstützt von der Geschäftsstelle überarbeitete die SWR-Arbeitsgruppe den Bericht, die revidierte Fassung wurde am 3. September 2018 vom SWR-Plenum verabschiedet.

Die Analyse des SWR stützte sich insbesondere auf:

- die Selbstevaluation des SystemsX.ch-Konsortiums;
- Recherche- und Analysegespräche mit 20 mit SystemsX.ch vertrauten Personen;[17]
- die Gespräche mit Vertretern von SystemsX.ch, dem SNF[18] und den internationalen Experten vom 14./15. Juni 2017;[19]
- den Bericht des Expertenpanels;
- den Bericht von Prof. Dr. Fritz Sager et al. zur Dateninfrastruktur;
- Strategiedokumente, die der SWR insbesondere von SystemsX.ch sowie vom SNF und vom SBFI auf Anfrage erhalten hatte und die der Vertraulichkeit unterliegen, sowie öffentlich zugängliche Unterlagen;
- Erfahrungen und Kenntnisse der SWR-Mitglieder.

Mögliche Zusammenhänge mit der SWR-Wirkungsprüfung von Nano-Tera.ch wurden durch das Ratsplenum, ein Treffen der beiden Ratsarbeitsgruppen wie auch durch die Koordinationsarbeit innerhalb der SWR-Geschäftsstelle erfasst.

Die im Mandat vorgesehene umfassendere Sichtweise des Rates interpretierte der SWR als systemische Perspektive. Dadurch wurde das Programm zusätzlich aus einem übergeordneten Blickwinkel bewertet. Die Datenauswertung erfolgte nach qualitativen Kriterien, wobei die gewonnenen Informationen zusammengeführt und in ihrer Gesamtheit zur Beantwortung der Fragestellungen berücksichtigt

[17] Es wurden halb-strukturierte Interviews mit vom SWR als besonders relevant eingeschätzten Akteuren durchgeführt. Eine Liste der Gesprächspartnerinnen und Gesprächspartner findet sich im Anhang F.

[18] Der SNF ist nicht Objekt der Wirkungsprüfung. Als wichtiger Akteur im gesamten Prozess unterstützte er den SWR bei seiner Arbeit mit Dokumenten, Gesprächen und einer statistischen Auswertung (Anhang E).

[19] Siehe Anhang F.

wurden. Mit der Triangulation unterschiedlicher Quellen wurde versucht, eine möglichst umfassende und überprüfte Sichtweise zu erlangen.

1.5 Möglichkeiten und Grenzen der Wirkungsprüfung

Obgleich sich die Analyse gemäss dem Mandat des SBFI auf eine Prüfung der Wirkungen von SystemsX.ch bezieht, bezweckt der vorliegende SWR-Bericht nicht, einen kausalen Zusammenhang zwischen dem Programm und seinen Auswirkungen (Outcomes, Impact) nachzuweisen. Die existierenden Methodologien insbesondere der Wirtschafts- und Sozialwissenschaften,[20] deren Sinn es ist, mit quantitativen Methoden die Wirkungen öffentlicher Massnahmen festzustellen, sind bei einem grossen Programm wie SystemsX.ch nicht anwendbar. So gehören verschiedene wissenschaftliche Gemeinschaften und öffentliche Handlungsebenen, die ein komplexes System von Zusammenhängen bilden, zu SystemsX.ch; das Programm ist dabei nur einer der bestimmenden Faktoren. Zudem sind die verfügbaren Daten nicht ausreichend detailliert und präzise, um Aufschluss über sämtliche Prozesse im Programm zu bieten.[21] Schliesslich beschränkt die Aussergewöhnlichkeit des Programms (siehe Kapitel 2) die Möglichkeit, sich auf einen Vergleich oder eine Kontrollgruppe zu stützen.

Obgleich SystemsX.ch und Nano-Tera.ch im gleichen Forschungsförderungskontext lanciert worden sind, unterscheiden Sie sich in wesentlichen Aspekten, insbesondere in ihren wissenschaftlichen und sozioökonomischen Zielen. Diese Unterschiede unterstreichen den aussergewöhnlichen Charakter von beiden Programmen und machen einen Vergleich schwierig. Den hauptsächlichen Referenzpunkt (Benchmark) des Programms SystemsX.ch bilden daher seine ursprünglichen Zielsetzungen respektive die Erwartungen, die es hervorrief und die zu seiner Existenz beitrugen. Informationen aus anderen Programmen und Instrumenten der schweizerischen Forschungsförderung werden als Grössenordnungen beigezogen.

Auf diese Weise trägt der SWR mit seiner qualitativen Analyse dazu bei, die Ergebnisse des Programms im Hinblick auf seine Ziele und seine Umsetzung zu ermitteln und zu bewerten. Er hofft damit, die Reflexionen und Diskussionen bei den Begünstigten des Programms wie auch bei den politisch Verantwortlichen zu fördern.

1.6 Die Struktur des Berichts

Der vorliegende Bericht enthält im zweiten Kapitel Informationen zur Förderinitiative und zum Programm SystemsX.ch. Dabei werden auch die Entstehung und die Einbettung ins BFI-System berücksichtigt (Kapitel 2.1 und 2.2) und die Ziele des Programms aufgeführt (2.3). Im dritten Kapitel folgen die Analyse und Ergebnisse des SWR zuerst im Sinne einer Gesamtwürdigung (3.1), danach anhand der Hauptthemen des SBFI-Auftrags, eingeleitet durch die Key Statements des SBFI (3.2). Abschliessend legt der SWR seine Überlegungen aus systemischer Perspektive dar (3.3).

Im Anhang sind unter anderem das Mandat des SBFI (Anhang A), die Selbstevaluation des SystemsX.ch-Konsortiums (Anhang B), der Bericht des Expertenpanels (Anhang C), der Bericht zur Analyse der Dateninfrastruktur (Anhang D), eine Übersicht über Zuwendungen des SNF (Anhang E) und eine Liste der SWR-Gesprächspartnerinnen und Gesprächspartner (Anhang F) zu finden.

[20] Siehe Pauline Givord (2010), *Méthodes économétriques pour l'évaluation de politiques publiques*, Paris: Institut National de la Statistique et des Etudes Economiques sowie Albert N. Link et al. (Hrsg.) (2013), *Handbook On The Theory And Practice Of Program Evaluation*, Cheltenham: Edward Elgar Publishing.

[21] Siehe Kapitel 3.

2 Die Förderinitiative SystemsX.ch

2.1 Die Entstehung von SystemsX.ch

Die Entstehungsgeschichte von SystemsX.ch ist eng mit den Annäherungsbestrebungen seit Mitte der 1990er Jahre zwischen der Universität Basel (UniBas) und der Eidgenössischen Technischen Hochschule Zürich (ETHZ) verbunden.[22] In Basel war die Stärkung der Life Sciences schon länger eine wissenschaftspolitische Priorität, insbesondere nachdem Roche Anfang 2000 die Schliessung des Basel Institute for Immunology (BII) bekannt gegeben und damit für grosse Verunsicherung gesorgt hatte. Nach der Lancierung des Basel Institute for Diseases of Ageing Ende 2000, mit dem eine Gruppe Forschender aus dem Bereich der Life Sciences politische und wirtschaftliche Ressourcen mobilisierte, tauchte Mitte 2002 erstmals die Idee einer ETH-Basel auf, also das Ziel, ein Life Sciences-Institut der ETHZ in Basel anzusiedeln.[23] Solche Projekte wurden nicht nur von den beiden Hochschulen unterstützt, sondern auch von kantonalen und Bundesbehörden, wie sie in der Genferseeregion um die Eidgenössische Technische Hochschule Lausanne (EPFL), die Universität Lausanne (UniL) und die Universität Genf (UniGe) im Rahmen des „Projet triangulaire lémanique" gefördert wurden.[24]

2003 gründeten die Universitäten Basel und Zürich sowie die ETHZ eine systembiologische Forschungsinitiative unter dem Namen „SystemsX". 2006 wurde das erste und einzige Departement der ETHZ ausserhalb von Zürich in Basel gegründet,[25] das Department of Biosystems Science and Engineering (D-BSSE). Parallel dazu schuf die ETHZ 2005 in Zürich das Institute of Molecular Systems Biology. Dieses Institut wurde vom aus Seattle zurückgekehrten Prof. Dr. Ruedi Aebersold[26] geleitet, der gleichzeitig 2006–2012 das Scientific Executive Board (SEB) von SystemsX.ch präsidierte. Mit diesem „Personalentscheid"[27] wurde SystemsX gestärkt. Dabei verschob sich das Aktionszentrum von der Basler Institutsgründung zu einer interuniversitären Initiative für die Systembiologie.

Im März 2004 reichten die drei Hochschulen bei der Schweizerischen Universitätskonferenz (SUK) auf der Grundlage des Bundesgesetzes über die Förderung der Universitäten und über die Zusammenarbeit im Hochschulbereich[28], Art. 20ff, einen Antrag auf Fördergelder ein. Im gleichen Jahr entschied die SUK, SystemsX im Rahmen der Kooperationsprojekte 2004–2007 mitzufinanzieren.[29] 2005–2007 erhielt SystemsX via SUK insgesamt 10 Mio. CHF (nach dem Prinzip der „matching funds", einer Eigenbeteiligung der drei Partnerinstitutionen in mindestens der gleichen Höhe). Die in diesem Rahmen geförderten Projekte wurden mithilfe eines speziellen systembiologischen Review Panels der Forschungskommission der ETHZ ausgewählt.

Bereits im Antrag an die SUK 2004 wiesen die Gründerhochschulen von SystemsX darauf hin, dass weitere Hochschulen mit Kompetenzen auf dem Feld der Systembiologie nach Konsolidierung des Projekts dazu stossen könnten. Gleichzeitig wurde betont, dass die Beiträge der SUK auf die Jahre 2005–2007 begrenzt seien, alle Aktivitäten des Projekts SystemsX ab 2008 würden aus den ordentlichen Hochschulbudgets finanziert.

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22 Eine umfassende Einbettung liefert Alban Frei (2017), *Sichtbare Netzwerke. Forschungspolitik und Life Sciences zwischen 1990 und 2016 in der Schweiz. Eine Fallstudie zu SystemsX.ch*, Dissertation ETHZ 2017, Publikation 2018 geplant.

23 Frei (2017), S. 71f.

24 Siehe Jean-Philippe Leresche et al. (2012), *Gouverner les universités. L'exemple de la coordination Genève-Lausanne (1990–2010)*, Lausanne: Presses polytechniques et universitaires romandes.

25 Siehe https://www.ethz.ch/content/dam/ethz/news/medienmitteilungen/2017/pdf/Jubilaeum_D-BSSE/170405_MM_10_Jahre_D-BSSE.pdf.

26 Aebersold war in Seattle Mitbegründer des Institute for Systems Biology, https://www.systemsbiology.org/about/overview/.

27 Frei (2017), S. 84f.

28 Bundesgesetz vom 8. Oktober 1999 über die Förderung der Universitäten und über die Zusammenarbeit im Hochschulbereich (Universitätsförderungsgesetz, UFG) aSR 414.20, in Kraft getreten am 1. April 2000, ausser Kraft gesetzt am 1. Januar 2015.

29 Im Jahresbericht 2004 beschreibt die Schweizerische Universitätskonferenz SystemsX wie folgt: „Das Projekt will Lehre und Forschung in Systembiologie auf der Achse Zürich-Basel vorantreiben. In Basel soll ein neues wissenschaftliches Zentrum (‚Center of Bioystems Science and Engineering') gegründet werden. In Zürich ist ein Verbund für Biosysteme (‚Cluster of Biosystems Science') zwischen der ETHZ und der Universität Zürich vorgesehen." Schweizerische Universitätskonferenz (SUK) (2005), *Jahresbericht 2004*, Bern: SUK, S. 9.

Gemäss Frei brauchte SystemsX dringend Planungssicherheit, um eine längerfristig wirksame Strukturänderung zu bewirken, wie es dem „Zweck" der Initiative entsprach. Eine verbindliche Zusage ausreichender Finanzmittel würde diese erheblich erhöhen, so Frei weiter; angestrebt wurde eine Expansion zwecks Ressourcenallokation.[30] Eine deutliche Erhöhung der Bundesfinanzierung ab der Finanzierungsperiode 2008–2011 (BFI-Botschaft 2008–2011) knüpfte das Staatssekretariat für Bildung und Forschung (SBF, heute SBFI) an die Bedingung, dass es sich um eine nationale Forschungsinitiative handeln müsse.[31] 2006 wurde die einfache Gesellschaft „SystemsX.ch" gegründet; das Suffix „.ch" verwies auf die angestrebte gesamtschweizerische Positionierung des Konsortiums. Bei der Lancierung des neuen Programms 2007 waren schliesslich elf Institutionen als Partner mit dabei.[32] Für den Bundesrat gehörte SystemsX.ch denn auch zu den Massnahmen zugunsten der biotechnologischen Forschung und Innovation (F&I).[33]

Das SBF beauftragte zudem den SNF im Dezember 2006, eine übergeordnete Beurteilung des Gesamtvorhabens abzugeben und mögliche Evaluationsmechanismen vorzuschlagen, um die wissenschaftliche Qualität und Exzellenz der geförderten Projekte sicherzustellen. Wie der SNF in seinem Bericht zuhanden des SBF 2007 feststellte, waren vor dem Start der Initiative die für die Entwicklung der Systembiologie relevanten Fachgebiete „in der Schweiz allesamt hervorragend vertreten"[34].

Mit der BFI-Botschaft 2008–2011 erhielt SystemsX.ch einen Bundesbeitrag von 100 Mio. CHF (50 Millionen via SUK, 50 Millionen via ETH-Rat) zugesprochen.[35] Die BFI-Botschaft 2008–2011 hält dazu fest: „Das Pilotprojekt SystemsX wurde 2006 durch eine internationale Expertengruppe evaluiert und bezüglich strategischer Ausrichtung und Qualität äusserst positiv beurteilt. Auf dieser Basis wurde im Hinblick auf die Periode 2008–2011 einerseits der Grundsatzentscheid zur Weiterführung der ETH-Antenne in Basel gefällt. Andererseits haben die Gründerinstitutionen von SystemsX (Universitäten Basel, Zürich und ETH Zürich) angesichts der wissenschaftlichen Tragweite und des hohen Anwendungspotenzials der Systembiologie (namentlich im Bereich der Medizin) im Jahr 2006 eine einfache Gesellschaft gegründet, mit dem Ziel, eine nationale Initiative zur Forschungskooperation im Bereich der Systembiologie zu lancieren."[36]

Für den SNF war das umfassende und übergeordnete Ziel der Systembiologie das „quantitative, die verschiedenen Organisationsebenen übergreifende Verständnis biologischer Prozesse (Gene, Proteine, Zellen, Zellverbände, Organe, Verhalten von Organismen und Populationen)"[37]. Das SEB von SystemsX.ch publizierte eine Definition von Systembiologie – und damit den Anwendungsbereich des Programms – im ersten Call for Proposals (6. September 2007)[38]: „The primary objective of Systems Biology is to achieve an integral and comprehensive understanding of the quantitative behavior of biological systems that arises from the dynamic interplay of its components. It is expected that Systems Biology research projects will culminate in a model (e.g. mathematical) that simulates in silico the system's properties and predicts its quantitative response to internal or external perturbations. Frequently, biological systems are represented as networks of interacting elements, whereby the structure and the dynamic behavior of the network determine its phenotypic traits. The study of biological systems in this

30 Frei (2017), S. 86.
31 Gemäss übereinstimmenden Angaben der damals beteiligten SWR-Gesprächspartner.
32 Die Universitäten Basel (UniBas), Bern (UniBe), Freiburg (UniFr), Genf (UniGe), Lausanne (UniL), Zürich (UniZH), die ETH Lausanne (EPFL), die ETHZ sowie das Friedrich Miescher Institute for Biomedical Research (FMI), das Paul Scherrer Institut (PSI) und das Schweizerische Institut für Bioinformatik (SIB).
33 Siehe Antwort des Bundesrats vom 29.08.2007 auf die Anfrage von Nationalrat Felix Gutzwiler (FDP/ZH), 07.1079, „Impulse für die Biotechnologie", https://www.parlament.ch/de/ratsbetrieb/suche-curia-vista/geschaeft?AffairId=20071079.
34 Die Zusammenfassung des Berichts ist auf der Webseite des SNF veröffentlicht: Schweizerischer Nationalfonds SNF (2007), Präsidium des Nationalen Forschungsrats, 13. März 2007 (rev. 26. April 2007), *SystemsX.ch. Zusammenfassung des Berichtes des Schweizerischen Nationalfonds zuhanden des Staatssekretariats für Bildung und Forschung*, Bern: SNF, http://www.snf.ch/SiteCollectionDocuments/Dossiers/dos_systemsx_bericht_kurz_d.pdf.
35 Die jährliche Aufteilung der Mittel, die zweckgebunden an den SNF gingen, wurden in den entsprechenden Verfügungen von ETH-Rat und SBF festgeschrieben. Das Konsortium war für die Mittelverwaltung und selbständige Rechnungsführung auf Ebene Gesamtprogramm verantwortlich.
36 BFI-Botschaft 2008–2011, S. 1352f.
37 Schweizerischer Nationalfonds SNF (2007), Präsidium des Nationalen Forschungsrats, 13. März 2007 (rev. 26. April 2007), *SystemsX.ch. Zusammenfassung des Berichtes des Schweizerischen Nationalfonds zuhanden des Staatssekretariats für Bildung und Forschung*, Bern: SNF, S. 2, http://www.snf.ch/SiteCollectionDocuments/Dossiers/dos_systemsx_bericht_kurz_d.pdf.
38 Die Calls for Proposals sind auf der Webseite von SystemsX.ch verfügbar, http://www.systemsx.ch/systemsxch/calls-for-proposals/past-systemsxch-calls/.

framework requires interdisciplinary cooperation and a division of labor between biologists, medical scientists, mathematicians, physicists, computer scientists, chemists, and engineers. The present Call for Proposals is based on this definition of Systems Biology."[39]

2.2 Die Einbettung im BFI-System

Die Finanzierung von SystemsX.ch erfolgte auf den bestehenden rechtlichen Grundlagen, auf dem ETH-Gesetz[40] sowie dem Universitätsförderungsgesetz (UFG) und insbesondere seinen Art. 20 und 21, welche die Regeln und Verfahren für eine Bundesunterstützung als „Projektgebundene Beiträge" für „Kooperationsprojekte sowie Innovationen von gesamtschweizerischer Bedeutung" festlegten (Art. 45 bis 47 der Verordnung zum UFG regelten dazu die Details)[41]. Dieses Instrument des UFG war das einzige, das zur Verfügung stand, auch wenn es nicht dafür vorgesehen war, um grosse Forschungsprojekte zu finanzieren, wie die SUK 2011 festhielt.

Im Rahmen der Vernehmlassung zur Totalrevision des FIFG verlangten die SUK, der ETH-Rat und der SNF 2010, den Rahmen zur Finanzierung von Grossprojekten wie SystemsX.ch und NanoTera.ch im neuen FIFG zu verankern und nicht im künftigen Hochschulförderungs- und -koordinationsgesetz (HFKG)[42] zu belassen.[43] Im Zuge dessen wurde ab 2014 die Koordination des Bundesrates bei der Planung und der Durchführung nationaler Förderinitiativen von grosser organisatorischer und finanzieller Tragweite im Bereich von Forschung und Innovation im neuen FIFG geregelt.[44] Art. 41 Abs. 5+6 FIFG bildet seit 2014 die Grundlage für eine derartige Bundesförderung (wie für das Swiss Personalized Health Network SPHN).

SystemsX.ch blieb mit seiner Organisation in Form eines Konsortiums der beteiligten Institutionen[45] ausserhalb der üblichen Förderorganisationen SNF und KTI (heute Innosuisse). Der Plan, den SNF ins Evaluationsverfahren einzubeziehen, entstand gemäss den vom SWR befragten Personen innerhalb des SBF, im Rahmen des Entstehungsprozesses der BFI-Botschaft 2008–2011.

Exkurs: Die Rolle des SNF[46]

Die Qualitätssicherung durch den SNF war ein wichtiges Argument bei der Promotion des Programms SystemsX.ch in der BFI-Botschaft 2008–2011. Allerdings konnte der SNF in seinem Bericht vom März/April 2007[47]

[39] Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 6.
[40] Bundesgesetzes vom 4. Oktober 1991 über die Eidgenössischen Technischen Hochschulen (ETH-Gesetz), SR 414.110.
[41] Verordnung zum Universitätsförderungsgesetz (UFV) vom 13. März 2000, aSR 414.201.
[42] Bundesgesetz vom 30. September 2011 über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich (Hochschulförderungs- und -koordinationsgesetz), SR 414.20, in Kraft getreten am 1. Januar 2015.
[43] Gemäss Art. 41 Abs. 5+6 FIFG koordiniert der Bundesrat „die Planung und die Durchführung nationaler Förderinitiativen im Bereich von Forschung und Innovation, die aufgrund ihrer organisatorischen und finanziellen Tragweite nicht im Rahmen der ordentlichen Förderaufgaben der Forschungsförderungsinstitutionen und der Innosuisse verwirklicht werden können. […] Er stellt dabei sicher, dass die Forschungsorgane, die Schweizerische Hochschulkonferenz und der ETH-Rat in die Planung einbezogen werden. Anträge an die Bundesversammlung betreffend Fördermassnahmen nach Absatz 5, einschliesslich der Festlegung von Finanzierung und Durchführung, erstellt er im Einvernehmen mit der Schweizerischen Hochschulkonferenz."
[44] Das Eidgenössische Departement des Innern (EDI) hielt dazu fest: „Zusätzliche grundsätzlicher orientierte Abklärungsfragen werden von SP [Sozialdemokratische Partei], SGB [Schweizerischer Gewerkschaftsbund], SUK, ETH-Rat und SNF betreffend Grossprojekten wie SystemsX.ch und NanoTera.ch aufgeworfen, deren rechtlicher Rahmen als Kooperationsprojekte gemäss Artikel 59 E-HFKG [Entwurf des Bundesgesetzes vom 30. September 2011 über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich, SR 414.20] nicht restlos überzeuge und aus Sicht dieser Vernehmlassungsteilnehmer in das FIFG gehört. Laut SNF könnte Artikel 6 Absatz 3 FIFG dafür eine ausbaufähige Grundlage bilden. Der SNF seinerseits will allerdings auch eine Lösung im Rahmen des HFKG nicht ausschliessen, da solche Förderinitiativen bedeutende strukturelle Effekte an den beteiligten Hochschulen nach sich ziehen. Für die SUK sollte jedoch […] gewährleistet sein, dass sie angemessen in den Entscheidungsprozess über solche Initiativen bzw. Programme des Bundes eingebunden wird. Auch sollten solche Programme nur mit der Zustimmung der SUK beschlossen werden können." EDI, Totalrevision des Bundesgesetzes über die Förderung der Forschung und Innovation (FIFG), Ergebnisbericht der Vernehmlassung (2010), S. 14, https://www.admin.ch/ch/d/gg/pc/documents/1764/Ergebnis.pdf.
[45] Ein Partnership Agreement regelt die einfache Gesellschaft, siehe SystemsX.ch Partnership Agreement 2013–2016ff, http://www.systemsx.ch/fileadmin/redaktion/SystemsX.ch/Organization/PartnershipAgreement_SystemsX-ch_2013-2016ff.pdf.
[46] Es sei nochmals darauf hingewiesen, dass der SNF nicht Objekt der Wirkungsprüfung des SWR ist.
[47] Schweizerischer Nationalfonds SNF (2007), Präsidium des Nationalen Forschungsrats, 13. März 2007 (rev. 26. April 2007), *SystemsX.ch. Zusammenfassung des Berichtes des Schweizerischen Nationalfonds zuhanden des Staatssekretariats für*

de facto nur die Modalitäten der Kooperation beeinflussen und Bedingungen für seine Beteiligung im Auswahlverfahren stellen. Der Grundsatz für eine Unterstützung wie auch die doppelte Entscheidstruktur mit einerseits einem von einem Konsortium organisierten Programm, andererseits der Evaluation der zu fördernden Projekte durch den SNF waren bereits im Januar 2007 in der BFI-Botschaft 2008–2011 publiziert worden.

Grundsätzlich begrüsste der SNF 2007 die Initiative zur gezielten Förderung von Systembiologie in der Schweiz.[48] Allerdings befürchtete er, dass das Programm nicht ausreichend multidisziplinär und fast ausschliesslich auf die molekulare Ebene ausgerichtet sei. Um das Ziel zu erreichen, biologische Systeme auf allen Hierarchieebenen quantitativ zu beschreiben und zu verstehen, müsse die Systembiologie Wissenschaftlerinnen und Wissenschaftler aus Biophysik, Mathematik, Informatik, Ingenieurwissenschaften, Physik, Chemie sowie Medizin gleichberechtigt zusammenbringen, forderte der SNF. Für seine Mitarbeit bei der Auswahl und wissenschaftlichen Begleitung von Gesuchen stellte der SNF zudem eine Reihe von Bedingungen. Dazu gehörte insbesondere, dass die Gesuche direkt beim SNF eingereicht wurden. Zur Prüfung der Gesuche schuf der SNF ein SNF-Panel Systembiologie. Das SNF-Reglement über Gesuche SystemsX.ch des Nationalen Forschungsrats hält weiter fest (Art. 6 Abs. 2): „Divergierende Meinungen zwischen dem Panel Systembiologie und SystemsX.ch werden wenn möglich vor den Entscheiden bereinigt. Die Entscheidung liegt beim Panel Systembiologie.“[49]

2010 konstatierte der SNF, die gesammelten Erfahrungen mit den neuen Evaluationsdienstleistungen (SystemsX.ch, Nano-Tera.ch sowie die bilaterale Forschungszusammenarbeit mit Schwerpunktländern) zeigten, dass die Übernahme solcher Aufgaben Chancen und Risiken bergen würden. „Einerseits verfügt der SNF über eine breite Erfahrung, sodass es ihm in der Regel gelang, breit akzeptierte Evaluationsentscheide zu treffen. Andererseits besteht in gewissen Konstellationen die Gefahr von äusseren Beeinflussungsversuchen, die den Ruf des SNF als unabhängige Institution schädigen könnten.“[50]

Auch wenn sich die Zusammenarbeit zwischen SystemsX.ch und dem SNF mit den Jahren einspielte, blieb die Haltung des SNF ambivalent. Im Mai 2012 stellte das Präsidium des Forschungsrats in einem Schreiben an die SUK allgemein fest, dass die Konstruktion solcher Förderinitiativen grundsätzlich überdacht werden müsste, sollte die Absicht bestehen, in Zukunft ähnliche Initiativen zu lancieren.[51] 2013 hielt der SNF in einer Selbstevaluation fest: „The SNSF should not try to integrate very large initiatives like SystemsX.ch or Nano-Tera into its portfolio. If such initiatives prove to be necessary, the SNSF should be involwved early on in the set-up process.”[52]

Betrachtet man das finanzielle Volumen, so gehört SystemsX.ch bis heute zu den grössten Forschungsprogrammen auf nationaler Ebene (konzentriert auf einen spezifischen Bereich in der Grundlagenforschung). SystemsX.ch stelle praktisch einen grossangelegten, gesamtschweizerischen NCCR dar, erklärte der damalige Staatssekretär Charles Kleiber bei der Lancierung der Initiative im Dezember 2007.[53] Der Umfang der thematischen Förderung durch SystemsX.ch wurde in den meisten SWR-Gesprächen angesprochen, und es wurde auf die weit über die 220 Mio. CHF hinausreichende Gesamtinvestition zugunsten der Systembiologie verwiesen.[54]

2.3 Ziele und Ablauf des Programms

Das Programmziel gemäss BFI-Botschaft 2008–2011 (siehe Kapitel 1.1), „im übergeordneten Interesse des Wissenschafts- und Technologiestandorts Schweiz eine umfassende Initiative zur Entwick-

Bildung und Forschung, Bern: SNF, http://www.snf.ch/SiteCollectionDocuments/Dossiers/dos_systemsx_bericht_kurz_d.pdf.

48 Ebenda, S. 2: „Die Schweizer Wissenschaftslandschaft würde eine grosse Chance verpassen, wenn die zur Zeit und auch zukünftig hier tätigen Forscherinnen und Forscher keine gemeinsamen technischen und wissenschaftlichen Plattformen bekommen und so nicht gezielt gefördert würden.“

49 Schweizerischer Nationalfonds SNF (2016), *Reglement über Gesuche SystemsX.ch,* Bern: SNF (Reglement vom 3. Juli 2007, angepasst; verfügbar via Webseite des SNF).

50 Schweizerischer Nationalfonds (2010), *Mehrjahresprogramm 2012–2016. Planungseingabe zuhanden der Bundesbehörden*, Bern: SNF.

51 Siehe dazu: Schweizerischer Wissenschaftsrat SWR (2018), *Appréciation de l'impact du programme national d'encouragement Nano-Tera.ch*, Bern: SWR, S. 14 https://www.wissenschaftsrat.ch/images/stories/pdf/fr/20180830_Nano-Tera_SSCreport_Final_publ_FR.pdf.

52 Schweizerischer Nationalfonds SNF (2013), *Evaluation of the Swiss National Science Foundation: Funding of infrastructure and development of research fields. Self-evaluation report of the SNSF,* Bern: SNF, http://www.snf.ch/SiteCollectionDocuments/news_151005_self_evaluation_report_snsf.pdf.

53 Charles Kleiber, „Initiative SystemsX.ch'“, Dokument der Pressemappe für die Medienkonferenz vom 5. Dezember 2007, Aussage gemäss Redetext.

54 In der Regel wurde dabei auf die 588 Mio. CHF in der BFI-Botschaft 2008–2011, S. 1353, verwiesen.

lung der Systembiologie in der Schweiz zu lancieren und damit eine weitere Grundlage für das Zusammenwirken der Forschungsförderung des Bundes mit der Privatwirtschaft zu schaffen (Public Private Partnership)“, lässt sich sowohl als Ausrichtung auf Grundlagen- wie auch anwendungsorientierte Forschung lesen. Breit gefächert sind auch die ursprünglichen Ziele des Programms, die SystemsX.ch 2007 in seinem Businessplan beschrieb:[55]

- „To provide the organizational and technological basis to enable systems biology research at the partner institutions;
- To foster the ongoing design, development and application of advanced technology and the training of scientists and engineers in the special skills required to understand biological systems;
- To develop, build and implement advanced technology platforms for the generation and management of the data required for systems biology projects;
- To initiate and nurture partnerships between the projects associated with the program and with other academic entities, industry and society;
- To carry out substantial projects that impact on and bring together the national and international systems biology research communities;
- To develop and coordinate curricula in systems biology at Swiss universities in order to educate a new generation of bioengineers and natural scientists for research and industry.”

Ausführlich äussern sich die Verantwortlichen im Businessplan (2007) zudem zur Kooperation mit der Wirtschaft. Es wurde eine enge, gar weltweit einzigartige Kooperation mit Industriepartnern vorhergesagt.

Im Hinblick auf die zweite Förderperiode[56] wurden die Prioritäten in einem mehrstufigen Prozess (unter Einbezug einer Stellungnahme des SNF auf der Grundlage der wissenschaftlichen Zwischenevaluation)[57] 2009–2012 angepasst und den Zielen neue Aspekte beigefügt.[58] Diese bezogen sich insbesondere auf die Postdoc-Förderung, die weiter zu stärkende Zusammenarbeit mit der Privatwirtschaft sowie die Nachhaltigkeit (inklusive Professuren).

Konkret erwähnte der Zweckartikel des Partnership Agreement (Stand Juni 2013) der SystemsX.ch-Partnerinstitutionen folgende Ziele:[59]

- „Coordinate the national and international collaboration of the Partners in the field of systems biology;
- Carry out scientific projects and establish highly specialized development and technology platforms in the field of systems biology;
- Coordinate the financial contributions for research projects in the field of systems biology;
- Coordinate the presentation of the Partnership under the name ‚SystemsX.ch’ and enforce this name as a mark of quality in the field of systems biology;
- Develop and implement common training programmes targeted to young researchers in the field of systems biology;
- Coordinate and intensify the cooperation with the private sector, politics and public administration;
- Promote a dialogue in and with the public on systems biology;
- Develop a concerted strategy to create and fill professorships in the field of systems biology;
- Secure additional external funding.”

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55 Zitiert aus: Selbstevaluation SystemsX.ch, Anhang B, S. 12.

56 Im Hinblick auf die Regelung des Zwischenjahres 2012 sowie die BFI-Periode 2013–2016 lud das SBF SystemsX.ch 2009 ein, eine Mehrjahresplanung für die Jahre 2012–2016 zu erarbeiten.

57 Das SNF-Panel lobte 2010 die exzellente disziplinenübergreifende Forschung und äusserte Empfehlungen für die nächste Finanzierungsperiode. Dazu gehörte unter anderem, sich weniger auf Infrastruktur, sondern mehr auf Forschung zu fokussieren sowie die Kapazitäten und Spitzenleistung in quantitativer Modellierung, Data Mining und physikalischen Interpretationen auf allen Ebenen (inklusive Fakultätsmitgliedern) zu erhöhen.

58 Eine umfassendere Darstellung der Ziele und ihrer Veränderung und Ergänzung ist in der Selbstevaluation von SystemsX.ch zu finden, Anhang B, S. 12ff. Die definitive Mehrjahresplanung von SystemsX.ch datiert vom April 2012.

59 SystemsX.ch Partnership Agreement 2013–2016ff. Stand: 18. Juni 2013, http://www.systemsx.ch/fileadmin/redaktion/SystemsX.ch/Organization/PartnershipAgreement_SystemsX-ch_2013-2016ff.pdf.

Zur Erreichung dieser Ziele schuf SystemsX.ch 2008–2016 zehn Fördergefässe sowie das IT-Projekt SyBIT und lancierte insgesamt zwölf Calls for Proposals[60]. Der grösste Anteil der Mittel floss an Research, Technology and Development (RTD) Projects (Auswahl durch SNF-Panel Systembiologie), ein Gefäss, das über die gesamte Lebensdauer von SystemsX.ch existierte. Ab 2015 wurde es mit einem Gefäss für Grossprojekte mit explizit medizinischer (oder idealerweise klinischer, wie der Call for Proposals betont) Ausrichtung ergänzt (Medical Research and Development, MRD Projects, Auswahl durch SNF-Panel Systembiologie). Die interdisziplinäre PhD-Förderung (IPhD) wurde in der zweiten Finanzierungsperiode mit einem ebenfalls interdisziplinär ausgerichteten Fördergefäss für Postdocs ergänzt (Transition Postdoc Fellowships TPdF, Auswahl ebenfalls durch den SNF).[61] Seit 2012 verfügte SystemsX.ch zudem über kleine Transfer-Förderungen zu industriellen Partnern (Transfer Projects).

SyBIT nahm eine Sonderstellung innerhalb von SystemsX.ch ein, sowohl bezogen auf die Organisation (siehe Kapitel 2.4) als auch durch seine Aufgabe als Unterstützer und Ermöglicher von systembiologischer Forschung. SyBIT verortete sich an der Schnittstelle zwischen den institutionellen IT-Ressourcen und der Forschung.[62]

Ein *phasing out* nach der BFI-Periode 2013–2016 hielt das SBF bereits 2010 fest.

2.4 Die Organisation

SystemsX.ch war als einfache Gesellschaft organisiert. Die Zusammensetzung der jeweiligen Organe ist in den jährlichen Scientific Reports von SystemsX.ch aufgeführt. Im Board of Directors waren die Leitungen der Partnerinstitutionen vertreten, für Entscheide von wissenschaftlichen und operationellen Fragen war das SEB zuständig.[63] Zu seinen Aufgaben gehörte:

- „Establish the business plan, the budgets, the annual account and the annual management report of SystemsX.ch to be submitted to the Board of Directors' Meeting;
- Call for project proposals to the Partners of SystemsX.ch in collaboration with the Swiss National Science Foundation and determine the funding level of the call;
- Comment on each proposal for Research, Technology and Development (RTD) Project, Transfer (TF) Project, Transition Postdoc Fellowship (TPdF) Project and Interdisciplinary PhD-Project (IPhD) to the Swiss National Science Foundation;
- Confirm (1) the final decision of the Swiss National Science Foundation on acceptance / rejection and (2) the budget of the approved RTD Projects, TF Projects, TPdF Projects and IPhD Projects in concert with the Swiss National Science Foundation;
- Meet the Swiss National Science Foundation to settle disagreements on the evaluation of RTD Projects, TF Projects, TPdF Projects and IPhD Projects;
- Monitor the approved RTD Projects and TF Projects in collaboration with the Swiss National Science Foundation;
- Render the final decision on acceptance and budget of approved ERANET ERASysAPP Projects involving Swiss research groups, Special Opportunity Projects and other requests (e.g. to support conferences etc.) put forward to SystemsX.ch;
- Create and appoint commissions or committees for specific purposes (e.g. education) and appoint and dismiss the members of such bodies;
- Create a Management Office and select a Managing Director to be proposed to the Board of Directors;

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60 http://www.systemsx.ch/systemsxch/calls-for-proposals/past-systemsxch-calls/. Eine umfassende Darstellung der Fördergefässe ist in der Selbstevaluation SystemsX.ch, Anhang B, S. 17 zu finden.

61 Zwei gleichnamige Nachwuchsförderlinien sind im ersten Call, 2017, der Personalized Health and Related Technologies-Initiative (PHRT) zu finden, einem strategischen Fokusbereich des ETH-Bereichs für personalisierte Medizin. Weitere Informationen siehe https://www.sfa-phrt.ch/.

62 Für weitere Informationen siehe SystemsX.ch und die Dateninfrastruktur, Anhang D, sowie die SyBIT-Selbstdarstellung aus heutiger Sicht http://www.sybit.net/about.

63 Die Funktionsweise der Gesellschaft wurde durch ein Partnership Agreement geregelt (Stand: Juni 2013) http://www.systemsx.ch/fileadmin/redaktion/SystemsX.ch/Organization/PartnershipAgreement_SystemsX-ch_2013-2016ff.pdf.

- Coordinate the collaboration in research and education in the field of systems biology. The Scientific Executive Board may, within the limits of financial resources available to SystemsX.ch for this purpose, support interdisciplinary programmes of Partners;
- Submit proposals for the composition of appointment committees to the competent bodies of the Partners;
- Represent the Partnership;
- Ensure the internal communication;
- All other powers not assigned to another body in this Partnership Agreement."[64]

Das Scientific Advisory Board (SAB) bestand bis 2012 und wurde danach aufgelöst.

Auf die Rolle des SNF wurde bereits eingegangen (siehe Kapitel 2.2 und 2.3). Der SNF war insbesondere für die unabhängige Prüfung der Projektgesuche und, darauf gestützt, für die definitiven Beitragsentscheide sowie die Sicherung der übergeordneten wissenschaftlichen Qualität, die Prüfung der Finanz- und Revisionsberichte und das Reporting an das SBFI (inkl. periodisch durchgeführte wissenschaftliche Zwischenevaluationen) zuständig.[65]

Die Organisationsform von SystemsX.ch wurde gegenüber dem SWR von den damals Beteiligten mit der Entstehungsgeschichte begründet. Für Staatssekretär Kleiber war es eine „exemplarische Organisationsform für die Realisierung gemeinsamer Ziele und für die permanente Herausforderung, kostenintensive Forschungsinfrastrukturen gemeinsam zu planen und zu nutzen sowie Kompetenzen und Know-how durch Forschungskooperationen zu vernetzen und zu bündeln"[66], wie er bei der Lancierung 2007 erklärte. Die Förderinitiative sei somit exemplarisch für eine Public Private Partnership (PPP) und leiste mittelfristig einen wichtigen Beitrag zur Standortförderung Schweiz.

Über eine eigene Organisationsstruktur innerhalb von SystemsX.ch verfügte das IT-Projekt SyBIT; es bestand aus einem Mixmodell mit voller Integration auf RTD-Projektebene (gemeinsame Infrastrukturen) sowie externer Integration auf übergeordneter Ebene (Metadaten-Plattform).[67]

[64] Ebenda, Art. 20 (Auszug).

[65] Die Zuständigkeiten und Verantwortlichkeiten sind in den Verfügungen des SBF aufgeführt, das Verhältnis des SNF zu SystemsX.ch ist in einem SNF-Reglement geregelt. (Schweizerischer Nationalfonds SNF 2016, *Reglement über Gesuche SystemsX.ch,* Bern: SNF; Reglement vom 3. Juli 2007, angepasst; verfügbar via Webseite des SNF).

[66] Charles Kleiber, „Initiative SystemsX.ch'", Dokument der Pressemappe für die Medienkonferenz vom 5. Dezember 2007, Aussage gemäss Redetext.

[67] Das Konzept wurde im Herbst 2008 vom SEB SystemsX.ch erarbeitet und Anfang 2009 vom SNF bewilligt. Weiteres siehe SystemsX.ch und die Dateninfrastruktur, Anhang D.

3 Analysen und Ergebnisse

3.1 Gesamtwürdigung

Die Denkweisen der Biologie haben sich in diesem Jahrhundert, seit der Genomsequenzierung, stark entwickelt. Die Systembiologie hat sich als neuer Ansatz in der biologischen Forschung etabliert – und Schweizer Forschende aus verschiedenen Institutionen sind an der Weltspitze mit dabei. Die Förderung von SystemsX.ch führte zu qualitativ hochstehenden Forschungsergebnissen. Das zeigte die Analyse der Publikationen im Rahmen der Selbstevaluation (siehe Anhang B) und wurde übereinstimmend von Schweizer Fachleuten im Gespräch mit dem SWR bestätigt. Äusserst positiv fällt auch die wissenschaftliche Beurteilung des Expertenpanels aus: „SystemsX has produced the very best science and has put Switzerland firmly on the international map as a major hub of systems biology research.“[68]

Bei der raschen Etablierung der Systembiologie in der Schweiz spielte SystemX.ch für das Expertenpanel „a seminal role”[69]. Die fokussierte Sonderfinanzierung sei bei der Implementierung ein zentraler Faktor gewesen, lautet die übereinstimmende Einschätzung der internationalen wie der Schweizer Fachleute; Schweizer Akteure betonten die Rolle der zusätzlichen Fördermittel als wichtigen Beschleuniger und verwiesen als Beispiel darauf, dass Bioinformatiker heute ihren Platz in den Labors hätten.[70]

Die Forschenden haben die Gelegenheit genutzt; sie steigerten mit der aus der Sonderförderung resultierenden Spitzenforschung die Bekanntheit und die internationale Wettbewerbsfähigkeit der systembiologischen Forschungsgemeinschaft, was sich auch positiv auf die Positionierung des schweizerischen BFI-Systems auswirkte. Diese Folgerung ist für den SWR evident, auch wenn sich die Kausalität anhand der existierenden Daten nicht nachweisen lässt.

Nachfolgend werden die Hauptthemen des SBFI-Mandats analysiert und in Zusammenhang mit den Zielen des Programms gestellt. Ergänzt wird das Kapitel mit einer systemischen Perspektive. Seine Schlussfolgerungen zieht der SWR auf der Basis einer Triangulation der Informationen; die jeweils angefügten Schlussfolgerungen sind im Hinblick auf Verbesserungspotenzial für allfällige andere Grossinitiativen als *lessons learned* verfasst.

3.2 Analyse der Hauptthemen des Auftrags

In diesem Kapitel beschäftigt sich der SWR mit den Hauptthemen des SBFI, jeweils eingeführt von den Key Statements. Einleitend ist darauf hinzuweisen, dass die von SystemsX.ch und vom SNF erhaltenen Dokumente zwar ermöglichten, einige Aspekte der Realisierung von SystemsX.ch zu erhellen. Es war jedoch aufgrund der Datenlage nicht möglich, die Prozesse des Programms lückenlos nachzuzeichnen.

3.2.1 Strukturelle Auswirkungen auf die Partnerinstitutionen

3.2.1.1 Key Statements SBFI

- *SystemsX.ch has supported the partner institutions in setting up the organizational and technological infrastructure necessary to practice systems biology research.*
- *SystemsX.ch has enabled sustainability of research assets by supporting science IT and data management services.*

[68] Siehe Bericht des externen Expertenpanels, Anhang C, S. 2.
[69] Ebenda.
[70] Gemäss Angaben von SWR-Gesprächspartnern.

3.2.1.2 Analyse

Für den SWR sind im Zusammenhang mit SystemsX.ch vielfältige strukturelle Auswirkungen zu berücksichtigen: namentlich die Schaffung, resp. Neuorientierung von Professuren und Zentren, die Reorganisation von Forschungsschwerpunkten, die Entwicklung neuer Lehrinhalte bis hin zur Einführung neuer Ausbildungsgänge sowie die Bereitstellung neuer Forschungsmittel und -infrastrukturen für die Erhebung, Speicherung, Analyse und den Austausch von Daten. Zentrales Kriterium der Nachhaltigkeit ist für den SWR, dass die Massnahmen in den Partnerinstitutionen nach Auslaufen der Sonderfinanzierung fortgeführt werden.

Organisationale Veränderungen: Zentren, Professuren, Forschungsgruppen

Laut SystemsX.ch sollte das Prinzip der „matching funds" dazu dienen, dass sich die Partnerinstitutionen zu einer nachhaltigen Implementierung des systemischen Ansatzes bekennen.[71] Zudem mahnte der SNF im Hinblick auf die zweite Förderperiode mehr Anstrengungen zur Nachhaltigkeit an (siehe Kapitel 2.3). Allerdings hatte SystemsX.ch gemäss den SWR-Gesprächspartnern gesamtschweizerisch betrachtet nur teilweise strukturbildenden Einfluss.[72]

Entsprechend den Angaben von SystemsX.ch[73] unterscheidet sich die organisationale Veränderung zwischen den beteiligten Institutionen beträchtlich. An der ETHZ, der UniZH und der UniBas wurde die Systembiologie bereits ab 2004 im Rahmen von SystemsX als Schwerpunkt ausgewiesen; dort ist die Strukturbildung am stärksten ausgeprägt. In Relation zu den erhaltenen Fördermitteln wurden hingegen in den Hochschulen der Genferseeregion wenige neue Zentren und Professuren geschaffen (keine an der UniGe).[74] Im Hinblick auf das im Partnership Agreement anvisierte Ziel, eine konzertierte Strategie zu entwickeln, um Lehrstühle im Bereich der Systembiologie zu schaffen und zu besetzen (siehe Kapitel 2.3), ist keine explizite Umsetzungsstrategie ersichtlich. Zudem ist das Monitoring, resp. Reporting, in diesem Punkt lückenhaft.[75]

Die Arbeit mit grossen Datenmengen

Wesentlicher Teil der auf quantitativen Ansätzen fussenden Systembiologie ist die Arbeit mit grossen Datensätzen. Dies war den SystemsX.ch-Verantwortlichen von Beginn an bewusst und manifestierte sich in den Strategiepapieren. Die grundsätzliche Diskussion über die Erhebung und Verwendung der neu gewonnenen Daten wurde jedoch zu wenig vorangetrieben. Dies zeigt sich auch daran, dass Computational Biology, anders als ursprünglich konzipiert, nie zum Schwerpunkt der Initiative wurde (siehe Kapitel 3.2.4).

Datenerhebung, -analyse, -lagerung und -austausch sollten mit der Hilfe von SyBIT gefördert werden. Die hohen Ansprüche wurden jedoch nur teilweise eingelöst, wie die vom SWR in Auftrag gegebene Analyse feststellte.[76] Nach Abschluss von SystemsX.ch sind Dateninfrastrukturen in der Deutsch-

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71 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 19.

72 Für das aussergewöhnliche Programm SystemsX.ch lässt sich kein Benchmark zur Verifizierung dieser Aussagen beiziehen. Mögliche Hinweise bieten thematisch verwandte abgeschlossene NCCRs der ersten Serie (2001–2013): im NCCR Genetics wurden 3 neue Professuren, 3 neue Tenure Tracks und 3 Nachfolgeprofessuren geschaffen / im NCCR Neuro wurden 1 neue Vollprofessur, 9 neue Assistenzprofessuren und 3 Nachfolgeregelungen geschaffen / im NCCR Molekulare Onkologie wurden 7 neue Assistenzprofessuren geschaffen (Quelle: SNF, Übersicht über abgeschlossene NCCRs, http://www.snf.ch/de/fokusForschung/nationale-forschungsschwerpunkte/Seiten/default.aspx#Abgeschlossene%20NFS). Siehe zudem Selbstevaluation SystemsX.ch, Anhang B, Appendix B, Tabellen A2 und A3.

73 Siehe Selbstevaluation SystemsX.ch, Anhang B, Appendix B, Tabellen A2 und A3.

74 Allerdings zeigt sich in der Romandie eine weitaus grössere Überlappung von SystemsX.ch und NCCRs als in Deutschschweizer Hochschulen. Betrachtet man SystemsX.ch-Gesuchsteller, die gleichzeitig in einem NCCR aktiv sind, steht das NCCR Genetics (Heiminstitution UniGe) zuoberst, gefolgt von NCCR Neuro (UniZH), NCCR Molekulare Onkologie (UniL) und NCCR Chemische Biologie (UniGe und EPFL).

75 Als Beispiel sei auf die Selbstevaluation SystemsX.ch, Anhang B, Appendix A, Tabelle A3 verwiesen, „Staff hired since 2008 to foster systems biology research" beruht auf einer Umfrage bei den Partnerinstitutionen 2016. Präzise Informationen zur Entwicklung im Verlauf des Programms und zur Nachhaltigkeit lassen sich daraus nur beschränkt herauslesen. Gleichzeitig bezweifelt der SWR nicht, dass sich die biologische Forschung und Lehre seit 2004 stark in Richtung quantitatives Verständnis der biologischen Prozesse entwickelte und dass die beträchtliche Sonderfinanzierung der hierzu notwendigen Forschung den Wandel beschleunigte.

76 Siehe SystemsX.ch und die Dateninfrastruktur, Anhang D.

schweiz auf universitärer Ebene verankert, in der Romandie findet sich mit Vital-IT des Schweizerischen Instituts für Bioinformatik (SIB)[77] ein zentraler Ansprechpartner für alle universitären Hochschulen.

Trotz des Strategiewechsels und der Abkehr vom Bau neuer Infrastrukturen im Hinblick auf die zweite Förderperiode[78] und entsprechend einer dezentraleren Sichtweise gehörten Koordinationsaufgaben zwischen den Projekten und Institutionen gemäss der Interpretation des SWR während der gesamten Laufzeit zum Auftrag von SyBIT. Eine nachhaltige gesamtschweizerische Koordination wurde jedoch nicht geschaffen.

Wie SystemsX.ch in seiner Selbstevaluation ausführt, profitierten viele RTD Projects nicht von SyBIT; entweder, weil sie das Angebot nicht gut genug kannten, oder weil SyBIT nicht bot, was sie brauchten.[79] Gemäss der Analyse von SystemsX.ch lag das daran, dass SyBIT top-down geschaffen worden war und die Bedürfnisse der Forschenden zu wenig einbezogen wurden. Der SWR teilt diese Analyse nur bedingt: Die Kooperation mit den Partnerinstitutionen zu fördern und die Serviceorientierung von SyBIT (für die Forschenden) einzufordern, hätte namhaft zu den Führungsaufgaben des SEB gehört.[80] SystemsX.ch mit seiner auf konkrete Forschungsvorhaben fokussierten Dateninfrastruktur hätte eine Vorreiterrolle spielen können bei der Koordination der Bedürfnisse von Partnerinstitutionen und Forschenden.

3.2.1.3 Schlussfolgerungen

Wenig Koordination der Partnerinstitutionen

- Die gemeinsame Vision, gesamtschweizerisch belegbare, nachhaltige Veränderungen der Forschungsausrichtungen in den SystemsX.ch-Partnerinstitutionen zu realisieren, wurde nur zögerlich operationalisiert. Gemeinsame Strategien zur Umsetzung und Realisierung der dazu notwendigen Forschungsgruppen, Professuren und auch technologischen Infrastrukturen fehlten weitgehend. Auch das Monitoring blieb lückenhaft.

Mehr Führung des SEB von SystemsX.ch

- Der für die Arbeit mit „big data“ verstärkten Kooperation zwischen zentralisierten und dezentralisierten IT-Einheiten und zwischen Institutionen wurde vom Konsortium zu wenig Aufmerksamkeit zuteil. Zentraler Faktor einer erfolgreichen Zusammenarbeit sind die Forschenden und ihre Bedürfnisse im Rahmen ihrer Forschungsprojekte: Die nationale Kooperation zu fördern und gleichzeitig die Forschungsnähe zu vertreten, ist eine Führungsaufgabe.[81]

3.2.2 Auswirkungen auf interdisziplinäre und interinstitutionelle Kooperationen

3.2.2.1 Key Statements SBFI

- *SystemsX.ch systematically initiated and funded interdisciplinary, interinstitutional research collaborations between the partner institutions.*
- *SystemsX.ch has reached out towards the private sector to facilitate the implementation of system biology approaches in industry and SMEs.*
- *SystemsX.ch has created the basis for international research collaborations.*

3.2.2.2 Analyse

Für den SWR ist die Zusammenarbeit auf verschiedenen Ebenen zu betrachten; dazu gehört die Kooperation von Forschenden wie von Institutionen sowie allenfalls deren Auswirkungen auf die BFI-Landschaft.

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77 Das Kompetenzzentrum existierte bereits vor der Lancierung von SystemsX.ch, https://www.vital-it.ch/.
78 SystemsX.ch und die Dateninfrastruktur, Anhang D, S. 9.
79 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 62.
80 SystemsX.ch und die Dateninfrastruktur, Anhang D, geht detaillierter auf diese Punkte ein und beleuchtet auch die positiven Entwicklungen im Umgang mit grossen Datenmengen, darunter die Förderung der dezentralen wissenschaftlichen IT-Unterstützungseinheiten.
81 In diesem Sinn hat sich der SWR bereits zu Open Access geäussert. Siehe Schweizerischer Wissenschafts- und Innovationsrat (2015), *L'Open Access du point de vue de l'auteur-chercheur. Thèses et recommandation du CSSI*, SWIR Schrift 10/2015, Bern: SWIR.

Interdisziplinarität
Die interdisziplinäre Ausrichtung des Programms widerspiegelt sich in den Calls for Proposals[82], RTD Projects sind explizit Kooperationen von Forschenden mehrerer Disziplinen. Äusserst positiv ist die Bewertung des Expertenpanels, das aufgrund seiner Erfahrung festhält, „that a large number of highly visible papers have been co-authored by scientists representing different fields".[83] Die Selbstevaluation von SystemsX.ch analysiert die Publikationen ebenfalls ausführlich.[84] Gemäss übereinstimmenden Aussagen der befragten Schweizer Fachleute sind Bioinformatiker heute (wie bisweilen weitere Ingenieurwissenschaftler) fester Bestandteil von biologischen Labors; diese sind multidisziplinärer, die Mitarbeitenden „mehrsprachiger" geworden (siehe Kapitel 3.2.3). Der SWR bewertet diese von SystemsX.ch vorangetriebene Entwicklung sehr positiv. Auf die Frage zur Zusammenarbeit im Hinblick auf eine grundlegende Veränderung der Betrachtungsweise der Biologie (namentlich mathematische Modelle und theoriezentrierte Forschungsansätze) wird in Kapitel 3.2.4 eingegangen.

Interinstitutionelle Zusammenarbeit
Die Förderung der interinstitutionellen Zusammenarbeit wird in der Selbstevaluation von SystemsX.ch dargelegt.[85] Hervorgehoben werden soll hier einerseits, dass Forschende und Organe der ETH verstärkt kooperierten – in Zürich, Basel und Lausanne. Andererseits ermöglichte SystemsX.ch eine Zusammenarbeit von (aus systembiologischer Sicht) „kleineren" Universitäten mit dem ETH-Bereich; in den Gesprächen wurden explizit nicht nur die erfolgreiche Kooperation von Forschenden erwähnt, sondern auch der Zugang zu Forschungsinfrastrukturen anderer (grösserer) Institutionen. Die Kooperationen wirkten sich somit gesamtschweizerisch positiv auf die Systembiologie aus. Allerdings fällt auf, dass zu den Partnerinstitutionen als einzige Fachhochschule die Zürcher Hochschule für Angewandte Wissenschaften (ZHAW) gehört.

Kooperation mit der Privatwirtschaft
SystemsX.ch kommt zum Schluss, dass der Beitrag der Privatwirtschaft von den Initianten des Programms überschätzt wurde,[86] die ehrgeizigen Ziele wurden bei Weitem verfehlt. Für den SWR liegt der Grund primär in der ambivalenten Ausrichtung des Programms sowohl auf Grundlagenforschung wie auf Anwendungsorientierung. Die zweite dieser beiden Zielsetzungen wurde auf Programmebene weder präzisiert (z.B. angestrebte Technology Readiness Levels, TRLs[87]), noch wurden entsprechende Umsetzungskonzepte geschaffen, um die Kooperation der RTD Projects mit Industrie und Nutzerinnen und Nutzern zu unterstützen (Wissens- und Technologietransfer WTT).[88] Es lässt sich zudem feststellen, dass der angestrebte Fokus auf Technologie-Entwicklungen während der zweiten Förderperiode klar in den Hintergrund trat.[89]

Der SWR ist der Ansicht, dass die Orientierung auf die Grundlagenforschung (ergänzt mit explizit anwendungs- und transferorientierten Fördergefässen) durchaus eine richtige Entscheidung zur Förderung der schweizerischen Systembiologie sein kann, auch als Grundlage für PPP. Da bei Grundlagenforschung spätere Anwendungen kaum vorhersehbar sind, spricht sich der SWR (anders als das Expertenpanel[90]) rückblickend nicht dafür aus, RTD Projects generell zu WTT zu verpflichten. Dies hätte jedoch die einzelnen RTD Projects wie auch das gesamte Programm nicht davon entbunden,

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82 http://www.systemsx.ch/systemsxch/calls-for-proposals/past-systemsxch-calls/.
83 Siehe Bericht des externen Expertenpanels, Anhang C, S. 2.
84 Siehe Selbstevaluation SystemsX.ch, Anhang B, Appendix B.
85 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 26ff.
86 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 62. Bei den Diskussionen im Juni 2017 verwies SystemsX.ch zudem auf sieben Spin-offs, die im Zusammenhang mit dem Förderprogramm gegründet worden waren.
87 Siehe dazu auch die Überlegungen von Interface (2017), *Wissens- und Technologietransfer von Nano-Tera.ch*, Bern: SWR (Publikation im Rahmen der SWR-Wirkungsprüfung des nationalen Förderprogramms Nano-Tera.ch, https://www.wissenschaftsrat.ch/images/stories/pdf/fr/20180830_Nano-Tera_SSCreport_Final_publ_FR.pdf) sowie https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf.
88 Das SEB von SystemsX.ch beschloss 2008 ein Industry Cooperation Concept, identifizierte darin Zielgruppen aus der Wirtschaft und stellte mögliche Kooperationsmodelle vor (financial involvement in a specific research subject / visiting professorship / licenses, patents / sponsoring). Gemäss Selbstevaluation SystemsX.ch, Anhang B, Appendix A, Tabelle A5 blieb die Umsetzung jedoch auf der Ebene Management/SEB.
89 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 12.
90 „We think an important lesson for the future is that technology transfer activities should be a must in these large projects. […] Also reserving a small percentage of the budget for valorization will help." Aus: Bericht des externen Expertenpanels, Anhang C, S. 4.

den Grad der Anwendungsorientierung in jedem einzelnen Fall zu klären und allenfalls Umsetzungsmassnahmen darzulegen. Das Gleiche gilt in besonderem Masse für die (auf maximal drei Jahre begrenzten) translationsorientierten MRD Projects.

Es zeichnet das SystemsX.ch-Konsortium aus, dass sich die Fördergefässe im Lauf der Initiative veränderten. Als Beispiel sei hier auf die kleinen Transfer Projects verwiesen.[91] Allerdings widerspiegelt das Beispiel mit seinen acht geförderten Projekten auch die Grenzen solcher Kooperationsgefässe bei einer Sonderinitiative: Da nur drei Calls stattfanden (2012, 2013, 2014),[92] war es nicht möglich, das Angebot bei allen potenziell interessierten kleinen und mittleren Unternehmen zu verbreiten, wie SWR-Gesprächspartner betonten. Zudem erhielt der SWR in seinen Gesprächen keine Hinweise darauf, dass allfällige Lehren aus speziellen Fördergefässen in den traditionellen Förderinstitutionen vertieft analysiert wurden.

Internationale Kooperationen

Der Schub der systembiologischen Forschung durch die SystemsX.ch-Förderung und die Publikationen von Spitzenforscherinnen und -forschern (siehe Kapitel 3.1) wurden international zur Kenntnis genommen. Die Ergebnisse des Programms stärkten das Ansehen des Forschungsstandortes Schweiz. Dass ausländische Forschungsgruppen als Ko-Gesuchsteller zugelassen waren, half ebenfalls, eine Grundlage für internationale Forschungszusammenarbeit zu schaffen. Die Teilnahme am European Research Area Network for Applied Systems Biology (ERASysAPP)[93] und auch die Mitbegründung des FAIRDOM-Projektes (Dienstleistungseinrichtung für Daten- und Modellmanagement in der Systembiologie)[94] belegen für den SWR den Mehrwert eines Programms wie SystemsX.ch.

Exkurs: Der Austausch mit der Gesellschaft

Der Zweckartikel des Partnership Agreement von Systemsx.ch sah nicht nur eine Kooperation mit der Politik und der Verwaltung vor, sondern wollte auch „promote a dialogue in and with the public on systems biology“ (siehe Kapitel 2.3). Inwiefern dieses Ziel operationalisiert wurde und wie die Selbstevaluation von SystemsX.ch ausfällt, bleibt offen. Das Mandat des SBFI forderte keine entsprechenden Analysen ein. Der SWR bedauert dies. Denn SystemsX.ch, das sich von Beginn an als Wegbereiter für die personalisierte Medizin sah[95] und sich mit den MRD Projects in der zweiten Förderperiode explizit der medizinischen Forschung zuwandte, hätte bezüglich Dialog mit der Zivilgesellschaft erste Schritte unternehmen können und müssen. Entsprechende Aktivitäten hätten einen wichtigen Beitrag zur reflektierten und differenzierten Auseinandersetzung der Bevölkerung mit Fragen der Datenerhebung und -speicherung geleistet, die bei der Einführung der personalisierten Medizin eine zentrale Rolle spielen werden. Trotz des (in öffentlichen Umfragen dokumentierten) grossen Interesses der Bürgerinnen und Bürger an (Bio-)Medizin, traten kaum Forschende unter dem Label SystemsX.ch in den Schweizer Medien in Erscheinung.

Nachhaltigkeit der Förderung

Da es bei Kooperationen stets um die Interaktion von Individuen geht, ist der SWR zurückhaltend bei der Bewertung von Langzeitwirkungen. Zudem wurde das Programm erst kürzlich beendet. Die eher formalisierten Verflechtungen (insbesondere international) haben eine grössere Überlebenswahrscheinlichkeit als befristete projektbezogene Kooperationen unter Forschungsgruppen-Mitgliedern. Entsprechend wollten sich die befragten Schweizer Fachleute mehrheitlich nicht zur Nachhaltigkeit äussern, auch wenn in den Gesprächen, insbesondere bei Kooperationen zwischen ETHZ und EPFL, eine Verbesserung und bei der Vernetzung der Hochschulen der Romandie via Vital-IT eine Vertiefung festgestellt wurden.

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91 Detaillierte Informationen zur Förderung lagen nicht vor, ein umfassendes Monitoring hätte Aussagen über die Nachhaltigkeit der Transfer-Förderung ermöglicht.

92 Details siehe http://www.systemsx.ch/systemsxch/calls-for-proposals/past-systemsxch-calls/.

93 ERASysAPP hatte zum Ziel, während einer Laufzeit von drei Jahren (2013–2015) in Europa die Vernetzung und Zusammenarbeit zwischen Institutionen und Wissenschaftlern in der Systembiologie zu intensivieren. Beteiligt waren 16 europäische Partner aus 13 Ländern. SystemsX.ch (mandatiert vom SNF) leitete das Work Package 3 „Training and Exchange“. Weiteres siehe https://www.erasysapp.eu/home.

94 https://fair-dom.org/.

95 Und darauf auch in den Visionen des Businessplans 2007 hinwies.

3.2.2.3 Schlussfolgerungen

Verbindlichkeit zeitigt Erfolge

- SystemsX.ch forderte die interdisziplinäre Ausrichtung der systembiologischen Forschung in den Calls for Proposals verbindlich ein. Dadurch funktionierte diese Förderung der Interdisziplinarität gut.

WTT

- Das Gesamtprogramm und die unterschiedlichen Fördergefässe verfügten über wenig konkrete Strategien, um, angepasst an die einzelnen Projekte, WTT einzufordern. Bei Projekten, die sich in ihrem eigenen Rhythmus zwischen Grundlagenforschung, Anwendungsorientierung und Translation bewegen, sind eine individuelle Strategie und Umsetzungsplanung erfolgsversprechender als generelle Vorgaben.

Austausch mit F&I-Förderinstitutionen

- Es gehört zu einem Sonderprogramm wie SystemsX.ch, neue Fördergefässe zu testen und sie dynamisch anzupassen. Allerdings wurde der Mehrwert gerade für die gängige Forschungsförderung zu wenig abgebildet und verfügbar gemacht, um neue Entwicklungen zu ermöglichen.

3.2.3 Auswirkungen auf die Förderung junger Talente

3.2.3.1 Key Statements SBFI

- *SystemsX.ch has triggered the development of educational programs at Masters and PhD level at partner institutions to educate the next generation of systems biology researchers.*
- *SystemsX.ch implemented new funding instruments to promote interdisciplinary education and training for the next generation of systems biology researchers.*
- *SystemsX.ch has supported the training of scientists and engineers in special skills required to understand biological systems as well as in skills that are crucial to carrying out interdisciplinary research.*

3.2.3.2 Analyse

Für den SWR sind Veränderungen in den bestehenden Ausbildungsgängen ebenso wichtig wie die Schaffung spezifischer Angebote. Der Rat ist sich zudem der besonderen Herausforderungen von interdisziplinären PhDs und sich daran anschliessenden beruflichen Entwicklungen der Doktorandinnen und Doktoranden bewusst.

Integration der Systembiologie in den Partnerinstitutionen

Die Systembiologie ist, beschleunigt durch die SystemsX.ch-Förderung, auf allen Ebenen der Ausbildung in die Schweizer Hochschulen integriert, da stimmt der SWR den befragten Schweizer Fachleuten zu. Die von SystemsX.ch in der Selbstevaluation aufgelisteten Master- und PhD-Programme[96] sind somit nur ein (sichtbarer) Teil einer grundsätzlichen Veränderung; diese ist durchaus auch als nachhaltiger struktureller Effekt der Initiative zu würdigen.

Noch weiter geht das internationale Expertenpanel: „There is now a pool of well-trained scientists on systems biology that can tackle the new challenge of precision medicine. Without SystemsX it is doubtful that a successful program in precision medicine could be launched."[97]

„Mehrsprachige" junge Forschende

Die Vermittlung von neuen Kompetenzen in der Ausbildung wie auch die Mitarbeit von Nachwuchsforschenden in interdisziplinären RTD und MRD Projects befähigen junge Forschende, vermehrt über disziplinäre Grenzen hinweg zu arbeiten. Sie haben sich mit Computational Biology sowie mathematischen und physikalischen Modellierungen auseinandergesetzt und sind häufig mit Ansätzen zur Bearbeitung grosser Datensätze wie auch mit der Kommunikation über ihre Forschungsarbeit vertraut.

[96] Siehe Selbstevaluation SystemsX.ch, Anhang B, Appendix A, Tabellen A10 und A11.
[97] Siehe Bericht des externen Expertenpanels, Anhang C, S. 3.

Gemäss einer Zusammenstellung von SystemsX.ch[98] arbeiteten rund 180 PhD-Studierende und 160 Postdocs bei RTD und MRD Projects mit. 63 % der jungen Forschenden blieben nach Abschluss ihres Engagements in den RTD/MRD Projects im akademischen Umfeld, 28 % wechselten in die Privatwirtschaft. Dies reflektiert die Ausrichtung des Programms, aber auch den Bedarf der Privatwirtschaft nach den ausgebildeten Fachleuten.

Interdisziplinäre PhDs und Transition Postdoc Fellowships
SystemsX.ch förderte 87 Studierende, die ihren PhD interdisziplinär in zwei verschiedenen Labors durchführten und ermöglichte (ab 2012) 32 Postdocs Zugang zu einem neuen Wissenschaftsgebiet (Fördergefässe IPhD und TPdF). Diese Förderung ist aus Sicht des SWR wichtig, da künftig vermehrt übergreifende Kompetenzen gefragt sein werden.[99]

In seiner Selbstevaluation weist SystemsX.ch auf das grundsätzliche Problem der Förderung von interdisziplinären PhDs hin.[100] Der SWR stimmt zu, dass der Weiterführung solcher Programme ohne Sonderfinanzierung Hindernisse im Weg stehen. Die disziplinäre Verortung bleibt das Hauptkriterium für die Organisation von akademischen Laufbahnen wie auch Publikationskanälen. Somit bleibt das akademische Reward-System von den Disziplinen bestimmt. Während sich der Zugang junger Forschender zu interdisziplinären Doktoratsprogrammen sehr positiv auf die Ausbildung auswirken kann, sind diese im Einzelfall für die akademische Förderung bisweilen hinderlich. Aus der Sicht des SWR sollten die Hochschulen von speziellen Programmen wie SystemsX.ch lernen und ihre Doktoratsförderung (insbesondere die interdisziplinäre) überdenken.

Hinzu kommt, dass in der Privatwirtschaft häufig Forschende für ganz spezifische Gebiete gesucht werden; ein interdisziplinärer PhD ist für den Start einer Karriere in der Privatwirtschaft somit nur in Einzelfällen ein Vorteil.

Gerade im Hinblick auf die Weiterführung durch die ETH im Rahmen der PHRT-Initiative ist zu bedauern, dass SystemsX.ch einem Langzeit-Monitoring der interdisziplinären Nachwuchsförderung nicht mehr Beachtung schenkte.

3.2.3.3 Schlussfolgerungen

Förderung von Interdisziplinarität

- „Mehrsprachige“ und interdisziplinäre Fachleute sind wichtig – insbesondere für die Zukunft der akademischen Forschung sowie, wenn auch in geringerem Ausmass, für die Forschung und Entwicklung der Privatwirtschaft. Mit seiner Förderung hat SystemsX.ch einen wichtigen Schritt gemacht. Nun sind die Partnerinstitutionen in der Pflicht, darauf hinzuwirken, dass die Bewertungssysteme der Akademie interdisziplinäre Karrierewege besser widerspiegeln. Inwiefern spezifisch interdisziplinär orientierte Nachwuchsfördergefässe dazu beitragen können, wäre noch zu prüfen.

3.2.4 Wissenschaftliche Auswirkungen

3.2.4.1 Key Statements SBFI

- *SystemsX.ch has initiated a movement in biological sciences from a descriptive, qualitative science to a quantitative, predictive science.*
- *SystemsX.ch has funded interdisciplinary research projects that had a high impact output.*
- *SystemsX.ch has fostered the design, development and application of advanced technology and technology platforms.*
- *SystemsX.ch has contributed to steering the funded research towards current social needs, in particular medicine.*

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98 Siehe Selbstevaluation SystemsX.ch, Anhang B, Appendix A, Tabelle A13.
99 In diesem Sinne ist es erfreulich, dass die Personalized Health and Related Technologies-Initiative (PHRT), ein strategischer Fokusbereich des ETH-Bereichs für personalisierte Medizin, diese Fördergefässe weiterführt. Weitere Informationen siehe https://www.sfa-phrt.ch/.
100 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 63.

3.2.4.2 Analyse

Im Rahmen von SystemsX.ch entstanden exzellente wissenschaftliche Ergebnisse, die zu hochdotierten Publikationen führten und systembiologische Ansätze in der biologischen Forschung etablierten. Darauf sei hier nochmals hingewiesen (siehe Kapitel 3.1).[101] Das Programm SystemsX.ch ist aber auch daran zu messen, inwiefern es seine selbst gesteckten Ziele erreicht und einen signifikanten Beitrag dazu geleistet hat, neue Betrachtungsweisen in der Biologie zu etablieren, die sich in neuartigen Forschungsansätzen sowie in der Ausbildung von Spezialisten niederschlagen.[102]

Der systembiologische Ansatz von SystemsX.ch

SystemsX.ch wollte „achieve an integral and comprehensive understanding of the quantitative behavior of biological systems“[103]. In der Definition von SystemsX.ch ist die mathematische und physikalische Modellierung von biologischen Prozessen zentral für die zu fördernde Systembiologie. Allerdings warnte der SNF bereits 2007, SystemsX.ch sei „fast ausschliesslich auf die molekulare Ebene ausgerichtet“.[104] Betrachtet man die Projekte des grössten Fördergefässes (die 34 RTD Projects) und ihre Principal Investigators, kann man auch rückblickend zu dieser Analyse kommen. Insbesondere Omics-Forschung spielte eine wichtige Rolle, molekularbiologische Ansätze dominierten.[105]

Der SWR ist überzeugt, dass im Rahmen von SystemsX.ch Spitzenforschung gefördert wurde. Er stellt sich jedoch die Frage, wie das Sonderprogramm seine in der Definition aufgeführte Vision umsetzte – und inwiefern das SEB seine eigenen Ziele bei der Suche nach Neuartigem ehrgeizig genug verfolgte: Inwiefern kreierte SystemsX.ch ein Umfeld, in dem Projekte entstanden, die die quantitative Modellierung unter Einsatz neuartiger Methoden vorantrieben? Was wurde unternommen, damit das SEB in seiner jeweiligen Zusammensetzung seine interdisziplinäre Botschafterrolle wahrnehmen konnte? Wie wurden theoretisch arbeitende Forschungsgruppen an die Förderung herangeführt und wie eine auf Augenhöhe geführte interdisziplinäre Zusammenarbeit gefördert? Mit welchen Mechanismen wurde die Fokussierung auf die besonderen Anforderungen, die durch die Arbeit mit grossen Datensätzen entstehen, sichergestellt? – Gemäss SWR gehören solche Fragen zu den Themen, die typischerweise von einem SEB, unterstützt durch ein SAB, reflektiert werden müssten.

Eine möglichst breit angelegte Betrachtungsweise wäre aus der Sicht des SWR umso wichtiger, als bei einer so grossen Förderinitiative in einem bestimmten Themengebiet ein echter Wettbewerb nur begrenzt möglich ist. An Schweizer Forschungsinstitutionen gibt es nur eine beschränkte Anzahl von Gruppen, welche über die notwendigen Kompetenzen zum Aufbau grosser Forschungsprojekte verfügen. Bei den teilnehmenden Forschungsgruppen verschiedener RTD Projects tauchen immer wieder die gleichen Namen auf (kritische Masse). In diesem Sinn leuchtet die explizite thematische Verbreiterung (10. Call for Proposals 2014)[106] mit dem Fördergefäss für MRD Projects hin zur medizinischen Forschung dem SWR durchaus ein.[107]

Förderung der Forschung mit grossen Datenmengen

Das Ziel, die datenzentrierte Forschung voranzutreiben, kann sowohl aus struktureller (siehe Kapitel 3.2.1) als auch aus wissenschaftlicher Sicht betrachtet werden. Der Stellenwert von Datenerhebung,

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101 In den Worten des Expertenpanels (Anhang C, S. 2): „The publication output has been outstanding and a number of systems biology techniques and results are now firmly linked to the names of Swiss researchers and research institutions.”

102 Als Beispiel sei auf die Mission im Businessplan 2007 hingewiesen, gemäss der SystemsX.ch anstrebte, die Biologie von einer deskriptiven, qualitativen Wissenschaft zu einer prädiktiven, quantitativen Wissenschaft zu bringen.

103 Siehe Selbstevaluation SystemsX.ch, Anhang B, S. 6, sowie Kapitel 2.1.

104 Schweizerischer Nationalfonds SNF (2007), Präsidium des Nationalen Forschungsrats, 13. März 2007 (rev. 26. April 2007), *SystemsX.ch. Zusammenfassung des Berichtes des Schweizerischen Nationalfonds zuhanden des Staatssekretariats für Bildung und Forschung*, Bern: SNF, S. 2, http://www.snf.ch/SiteCollectionDocuments/Dossiers/dos_systemsx_bericht_kurz_d.pdf.

105 Prof. Dr. Lucas Pelkman, Chairman des SEB seit 2013, fügt jedoch an: „However, the focus has, to some extent, shifted to a more quantitative biology at the single-cell level, which relies on phenomenological models of noise, complexity, symmetry breaking, phase transition and collective behavior, and less on the engineering's paradigm of a molecular blueprint.” Aus: Selbstevaluation SystemsX.ch, Anhang B, S. 2.

106 Details siehe http://www.systemsx.ch/fileadmin/redaktion/SystemsX.ch/Call_for_Proposals/10th_call_SystemsX_ch_March_2014.pdf.

107 Das SAB von SystemsX.ch hatte das Fehlen der medizinischen Forschung bei den RTD Projects bereits 2009 kritisiert.

-speicherung, -analyse und -austausch in der biomedizinischen Forschung veränderte sich in den vergangenen zehn Jahren stark.[108] Aus Sicht des SWR hätte SystemsX.ch das Augenmerk stärker auf quantitative Modellierung und datenzentrierte Analysen richten sollen. Der Verweis von SystemsX.ch zu den sich nicht rasch genug entwickelnden auf Computational Biology ausgerichteten Forschungsgruppen[109] stellt eine Erklärung dar. Diese führt aber auch zur Frage, weshalb auf der Leitungsebene nur in geringem Ausmass Konsequenzen, eine Anpassung oder gar Neuausrichtung des Programms, gezogen wurden.[110]

Zu einer vermehrten Förderung der Forschung mit „big data" gehört auch die grundsätzliche Diskussion über die Arbeit von Forschenden mit grossen Datensätzen.[111] Gerade die von SystemsX.ch von Beginn an angestrebte Interoperabilität bedingt nicht nur die Beteiligung von IT-Experten, die für die Standardisierung von Metadaten verantwortlich zeichnen, sondern erfordert ein vertieftes Verständnis aller Beteiligten für die spezifischen Anforderungen eines Forschungsbereichs an die Erzeugung und den Umgang mit neuartigen Datensätzen. Im Zusammenhang mit der Entwicklung hin zu personalisierter Medizin werden zudem Diskussionen über die Komplexität und Grenzen der Interpretation von biologischen Daten immer wichtiger.[112]

3.2.4.3 Schlussfolgerungen

Selbstreflexion auf Programmebene

- Die Qualität der wissenschaftlichen Produkte ist bemerkenswert. Allerdings hätte die Konzeption der Forschung mit grossen, heterogenen Datensätzen von mehr grundsätzlichen Diskussionen des SEB profitiert.

3.3 Systemische Analyse

Die systemische Betrachtung, die die gesamte Schweizer BFI-Landschaft einbezieht, ermöglicht es, SystemsX.ch aus einem anderen, übergeordneten Blickwinkel zu bewerten.

3.3.1 Die Entstehung der Initiative und ihre Folgen

3.3.1.1 Analyse

Alle vom SWR im Rahmen seiner Analyse befragten damaligen Akteure betonten, die Fokussierung auf Programme wie SystemsX.ch und Nano-Tera.ch habe den Zufluss zusätzlicher Mittel an das BFI-System 2008–2011 ermöglicht.[113] Und im Rahmen der Sonderförderung entstand Spitzenforschung, die das Renommee der Schweiz als Forschungsstandort international stärkte. Allerdings führte das finanzielle Volumen von SystemsX.ch in der Forschungsgemeinschaft zu Fragen der angemessenen Verteilung der Fördermittel. Zudem bewerteten die meisten Gesprächspartner des SWR aufgrund des Entstehungsprozesses die Governance dieser „nationalen Verbundaufgabe" kritisch; die Organisationsform eines Konsortiums wurde hinterfragt.

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[108] Siehe dazu beispielsweise die Analyse von Prof. Dr. Sabina Leonelli: Schweizerischer Wissenschafts- und Innovationsrat SWIR (2017), *Biomedical knowledge production in the age of big data*, Bern: SWIR.

[109] Siehe die Erklärung unter Verweis auf den SNF, Selbstevaluation SystemsX.ch, Anhang B, S. 62.

[110] Gemäss mündlichen Informationen zu SystemsX.ch (im Rahmen der SWR-Gespräche) ist der Strategiewechsel hin zur Medizin eine entsprechende Anpassung des Programms.

[111] In diesem Zusammenhang sei auf die Analyse zur Dateninfrastruktur verwiesen. In diesem Rahmen erklärte ein Interviewpartner, es sei für Forschende nicht wirklich interessant, Energie und Ressourcen für das Teilen von Daten aufzuwenden, wenn sie eigentlich forschen und publizieren sollten. Es sei auch unklar, wie man als Forschender Anerkennung für seine erhobenen Daten bekommen würde. Es müsse erst einmal Vertrauen entstehen, dass es einen Mehrwert geben kann, die erhobenen Daten zu teilen. Siehe SystemsX.ch und die Dateninfrastruktur, Anhang D, S. 15.

[112] Der SWR wird sich in den kommenden Monaten weiterhin mit diesem Thema beschäftigen. Siehe dazu beispielsweise Cristian S. Calude und Giuseppe Longo (2017), „The Deluge of Spurious Correlations in Big Data", *Found Sci*, 22: 595.

[113] Anders gesagt: Es wurde in den SWR-Gesprächen rückblickend bezweifelt, ob ohne inhaltliche Priorisierung mit SystemsX.ch und Nano-Tera.ch eine (zusätzlich zur 2008–2011 beschlossenen) weitere Erhöhung des Finanzrahmens möglich gewesen wäre.

Es ist nicht Aufgabe des SWR, im Rahmen einer Wirkungsprüfung die gesamten Prozesse zu untersuchen. Nachfolgend werden daher nur einige zentrale Folgerungen der SWR-Analyse erwähnt. Die Kritikpunkte am Programm SystemsX.ch lassen sich auch als generalisierbare Befunde lesen, die den zentralen Akteuren (insbesondere dem SBFI, der Schweizerische Hochschulkonferenz SHK, ETH und swissuniversities) bei anderen Fragestellungen ebenfalls begegnen könnten.

Blieb SystemsX.ch zu fokussiert auf SystemsX?
Das SBF forderte für eine Förderung der Systembiologie mit zusätzlichen Bundesmitteln (ab 2008) einen gesamtschweizerischen Fokus des Programms (siehe Kapitel 2.1). Der Name orientierte sich an der 2003 von den UniBas, UniZH und ETHZ gegründeten Initiative. Die Hochschulen der Genferseeregion hatten zuvor ebenfalls ihre eigenen Schwerpunkte in den Lebenswissenschaften.[114] Gegenüber dem SWR erwähnten verschiedene Akteure den ungleichen Zugang zu Beginn von SystemsX.ch, die Erfolgsraten der ersten Calls for Proposals deuten ebenfalls in diese Richtung.[115] Es fällt zudem auf, dass in denjenigen Institutionen, die bemängelten, zu Beginn zu wenig involviert gewesen zu sein, die Fördermittel selten zu nachhaltigen strukturellen Veränderungen führten (siehe Kapitel 3.2.1).

War das Programm so inklusiv wie möglich?
In der kleinräumigen Schweiz sind Interessenkonflikte und der Umgang damit in vielen Bereichen alltäglich.[116] SystemsX.ch hätte als Programm, das sich ausserhalb der Standard-Förderpfade bewegte, sämtliche Massnahmen treffen sollen, um einen noch so minimen Verdacht eines Interessenkonflikts bereits im Vorfeld auszuschliessen. Im SEB bestimmte eine kleine Expertengruppe[117] die Ausrichtung der Förderinitiative. Mit dieser selbstreferenziellen Vorgehensweise bleibt unsicher, ob die wichtigen Fragen in der angestrebten Breite gestellt und alle dazu relevanten Ansätze verfolgt wurden (siehe auch Kapitel 3.2.4).

Waren die Entscheidstrukturen zu wenig klar?
Der SNF konnte für seine Beteiligung bei der Auswahl der zu fördernden Projekte durchaus Bedingungen formulieren; eine frühzeitige Klärung der Entscheidstrukturen unter Einbezug aller wichtigen Akteure fand jedoch nicht statt. Dies zeitigte Auswirkungen bis zur Beendigung des Programms. Noch beim SWR-Treffen im Juni 2017 waren der SNF und SystemsX.ch uneinig über die Ergebnisse bei divergierenden Meinungen zwischen SNF und SEB.

Wurden die Forschungsgelder sinnvoll verteilt?
Für das Auswahlverfahren, das zum Entscheid führte, die Förderung des Programms SystemsX.ch in die BFI-Botschaft 2008–2011 aufzunehmen, fand kein offener Ideenwettbewerb statt, um die Vielfalt potenziell wichtiger Themen für die Schweiz auszuloten. Zudem wurde der SNF erst um eine Bewertung gebeten, als de facto der Entscheid für SystemsX.ch bereits gefallen war. Erste Konsequenzen aus diesem Verfahren wurden bereits gezogen: Art. 41 Abs. 5+6 FIFG stellt seit 2014 sicher, dass die Forschungsorgane, die Schweizerische Hochschulkonferenz und der ETH-Rat in die Planung von nationalen Förderinitiativen einbezogen werden.

Betrachtet man die Unterstützung der Forschenden, resp. die verantwortlichen Antragsteller und Ko-Antragsteller, dann zeigt sich, dass diese parallel zu SystemsX.ch sehr erfolgreich weitere SNF-Gelder einwarben.[118]

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[114] Siehe Kapitel 2.1.

[115] Bei den ersten beiden Calls 2007 und 2008 wurden gemäss den vom SNF dem SWR zur Verfügung gestellten Unterlagen 49 RTD-Projektvorschläge eingereicht, davon je 7–9 von ETHZ, UniZH, EPFL, UniBas und UniL. Die ETHZ reüssierte mit 63 % der Eingaben, die UniBas mit 44 %, die EPFL mit 22 %, die UniL mit 14 % und die UniZH mit 13 %. Dabei nicht einbezogen ist die UniGe, die im Rahmen der ersten beiden Calls nur 3 Projekte einreichte (Erfolgsrate: 0 %).

[116] Als Beispiel sei auf den SNF verwiesen, der die Details in Richtlinien zum Umgang mit Interessenkonflikten regelt. Schweizerischer Nationalfonds SNF (2014), *Richtlinien zum Umgang mit Interessenkonflikten im Gesuchsverfahren*, Bern: SNF http://www.snf.ch/SiteCollectionDocuments/richtlinien_interessenkonflikte_gesuchsverfahren_d.pdf.

[117] Erwähnenswert ist zudem die Konzentration auf die ETHZ bei der Besetzung der Chairmen des SEB wie auch des Boards of Directors.

[118] Siehe Anhang E, SystemsX: related grants awarded by the SNSF.

SNF Förderkategorie	Anzahl Grants	CHF (in Mio.)	% der gesamten SNF-Förderung
Projektförderung	799	391	13,7
Programmförderung[119]	218	225	24,8

Abbildung 2: Die Förderung von SystemsX.ch-Antragstellern durch weitere SNF-Förderkategorien (Quelle: SNF, Auszug aus Anhang E, SystemsX: related grants awarded by the SNSF)

Während SystemsX.ch 220 Mio. CHF Bundesmittel zugesprochen wurden, erhielten die Antragsteller und Antragstellerinnen von SystemsX.ch mittels SNF-Projektförderung 391 Mio. CHF, zudem im Rahmen der SNF-Programmförderung 225 Mio. CHF (sowie weitere Mittel für Infrastrukturen, Karriereförderung und Wissenschaftskommunikation). Die Forschenden, die von SystemsX.ch unterstützt wurden, warben im gleichen Zeitraum zusätzlich einen Viertel der Mittel der gesamten Programmförderung des SNF (ohne NCCR) sowie 14 % der SNF-Projektförderung ein. Dies führt zur Frage, ob die Inanspruchnahme eines signifikanten Anteils der Forschungsförderung durch einen bestimmten Bereich der Forschung und somit eine relativ begrenzte Gruppe von Forschenden inhaltlich und strategisch, im Sinne des Mehrwerts für das System, gerechtfertigt ist. Oder ob angesichts der geringen Grösse der Schweiz eine individuelle Projektförderung vorzuziehen ist, um eine möglichst grosse Vielfalt von Ansätzen fördern zu können.

Exkurs: Das Swiss Personalized Health Network

SPHN wird generell als Weiterentwicklung von SystemsX.ch gesehen. Die nationale Förderinitiative ist 2017–2020 in einer „Aufbauphase".[120] Die Forschungsförderung macht dabei nur einen geringen Teil aus (im Unterschied zur PHRT-Initiative des ETH-Bereichs), Priorität haben Projekte, die auf die Entwicklung, Implementierung und Validierung von Dateninfrastrukturen abzielen. Der Auftrag für die Umsetzung der Initiative ging anders als bei SystemsX.ch nicht an ein Konsortium, sondern an die Schweizerische Akademie der Medizinischen Wissenschaften (SAMW). Die BFI-Botschaft 2017–2020 hält dazu fest: „Die Förderinitiative muss […] als nationale Verbundaufgabe zwischen Hochschulen, (Universitäts-)Spitälern und Förderorganen (SNF) umgesetzt werden. Die entsprechenden Leitungsorgane (Rektorenkonferenz, ETH-Rat, SNF, SAMW) haben sich auf dieses Vorgehen und namentlich auch darauf geeinigt, dass die Gesamtkoordination in der Aufbauphase 2017–2020 als Sonderauftrag der SAMW zu übertragen ist. Eine weitere tragende Rolle als ‚nationales Datenkoordinationszentrum' wird auch dem Schweizerischen Institut für Bioinformatik SIB zukommen."[121] Der SNF, der die Forschungsförderung der personalisierten Medizin im Rahmen seiner herkömmlichen Fördergefässe betreibt, war somit von Beginn an involviert.

3.3.1.2 Schlussfolgerungen

Gesamtschweizerische Wirkung

- SystemsX.ch schöpfte sein gesamtschweizerisches Potenzial nicht vollumfänglich aus. Die Entwicklung einer nationalen Perspektive gleich zu Beginn ist unabdingbar, um gesamthaft eine systemische Wirkung zu erreichen.

Transparente Entscheidstrukturen

- Die Entstehung von SystemsX.ch entsprach nicht einem transparenten Auswahl- und Entscheidungsverfahren unter frühzeitigem Einbezug aller relevanten Akteure.

3.3.2 Weitere Überlegungen

Im Rahmen der Wirkungsprüfung von SystemsX.ch (und Nano-Tera.ch) hat der SWR begonnen, generell über nationale Sonderförderinitiativen nachzudenken.

„Nationale Förderinitiativen"
Mit dem totalrevidierten FIFG verfügt der Bund seit 2014 über eine eigene Gesetzesgrundlage für „nationale Förderinitiativen". Gemäss Art. 41 Abs. 5 des FIFG koordiniert der Bundesrat „die Planung und die Durchführung nationaler Förderinitiativen im Bereich von Forschung und Innovation, die aufgrund

[119] Ohne NCCR (Anhang E, SystemsX: related grants awarded by the SNSF).
[120] Botschaft vom 24. Februar 2016 zur Förderung von Bildung, Forschung und Innovation in den Jahren 2017–2020 (BFI-Botschaft 2017–2020), BBl 2016 3089ff, https://www.admin.ch/opc/de/federal-gazette/2016/3089.pdf.
[121] BFI-Botschaft 2017–2020, S. 3194.

ihrer organisatorischen und finanziellen Tragweite nicht im Rahmen der ordentlichen Förderaufgaben der Forschungsförderungsinstitutionen und der Innosuisse verwirklicht werden können". Art. 41 Abs. 6 stellt den Einbezug der Forschungsorgane (beispielsweise SNF, Innosuisse, Akademien sowie die Hochschulforschungsstätten), der Schweizerischen Hochschulkonferenz und des ETH-Rats in die Planung sicher. Laut der entsprechenden Verordnung (Art. 56 V-FIFG) ist dafür das Eidgenössische Departement für Wirtschaft, Bildung und Forschung (WBF) zuständig. Zu Ziel, Zweck, Dauer, Organisation oder insbesondere Auswahl- und Entscheidungsverfahren macht die Verordnung keine Angaben. Es wird einzig präzisiert, dass das WBF solche Initiativen mit dem ordentlichen Planungsverfahren koordiniert und sicherstellt, dass allfällige Anträge auf Fördermassnahmen im Rahmen einer BFI-Botschaft erfolgen. In Anbetracht der Heterogenität potenzieller Initiativen im Bereich Forschung und Innovation ist eine detaillierte Beschreibung nicht anzustreben. Allerdings ist aus Sicht des SWR eine der Lehren aus SystemsX.ch, dass sich eine Planung unter Einbezug aller relevanten Akteure und ein transparentes Auswahl- und Entscheidungsverfahren auf die Erfolgschancen auswirken können.

Seltene Sonderfälle
Für den SWR bewährt sich grundsätzlich die „reaktive" Forschungs- und Innovationsförderung im „responsive mode".[122] Sie kann durch mehr top-down beschlossene Schwerpunkte (umgesetzt von SNF und Innosuisse) ergänzt werden, die der SWR in der Vergangenheit durchaus positiv würdigte.[123] Grosse nationale Förderinitiativen können als Steuerungsmechanismus das BFI-System bereichern. Doch für den SWR müssen es seltene und aussergewöhnliche Initiativen von besonderer Tragweite bleiben, die die konzertierte Förderlandschaft punktuell ergänzen. So könnte eine solche ausserordentliche Bundesförderung auch im Einklang mit dem Subsidiaritätsprinzip bleiben.

Wirkung
Die Grösse einer Initiative bemisst sich nicht nur an ihrem finanziellen Umfang; die vom Gesetzgeber erwähnte organisatorische Tragweite ist ebenfalls von Bedeutung. Eine nationale Initiative wird international zur Kenntnis genommen und steigert im Erfolgsfall die Anerkennung des schweizerischen BFI-Systems.

Strategische Nischen
Die Auswahl solch spezieller Förderinitiativen kann nur aufgrund situativer Kriterien erfolgen, sie lassen sich auch nicht durch Foresight-Studien, sondern nur durch einen transparenten Auswahl- und Entscheidungsprozess eruieren.[124] Klar ist für den SWR jedoch, dass die Schweizer Forschungs- und Innovationsförderung dabei nationale Gegebenheiten einbeziehen und strategische Nischen identifizieren sollte.

Keine Präjudizien
Es ist evident, dass jeder Forschungsschwerpunkt einerseits zu weiteren Fragen führt und andererseits hoch qualifizierte Forschende hervorbringt, die diese neuen Schwerpunkte bearbeiten möchten. Eine Sonderinitiative sollte jedoch ein definiertes Ende haben und nicht eine nächste präjudizieren. Die Pfadabhängigkeit ist zu vermeiden, auch wenn sich bei der Entwicklung von SystemsX.ch zu SPHN eine vollständig neue Ausrichtung von der Forschungs- hin zur Infrastrukturförderung ergab.

[122] Siehe dazu auch Schweizerischer Wissenschafts- und Innovationsrat SWIR (2015), *Evaluation des Schweizerischen Nationalfonds in Bezug auf die strategische Förderung von Forschungsinfrastrukturen und Fachgebieten*, Bern: SWIR.

[123] Siehe beispielsweise Schweizerischer Wissenschafts- und Innovationsrat SWIR (2015), *Examen systématique des effets de l'instrument Pôles de recherche nationaux PRN (série 1, 2001–2013)*, Bern: SWIR oder die SWIR-Stellungnahme vom 14. Juli 2015 „Empfehlungen des SWIR zur Förderung der Energieforschung", http://www.swir.ch/images/stories/pdf/de/Stellungnahme_Energieforschung_Rat_def_Website.pdf.

[124] Als möglichen Ansatzpunkt für eine Klärung der Verfahren sei auf die FIFG-Verordnung verwiesen, die zum Beispiel das Prozedere bei der Schaffung von Nationalen Forschungsprogrammen oder von NCCRs beschreibt.

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Zusätzlich zu den Unterlagen der Selbstevaluation von SystemsX.ch (Anhang B) hat SystemsX.ch auf seiner Webseite http://www.systemsx.ch/ weitere Informationen veröffentlicht (Informationen zur Organisationsstruktur, zum Partnership Agreement, zu den Calls for Proposals, u.a.m.).

Abkürzungen

BBl	Bundesblatt
BFI	Bildung, Forschung und Innovation
BII	Basel Institute for Immunology
CHF	Schweizer Franken
CRUS	Rektorenkonferenz der Schweizer Universitäten
D-BSSE	Department of Biosystems Science and Engineering
EDI	Eidgenössisches Departement des Innern
EPFL	Eidgenössische Technische Hochschule Lausanne
ERASysAPP	European Research Network for Applied Systems Biology
ETHZ	Eidgenössische Technische Hochschule Zürich
F&I	Forschung und Innovation
FIFG	Bundesgesetz vom 14. Dezember 2012 über die Förderung der Forschung und der Innovation, SR 420.1, in Kraft getreten am 1. Januar 2014
FMI	Friedrich Miescher Institute for Biomedical Research
HFKG	Bundesgesetz vom 30. September 2011 über die Förderung der Hochschulen und die Koordination im schweizerischen Hochschulbereich (Hochschulförderungs- und -koordinationsgesetz), SR 414.20, in Kraft getreten am 1. Januar 2015
IPhD	Interdisciplinary PhD
IT	Informationstechnologie
kpm	Kompetenzzentrum für Public Management
KTI	Kommission für Technologie und Innovation (seit 01.01.2018 Innosuisse)
Mio.	Millionen
MRD	Medical Research and Development
NCCR	Nationaler Forschungsschwerpunkt (National Centre of Competence in Research)
PhD	Doctor of Philosophy
PHRT	Personalized Health and Related Technologies
PPP	Public Private Partnership
PSI	Paul Scherrer Institut
rev.	Revidiert
RTD	Research, Technology and Development
SAB	Scientific Advisory Board
SAMW	Schweizerische Akademie der Medizinischen Wissenschaften
SBF	Staatsekretariat für Bildung und Forschung
SBFI	Staatssekretariat für Bildung, Forschung und Innovation
SEB	Scientific Executive Board
SHK	Schweizerische Hochschulkonferenz
SIB	Schweizerisches Institut für Bioinformatik
SNF / SNSF	Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung
SPHN	Swiss Personalized Health Network
SR	Systematische Rechtssammlung
SUK	Schweizerische Universitätskonferenz
SWIR / SSIC	Schweizerischer Wissenschafts- und Innovationsrat (seit 01.01.2018: SWR)
SWR / SSC	Schweizerischer Wissenschaftsrat
TF Projects	Transfer Projects
TOR	Terms of reference
TPdF	Transition Postdoc Fellowships
TRL	Technology Readiness Level
UFG	Bundesgesetz vom 8. Oktober 1999 über die Förderung der Universitäten und über die Zusammenarbeit im Hochschulbereich (Universitätsförderungsgesetz), aSR 414.20, in Kraft getreten am 1. April 2000, ausser Kraft gesetzt am 1. Januar 2015
UniBas	Universität Basel
UniBe	Universität Bern
UniFr	Universität Freiburg
UniGe	Universität Genf
UniL	Universität Lausanne
UniZH	Universität Zürich
USA	Vereinigte Staaten von Amerika
V-FIFG	Verordnung zum Bundesgesetz über die Förderung der Forschung und der Innovation vom 29. November 2013, SR 420.11, in Kraft getreten am 1. Januar 2014
V-UFG	Verordnung zum Universitätsförderungsgesetz vom 13. März 2000, aSR 414.201, in Kraft getreten am 1. April 2000, ausser Kraft gesetzt am 1. Januar 2015
WBF	Eidgenössisches Departement für Wirtschaft, Bildung und Forschung
WTT	Wissens- und Technologietransfer
ZHAW	Zürcher Hochschule für Angewandte Wissenschaften

Anhang

Anhang A – Das Mandat des SBFI

- MANDAT Wirkungsprüfung der beiden nationalen Förderprogramme Nano-Tera.ch sowie SystemsX.ch
- FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM „SystemsX.ch"

Anhang B – Bericht Selbstevaluation SystemsX.ch

- SystemsX.ch Consortium Report. Self-evaluation of the Swiss Initiative in Systems Biology 2008–2016
- APPENDIX A Tables and lists complementing the SystemsX.ch Consortium Report 2008–2016
- APPENDIX B Bibliometric evaluation of the SystemsX.ch initiative: performance, benchmark and collaboration analysis
- APPENDIX C SyBIT Report for the SystemsX.ch Impact Analysis

Anhang C – Bericht des externen Expertenpanels

- Report on SystemsX.ch by the expert panel
- SystemsX.ch: Statement about the „Report on SystemsX.ch by the expert panel"
- Questions for the international expert panel
- Terms of reference for external experts (TOR)

Anhang D – SystemsX.ch und die Dateninfrastruktur

- Fritz Sager, David Kaufmann und Johanna Künzler (2017), *Wirkungsprüfung SystemsX.ch – Bericht zum Mandat „SystemsX.ch und die Dateninfrastruktur"*, Bern: Kompetenzzentrum für Public Management, kpm

Anhang E – SystemsX: related grants awarded by the SNSF

Anhang F – Gespräche SWR

- Diskussionen mit Vertretern des SystemsX.ch-Konsortiums und des SNF, „Site Visit", 14./15. Juni 2017
- Liste der weiteren Gesprächspartnerinnen und Gesprächspartner (Einzelinterviews)
- Gesprächsleitfäden

Anhang A

Das Mandat des SBFI

MANDAT Wirkungsprüfung der beiden nationalen Förderprogramme Nano-Tera.ch sowie SystemsX.ch

FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM „SystemsX.ch"

SBFI, September 2016

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Wirtschaft, Bildung und Forschung WBF

**Staatssekretariat für Bildung,
Forschung und Innovation SBFI**
Abteilung Nationale Forschung und Innovation

MANDAT

(Verwaltungsinterne Vereinbarung)

des

Eidgenössischen Departements für

Wirtschaft, Bildung und Forschung (WBF)

vertreten durch das

Staatssekretariat für Bildung, Forschung und Innovation (SBFI)

an den

Schweizerischen Wissenschafts- und Innovationsrat (SWIR)

Wirkungsprüfung der beiden nationalen Förderprogramme Nano-Tera.ch sowie SystemsX.ch

Vertragsnummer: 2016.0009

I. Ausgangslage

Unter dem Titel "NanoTera.ch" und "SystemsX.ch" wurden mit den Entscheiden zur BFI-Botschaft 2008-2011 zwei nationale Förderinitiativen lanciert. Angesichts des Profils dieser beiden Initiativen als "nationale Verbundaufgaben" wurde für jede eine spezifische *Aufbauorganisation* (Konsortium - verantwortlich u.a. namentlich für die strategische Führung) geschaffen. Mit einer Laufzeit von nunmehr insgesamt 9 Jahren werden beide Förderprogramme auf Ende 2016 beendet. Dabei hat der Bund über die gesamte Laufdauer insgesamt rund 340 Mio. CHF Fördermittel zur Verfügung gestellt.

In Absprache mit den involvierten Stellen hat das zuständige SBFI entschieden, beide Förderinitiativen vor ihrem Abschluss einer umfassenden Wirkungsprüfung zu unterziehen. Gestützt auf Artikel 44 Absatz 3 und Artikel 54 Absatz 2 FIFG sowie in Abstimmung mit seinem Legislaturprogramm 2016-2019 wird der SWIR mit der Wirkungsprüfung der beiden nationalen Förderprogramme "Nano-Tera.ch" sowie "SystemsX.ch" beauftragt.

II. Auftrag/Ziele – Gegenstand

Das SBFI beauftragt den SWIR mit der Durchführung einer Wirkungsprüfung beider Programme. Deren übergeordnetes Ziel besteht darin, unter programmspezifisch relevanten Aspekten die Wirkungen umfassend festzustellen und aus übergeordneter Sicht zu bewerten. Ziel und Gegenstand der Wirkungsprüfung sind in den beiden Konzeptdokumenten "Framework of the impact evaluation for the National Funding Program *NanoTera.ch*" sowie "Framework of the impact evaluation for the National Funding Program *SystemsX.ch*" detailliert dargestellt (fortan: *Konzeptunterlagen*).

III. Zeitplan

Die Arbeit des SWIR richtet sich nach Zeitplan gemäss Konzeptunterlagen. Danach ergeben sich folgende Meilensteine:

	NanoTera-ch (Abschluss)	SystemsX.ch (Abschluss)
Bericht der zuständigen Konsortien ("Selbstevaluation")	10/2017	03/2017
Bericht der externen Fachpanels ("Panelberichte")	3/2018	12/2017
Stellungnahmen zum "Panelbericht" (Konsortien; SNF)	tbd	tbd
SWIR Abschlussbericht (zuhanden SBFI)	06/2018	02/2018

IV. Weitere Bestimmungen

Methodisches Vorgehen
Der SWIR ist in der Wahl seiner Methoden frei.
Betreffend Nominierung der externen Fachpanels durch den SWIR gelten die in den Konzeptunterlagen gesetzten Rahmenbedingungen.

- Aktenzugang: Die Konsortien sind gegenüber dem SWIR auskunftspflichtig. Sie stellen ihm auf Nachfrage namentlich sämtliche offiziellen Strategie- und Entscheiddokumente in ihrem Zuständigkeitsbereich zur Verfügung.

- Weitere Vorgaben hinsichtlich Berichte der Konsortien, der externen Fachpanels sowie zu den übergeordneten Abschlussberichten des SWIR sind in den Konzeptunterlagen dargelegt.

Publikation
Über die Publikation seiner Abschlussberichte entscheidet der SWIR.

- Form: Die Publikation umfasst pro Abschlussbericht neben den übergeordneten Befunden / Bewertungen und allfälligen Empfehlungen des SWIR auch den Bericht des Konsortiums (Selbstevaluation), den externen Panelbericht, die formelle Stellungnahme des Konsortiums und des SNF zum Panelbericht sowie allfällige weitere Begleitmaterialien oder ergänzende Untersuchungen des SWIR.
- Fristen: Die Publikation der Abschlussberichte erfolgt frühestens nach Zustellung derselben an das SBFI.

Bestandteile: Konzeptunterlagen
Die beiliegenden Konzeptunterlagen "Framework of the impact evaluation for the National Funding Program *NanoTera.ch*" (datiert vom 29.08.2016) sowie "Framework of the impact evaluation for the National Funding Program *SystemsX.ch*" (datiert vom 30.08.2016) bilden einen integrierenden Bestandteil dieser Vereinbarung.

V. Finanzierung und Auszahlung

Finanzierung und Auszahlung
Das Staatssekretariat für Bildung, Forschung und Innovation SBFI beteiligt sich mit höchstens CHF 30'000 (inkl. MWST) an den Kosten, die dem SWIR durch die Erfüllung dieses Mandats entstehen (Kostendach).

Darin eingeschlossen sind namentlich die Aufwendungen für die vom SWIR mandatierten externen Fachpanels sowie für logistische Kosten der Expertisierung durch die Fachpanels.

Dieser Beitrag gilt als Obergrenze und darf ohne Abänderung dieser Vereinbarung im beiderseitigen Einvernehmen nicht überschritten werden. (Allfällige, dieses Kostendach übersteigende Aufwendungen des SWIR sind im Prinzip durch sein allgemeines Funktionsbudget zu decken wie unter Punkt 5 in den Konzeptunterlagen vermerkt.)

Die Auszahlung bzw. Freigabe der Mittel erfolgt gestützt auf eine entsprechende Rechnungsstellung des SWIR zuhanden SBFI (Ressort Nationale Forschung) unter Angabe der Vertragsnummer (siehe Deckblatt) an folgende Adresse

Staatssekretariat für Bildung, Forschung und Innovation SBFI
c/o. DLZ FI EFD
Effingerstrasse 27
3003 Bern

Eine erste Rechnung (1/3 des Gesamtbetrages) kann nach Unterzeichnung des Vertrages bis spätestens Ende November 2016 eingereicht werden. Weitere Teilrechnungen (zu einem Maximalbetrag von 10'000 CHF im Rechnungsjahr 2017 bzw. im

Rechnungsjahr 2018) können entweder nach effektiv anfallendem Aufwand *oder* tranchenweise (maximal je 1/3 des Gesamtbetrages) nach Abschluss der Hauptphasen (Abschluss Konsortialberichte - Abschluss Panelberichte - Abschlussbericht SWIR) eingereicht werden. Mit der letzten Teilrechnung muss auch eine Gesamtrechnung (Projektgesamtaufwand) vorgelegt werden. Die verrechneten Positionen werden in den Rechnungen detailliert ausgewiesen (Honorare, Spesen, etc.). Es gelten die Honoraransätze des SBFI bzw. die (Reise-)Spesenregelungen des Bundes.

Fehlerhafte Rechnungen werden zur Korrektur an den Absender zurückgeschickt.

VI. Schlussbestimmung

Inkrafttreten, Beendigung
Die Vereinbarung beginnt am 30.09.2016 und dauert bis 30.06.2018. Sie tritt nach beiderseitiger Unterzeichnung in Kraft. Sie ist mit der Erfüllung der vereinbarten Verpflichtung beendet, spätestens am 30.06.2018. Die vorzeitige Beendigung bleibt vorbehalten.

Kontaktperson

Für Fachkontakte zum Mandat und während der Durchführung der Wirkungsprüfung gemäss Mandat sowie für allfällige Anpassungen der vorliegenden Vereinbarung ist seitens des SBFI Dr. G. Haefliger, Vizedirektor und Leitung Abteilung Nationale Forschung & Innovation zuständig.

***

Staatssekretariat für Bildung, Forschung und Innovation SBFI

Dr. Mauro Dell'Ambrogio

Staatssekretär

Bern, der September 2016

Schweizerischer Wissenschafts- und Innovationsrat (SWIR)

Prof. Gerd Folkers

Präsident SWIR

Bern, der 29. September 2016

Beilagen:

- FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "SystemsX.ch" (SBFI, 30.08.2016)
- FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "Nano-Tera.ch" (SBFI, 29.08.2016)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Wirtschaft, Bildung und Forschung WBF

**Staatssekretariat für Bildung,
Forschung und Innovation SBFI**
Nationale Forschung und Innovation

CH-3003 Bern, NFI /SBFI/hae

FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "SystemsX.ch"

1. Background

Based on the decisions announced in the SERI message of 2008-2011[1], a national funding program named "SystemsX.ch" was launched in accordance with Article 41, paragraph 5 of the Federal Act on the Promotion of Research and Innovation (RIPA).[2]

The main objectives were to establish a comprehensive initiative for the development of Systems biology in the interests of Switzerland as a science and technology hub, to lead Switzerland to a leading international position in this research area, and in addition to provide a further basis for the cooperation between publically-funded research and the private sector (public-private partnership).

As the program was created in the form of a "national joint task", it has been implemented with a specific organizational structure (the SystemsX.ch Consortium, responsible in particular for the strategic management). In addition, a scientific evaluation mechanism independent from the Consortium has been institutionalized by the Swiss National Science Foundation in the form of a special commission (the SNSF Evaluation Panel). A specific reporting mechanism has also been established as part of the procedures associated to "project-linked contributions" (cooperative projects).

At its launch in 2008, the perspective of approximately 10 years of financial support was envisioned for the program. With a one-year extension in 2012 (SERI message of 2012) and a 4-year extension based on the decisions announced in the SERI message of 2013-2016, the SystemsX.ch program is terminating at the end of 2016 and will thus have been running for a total of 9 years. Altogether, the Swiss Confederation has provided a total funding of about CHF 220 million over the lifetime of the program.

In agreement with the involved parties, the SERI, as competent authority, decided that the "SystemsX.ch" program should undergo an impact evaluation before its formal conclusion[3].

[1] BBI 2007 1223 ; see in particular chapter 2.2.2, project-linked contributions.
[2] The current legal basis is ruled by the fully revised law of Dec. 14 2012 (AS 420.1). For the legal basis at the time concerning project-linked contributions, see SERI message of 2008-2011.
[3] The *formal* conclusion (including all final reports, audits and the dissolution of the associated legal entity) should take place at the end of 2019.

Staatssekretariat für Bildung,
Forschung und Innovation SBFI
Gregor Haefliger
Einsteinstrasse 2, 3003 Bern
Tel. +41 58 462 96 76, Fax +41 58 464 96 14
gregor.haefliger@sbfi.admin.ch
www.sbfi.admin.ch

2. SystemsX.ch Objectives

According to the SystemsX.ch business plan from 2007, SystemsX.ch pursued the vision to become one of the world's leading initiatives in the field of quantitative systems biology, combining genomics and biomedical research with chemistry, mathematics, physics and engineering. The initiative was meant to advance the paradigm shift from the "reductionist molecular biology" of the 20th century towards a more "holistic and predictive life science research". This involves the evolution of biomedical research from a descriptive, qualitative discipline to a quantitative, predictive research approach.

Original objectives
The original objectives of SystemsX.ch were described as follows in the 2007 business plan:

i. To provide the organizational and technological basis to enable systems biology research at the partner institutions;
ii. To foster the ongoing design, development and application of advanced technology and the training of scientists and engineers in the special skills requires to understand biological systems;
iii. To develop, build and implement advanced technology platforms for the generation and management of the date required for systems biology projects;
iv. To initiate and nurture partnerships between the projects associated with the program and with other academic entities, industry and society;
v. to carry out substantial projects that impact on and bring together the national and international systems biology research communities;
vi. to develop and coordinate curricula in systems biology at Swiss universities in order to educate a new generation of bioengineers and natural scientists for research and industry.

Extension of the original objectives during the initiative
In the succeeding plan for the years 2013-2016, these objectives remained largely unchanged, since the establishment of a cultural shift in the scientific community requires time and continuity. However, the *scale* of some of the objectives were altered slightly. In particular, in addition to the continued expansion of the large-scale RTD Projects, the importance of interdisciplinary PhDs was emphasized. With regard to educational measures, postdocs were explicitly included as a target group. Additionally, collaboration with the private sector was to be further strengthened.

3. Impact Evaluation

3.1 Goal / main issues for the impact evaluation

In addition to providing an overall synthesis of the SystensX.ch program (see below 3.3), the main objective of the evaluation is to assess the **impact** of the program in several key dimensions and based on various **objective metrics and parameters** described in the appendix.

The impact dimensions expected to be relevant are:

- Structural impact on the SystemsX.ch partner institutions (structural changes)
- Impact on interdisciplinary and inter-institutional collaborations (networking and partnerships)
- Educational impact (promoting young talents)
- Scientific impact (excellence in science)

For each of the impact dimensions indicated, there **is a set of the key statements** to be

assessed, along with related factual data and parameters to be used (see appendix).

For each of the key statements, the goal is to evaluate to what extent it has been fulfilled and to what extent the SystemsX.ch framework has been efficient.

Dimension I	**Structural impact on SystemsX.ch institutions (structural changes)**

Did the initiative succeed in supporting partner institutions to provide the organizational, personnel and technological basis necessary to practice sustainable systems biology research?

- *Key Statement 1:* SystemsX.ch has supported the partner institutions in setting up the organizational and technological infrastructure necessary to practice systems biology research.
- *Key Statement 2:* SystemsX.ch has enabled sustainability of research assets by supporting science IT and data management services.

Dimension II	**Impact on collaborations (networking and partnerships)**

To what extent has the initiative fostered the development of interdisciplinary research networks between researchers, academic institutions and private partners on a national and international level?

- *Key Statement 3*: SystemsX.ch systematically initiated and funded interdisciplinary, inter-institutional research collaborations between the part ner institutions.
- *Key Statement 4*: SystemsX.ch has reached out towards the private sector to facilitate the implementation of system biology approaches in industry and SMEs.
- *Key Statement 5*: SystemsX.ch has created the basis for international research collaborations.

Dimension III	**Educational impact (promoting young talents)**

Was it possible to create an environment which promoted the interdisciplinary education and training of systems biologists?

- *Key Statement 6*: SystemsX.ch has triggered the development of educational programs at Masters and PhD level at partner institutions to educate the next generation of systems biology researchers.
- *Key Statement 7*: SystemsX.ch implemented new funding instruments to promote interdisciplinary education and training for the next generation of systems biology researchers.
- *Key Statement 8*: SystemsX.ch has supported the training of scientists and engineers in special skills required to understand biological systems as well as in skills that are crucial to carrying out interdisciplinary research.

Dimension IV	Scientific impact (excellence in science)

Did SystemsX.ch fund interdisciplinary projects of high scientific quality and impact, which added to a better understanding of complex biological systems, the modeling of biological processes and/or the development of new technologies?

- *Key Statement 9*: SystemsX.ch has initiated a movement in biological sciences from a descriptive, qualitative science to a quantitative, predictive science.
- *Key Statement 10*: SystemsX.ch has funded interdisciplinary research projects that had a high impact output.
- *Key Statement 11*: SystemsX.ch has fostered the design, development and application of advanced technology and technology platforms.
- *Key Statement 12*: SystemsX.ch has contributed to steering the funded research to wards current social needs, in particular medicine.

3.2 Procedure and responsibilities

The impact evaluation is carried out in the two following steps:

- *An internal* impact evaluation under the responsibility of the SystemsX.ch Consortium. The result is an analysis report (hereinafter: the Consortium report; language: English) to the attention of the SSIC.
- *An external* impact evaluation under the responsibility of the SSIC.
  The result is a final report (hereafter: the SSIC final report; language: German / French) to the attention of the SERI.

3.3 Requirements / conditions for the internal impact analysis

Consortium report structure

Part I: Overview (Organization / Finances)	- Description of the organizational structure and of the main decision procedures (including SNSF) - Financial overview (whole period)	*Sources*: activity and financial reports
Part II: Objectives	- Original set of goals (presentation) - Presentation/justification of possible goal adjustments during the course of the program	*Sources*: relevant strategy documents and implementation measures
Part III: Overview of the outputs of the program	Overall synthesis of the SystemsX.ch program, in the form of a report compiling the main facts and statistics (at a high level of aggregation and limited	

	to the most important areas)	
Part IV: Impact analysis (main part)	Data analysis and assessment/justification of the key statements (1 to 12) identified for the impact analysis	*Sources*: data / outputs from the Consortium's monitoring procedure; metrics and parameters according to the appendix
Part V: Conclusion	Overall conclusions and lessons learned	

Methodology

The impact analysis (Part IV) is essentially carried out on the basis of the data and information identified in the established monitoring procedure (no additional extensive surveys).

A factual selection of the adequate data/information should be made for the assessment/justification of the key statements used for the analysis (in part IV). For the different areas or domains, a multi-methodological approach may be used to show evolution over the duration of the program.

In order to assess the impact, it is necessary to have comparisons. In the foreground is the temporal evolution on a national level, that is, a comparison between the state of things in 2008 with that in 2016. The evolution of the evaluation results from Phase 1 (2008-2012) to Phase 2 (2013-2016) may also be considered as an interesting aspect to analyze the impact of the program. An analysis of selected parameters for an international comparison also makes sense and is tenable, so that it may be possible to assess Switzerland's ranking as a research location in systems biology. Furthermore, it is expected that the main focus be placed on the "direct" impacts of the initiative (meaning that "indirect" impacts, such as the development and implementation of university courses of study at partner institutions, may be considered, but are not a focus of the analysis).

3.4 Requirements / conditions for the external impact evaluation

Expert panel

For the external impact evaluation, the SSIC appoints an expert panel, consisting of national and international experts. For this task, the SSIC consults the SystemsX.ch Consortium, and, if necessary, the SNSF. While only the SSIC is accountable and responsible for the final expert nomination, *the SystemsX.ch Consortium is given both a proposition and a veto right*.

The nomination and formal appointment of the panel experts is the SSIC's responsibility. The only associated condition is that the SSIC ensures the evaluation panel produces an independent evaluation report (hereinafter: the Panel report) according to the mandate specifications. Based notably on the Consortium report and further on the additional findings resulting from complementary measures agreed with the SSIC such as a site visit, discussions with the Consortium, etc., this report should present the panel's position/assessment about/of the key statements used for the impact evaluation (see 3.1 above).

SSIC Final Report

The SSIC produces an independent final report to the attention of the SERI. In this report, the SSIC takes a broader view to provide an overall evaluation in addition to their own position about the assessment of the key statements used for the impact evaluation (see 3.1 above). For this, the SSIC should take into account the Consortium report, the panel report, the Consortium and SNSF position about the panel report, as well as the SSIC's own findings.

3.5 Coordination

The coordination between internal and external impact evaluations (agreements on temporal and content related issues, specification and implementation) is exclusively the SSIC's responsibility. The required interactions and contacts with the SystemsX.ch Consortium and governing bodies are to take place under the direct authority and responsibility of the SSIC.

4. Timeline

Milestones (draft schedule) as follows:

09/2016	Mandate finalization	SERI (with SSIC and Consortium)
11/2016	Coordination & implementation scheduling	SSIC (with Consortium)
03/2017	Internal impact analysis; Consortium Report	Consortium transmits their report to SSIC by the end of March 2017.
01/2017	External impact evaluation: expert panel nomination	SSIC
04 to 12/2017	External impact evaluation: panel report	SSIC / expert panel
02/2018	Final report	SSIC transmits their report to SERI by the end of February 2018

5. Funding

The cost of the internal impact analysis, including all costs related to the production of the Consortium report as well as the direct Consortium contribution to the external impact evaluation according to the SSIC's specifications will be covered by the SystemsX.ch Consortium.

The cost of the external impact evaluation, including all organizational costs related to the production of the panel report and final report will be covered by the SSIC's operational budget. Any additional cost incurred by SERI will be settled in the framework of the SSIC's global mandate (impact evaluation of the "SystemsX.ch" & "Nano-Tera.ch" funding programs).

SERI,30/08/2016
Dr. G. Haefliger, Vice-director

Appendix: SystemsX.ch Consortium: objective metrics and parameters for the key statements.

Appendix

SystemsX.ch Consortium: objectives metrics and parameters for the key statements (Consortium report)

Dimension I Structural impact on SystemsX.ch institutions (structural changes)

Did the initiative succeed in supporting partner institutions to provide the organizational, personnel and technological basis necessary to practice sustainable systems biology research?

- *Key Statement 1:* SystemsX.ch has supported the partner institutions in setting up the organizational and technological infrastructure necessary to practice systems biology research.

  Data source: Scientific Reports 2008-2016, SystemsX.ch Strategy 2012-2016 (Dec 2009; Annex 1: Investments to systems approach research by the SystemsX.ch partner institutions 2005-2009), questionnaire answered by SystemsX.ch partner institutions

  Parameters:
  - *Organizational infrastructure*: newly created entities (professorships, group leaders, institutes and departments) in systems biology
  - *Technological infrastructure*: acquisition of new high-tech equipment, setting up of technology platforms

- *Key Statement 2:* SystemsX.ch has enabled sustainability of research assets by supporting science IT and data management services.

  Data source: SyBIT Business Plan, SyBIT Report, SIB annual report 2015

  Parameters: Description and usage of provided services, measures to guarantee sustainability beyond lifetime of SystemsX.ch, science IT entities at partner institutions, variety of provided tools

Dimension II Impact on collaborations (networking and partnerships)

To what extent has the initiative fostered the development of interdisciplinary research networks between researchers, academic institutions and private partners on a national and international level?

- *Key Statement 3*: SystemsX.ch systematically initiated and funded interdisciplinary, inter-institutional research collaborations between the partner institutions.

  Data source: Calls for Proposals #1 to #12 (especially RTD/MRD Projects): various records (applications, applicants, projects, co-/principle investigators, networking events), MoU SystemsX.ch-BMBF, questionnaire answered by SystemsX.ch PIs and Co-PIs

  Parameters: number of institutions, research groups and disciplines overall and per RTD/MRD project, diversity of involved institutions, number and pattern of joint publications, number of networking events and profile of participants

- *Key Statement 4*: SystemsX.ch has reached out towards the private sector to facilitate the implementation of system biology approaches in industry and SMEs

  Data Source: Calls for Proposals #1 to #12 (especially BIP, IPP, TF Projects), Scientific Reports 2008-2016, lists of events with industry involvement, FMI and IBM Zurich Research Lab as SystemsX.ch partner institutions

  Parameters: number of applications, approved projects and interaction with the private sector per project type; industry events organized by SystemsX.ch

- *Key Statement 5*: SystemsX.ch has created the basis for international research collaborations.

  Data source: List of funded ERASysAPP projects, MoU SystemsX.ch-BMBF, FAIRDOM proposal and reports, Scientific Reports 2008-2016.

  Parameters:
  - *ERASysAPP:* Number of funded transnational projects, number of countries and international research groups involved
  - *BMBF:* List of collaborations enabled by agreement
  - *Fairdom:* Description of international collaboration, number of supported research groups and services offered
  - *Number of supported and (co-)*organized international events (conferences, symposia, workshops, courses, etc)

Dimension III Educational impact (promoting young talents)

Was it possible to create an environment which promoted the interdisciplinary education and training of systems biologists?

- *Key Statement 6*: SystemsX.ch has triggered the development of educational programs at Masters and PhD level at partner institutions to educate the next generation of systems biology researchers

  Data source: questionnaire answered by SystemsX.ch partner institutions, ERASysAPP Graduate Study Program webpage, quotes PhD students and post-docs

  Parameters: Number, type and content of educational programs at partner institutions before/during SystemsX.ch; number of students in total and per program

- *Key Statement 7*: SystemsX.ch implemented new funding instruments to promote interdisciplinary education and training for the next generation of systems biology researchers.

  Data source: Calls for Proposals #1 to #12 (in particular for IPhD and TPdF projects), Scientific Reports 2008-2016, questionnaire answered by mentors and students of SystemsX.ch IPhD and TPdF Projects

  Parameters:
  - *IPhD Projects*: Number of applications and funded projects, disciplines involved, scientific output (publications, etc.), attendance at conferences and workshops, career tracks of PhD students
  - *TPdF Projects:* Number of applications and funded projects, original and new discipline of each postdoc, scientific output (publications, etc.), career tracks

- *Key Statement 8*: SystemsX.ch has supported the training of scientists and engineers in special skills required to understand biological systems as well as in skills that are crucial to carrying out interdisciplinary research.

  Data source: List of courses supported and/or organized by SystemsX.ch (national and international), Scientific Reports 2008-2016

  Parameters: Number and topics of supported/organized events, number and profile of participants

Dimension IV Scientific impact (excellence in science)

Did SystemsX.ch fund interdisciplinary projects of high scientific quality and impact, which added to a better understanding of complex biological systems, the modeling of biological processes and/or the development of new technologies?

- *Key Statement 9*: SystemsX.ch has initiated a movement in biological sciences from a descriptive, qualitative science to a quantitative, predictive science.

Data source: Calls for Proposals #1 to #12 (requirements for projects and scientists), review reports (SNSF expert panel and SystemsX.ch SEB), profile of publications (disciplinary categories, co-authorships, type of journal), quotes and questionnaire answered by SystemsX.ch co-/principle investigators, SNSF expert panel, examples
Parameters: number of research groups in non-biological disciplines in approved SystemsX.ch project consortia, numbers of publications with quantitative (including –omics) and modelling aspects per project and per year.

- *Key Statement 10*: SystemsX.ch has funded interdisciplinary research projects that had a high impact output.

  Data source: Scientific Reports 2008-2016 (publications reported to SystemsX.ch), publication in Web of Science acknowledging SystemsX.ch, questionnaire answered by SystemsX.ch co-/principle investigators, review reports of the SNSF expert panel
  Parameters:
  - *Interdisciplinary research:* disciplines of co-/principle investigators of funded projects (total and per project type), pattern of co-authorships in publications
  - *High scientific impact:* absolute and normalized measures of bibliometric performance (number of publications in high impact journals, top 10% publications, Knowledge User Profile), examples of projects with high scientific impact

- *Key Statement 11*: SystemsX.ch has fostered the design, development and application of advanced technology and technology platforms.

  Data source: Scientific Reports 2008-2016, questionnaire answered by SystemsX.ch partner institutions, questionnaire answered by SystemsX.ch co-/principle investigators, Calls for Proposals for High Tech Funds and Special Opportunity Funds
  Parameters: List and description of newly invented or further developed technologies, platforms and databases; where applicable: number of users and user profiles, purchased expensive equipment and infrastructure for SystemsX.ch projects (per institution)

- *Key Statement 12*: SystemsX.ch has contributed to steering the funded research towards current social needs, in particular medicine.

  Data source: Calls for Proposals #1 to #12 (explicitly mentioning medicine as research topic, MRD Projects), ERASysAPP Calls for Proposals, ERI dispatch 2017-2020;
  Parameters: Number of submitted proposals and funded projects with medical relevance

Anhang B

Bericht Selbstevaluation SystemsX.ch

SystemsX.ch Consortium Report. Self-evaluation of the Swiss Initiative in Systems Biology 2008–2016

APPENDIX A Tables and lists complementing the SystemsX.ch Consortium Report 2008–2016

APPENDIX B Bibliometric evaluation of the SystemsX.ch initiative: performance, benchmark and collaboration analysis

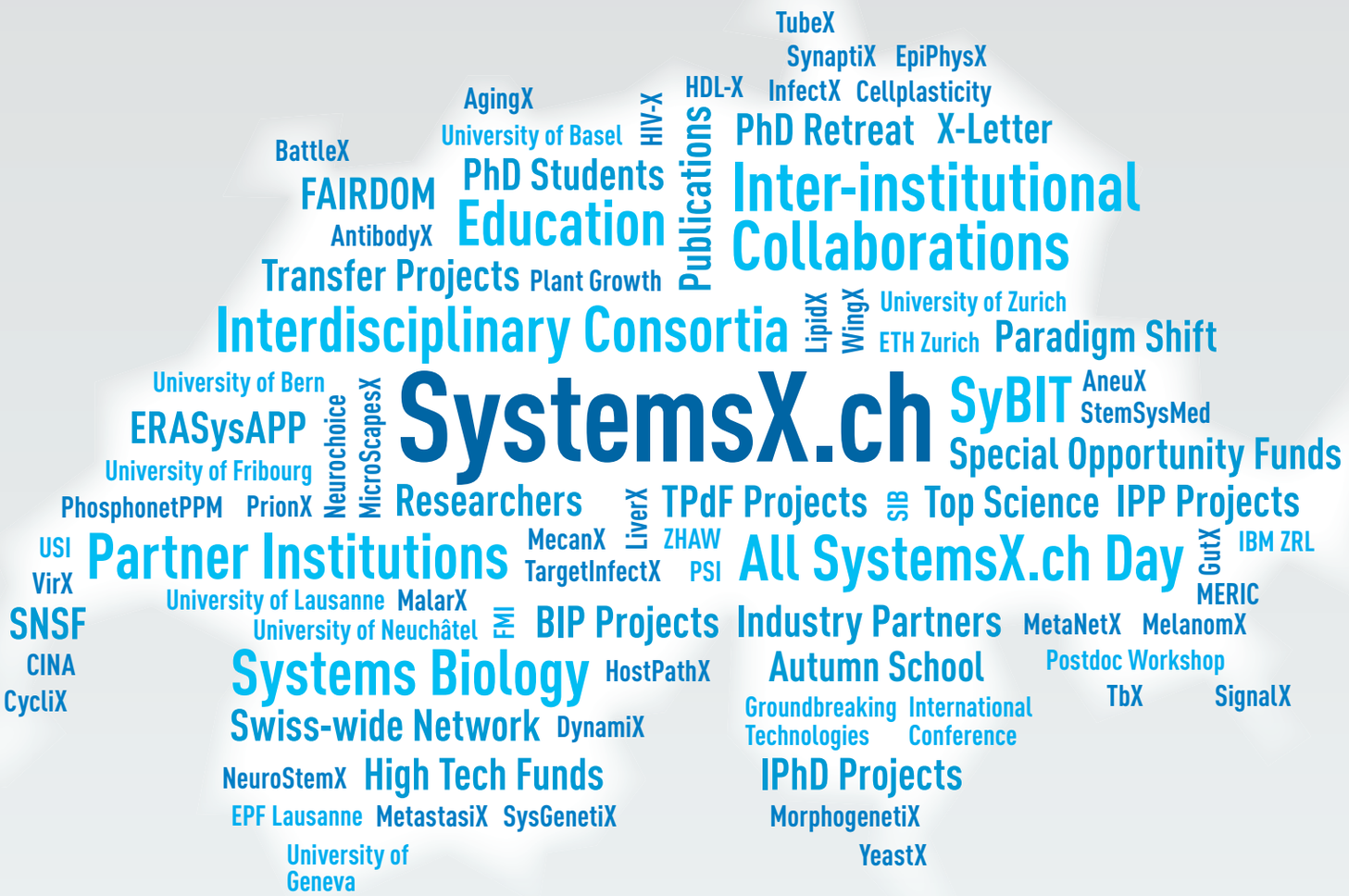
APPENDIX C SyBIT Report for the SystemsX.ch Impact Analysis

Konsortium SystemsX.ch, 31. März 2017

SystemsX.ch
Consortium Report

Self-evaluation of the Swiss Initative in Systems Biology

2008–2016



SystemsX.ch
The Swiss Initiative in Systems Biology

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SystemsX.ch
Swiss Initiative in Systems Biology
Clausiusstrasse 45
8092 Zurich
Switzerland

Tel. 044 633 83 25
www.systemsx.ch

Editors: Heide Hess, Eavan Dorcey, Daniel Vonder Mühll
Collaboration: Katy Pegg, Tim Aufdenblatten

Cover: Thomas Ritz

SystemsX.ch Consortium Report

Self-evaluation of the Swiss Initiative in Systems Biology 2008-2016

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FOREWORD BY PROF. RUEDI AEBERSOLD

The periodic table that displays the 112 known elements that constitute matter in an ordered format was a major achievement of science in the 19th and 20th century. One of the most stunning insights arising from this work was the recognition that all substances we know, from extremely hard diamond crystal to immensely complex biomolecules, are composed of a relatively small number of elements, and that the vast range of properties of molecules is determined by the spatial arrangement and the connections of the elements in the molecule.

The life sciences of the 20th century has seen a similarly monumental achievement, namely the recognition that the processes of life were essentially chemical processes catalyzed and controlled by biomolecules such as nucleic acids and proteins. This recognition led to the formation of departments of molecular biology, biochemistry and chemical biology at many universities and has shaped biology research for decades. It also led to the notion that a systematic catalog of all biomolecules and their functions, a kind of periodic table of biology, would go a long way in explaining the complexities of life's processes. The human genome project, culminating in the announcement of a draft of the human genome in 2000 and the ensuing "omics" technologies largely achieved this goal. Yet, just as the periodic table of elements does not explain the properties of molecules, the genome sequence and the knowledge of all biomolecules does not explain the properties of biological processes.

This realization led to the emergence of the field of systems biology, which essentially attempts to understand the structure and function of biological processes from the properties of biomolecules and their interactions, that is, to study biomolecules in the context of molecular networks. SystemsX and later SystemsX.ch were created to allow scientists in Switzerland to work at the forefront of systems biology in its early stages, by generating the required research infrastructures and providing support for researchers to learn and apply the new concepts and techniques of systems biology.

A budding systems biologist faces two types of challenges, scientific and societal. The scientific challenges center around the concepts and complexities of molecular networks and the techniques required to understand them. The societal challenges arise from the fact that successful systems biology projects require a breadth of skills not usually found in a single research group, thus forcing scientists to cooperate across disciplines. Apart from the many scientific successes resulting from SystemsX.ch supported projects, I consider the significant change in the sociology of life science research in Switzerland the most significant and lasting achievement of SystemsX.ch. Intense collaborations across disciplines, research groups, institutions and language regions are now the norm rather than the exception.

SystemsX and SystemsX.ch would not have been possible without the vision and the foresight of science politicians, the leaders of the Swiss universities, the SERI and the SNSF, and the support of the community of life scientists. As scientists who had the opportunity to shape the program and to benefit from it, we owe great thanks to all who made this unique experiment possible.

Ruedi Aebersold
Chairman of the Scientific Executive Board, 2006-2012

FOREWORD BY PROF. LUCAS PELKMANS

When I became chair of the Scientific Executive Board (SEB) of SystemsX.ch in 2013, I quickly learnt that the Management Office of SystemsX.ch was run in a very professional and efficient manner, and it was a pleasure to work with them. Without doubt, this has made my role as the chair of the SEB a lot easier. I am particularly proud of the fact that by multiple standards, the SEB has managed to maintain a broad definition of systems biology, and to support top science within that definition. The double evaluation strategy where both the SystemsX.ch SEB and the Swiss National Science Foundation conducted independent reviews has been particularly valuable. Comfortingly, the two independent outcomes overlapped to a very large extent.

Scientifically speaking, we have witnessed quite some development over the years. The early years of SystemsX.ch were very much dominated by omics disciplines: obtaining large sets of measurements on biological systems at the level of the genome, transcriptome, proteome, and metabolome, and representing such data in network models. However, the focus has, to some extent, shifted to a more quantitative biology at the single-cell level, which relies on phenomenological models of noise, complexity, symmetry breaking, phase transition and collective behavior, and less on the engineering's paradigm of a molecular blueprint. This is also very much a future challenge, as it has now become clear that living systems display emerging properties across multiple scales that are not explained by classical engineering and bottom-up modelling paradigms. Thus, the future of quantitative biology looks bright, and it is arguably entering its most exciting phase now. Thanks to SystemsX.ch, Switzerland has become a world-leading place to embark on these questions.

Another clear future direction is the translation of the systems biology approach to biomedicine. SystemsX.ch has already stimulated this by funding several 3-year Medical Research and development projects (MRDs), which were required to use a systems biology approach with clear clinical relevance and include medical doctors amongst the principal investigators. Evidently, with the current push for personalized health and precision medicine, the systems biology approach will become more important in the clinical sciences. Unsurprisingly, some of the same developments as those that took place over SystemsX.ch's lifetime can already be observed. Currently, largely omics-focused approaches are being employed, from which the likely conclusion will be that disease phenomena in individual patients cannot be easily predicted using bottom-up engineering-style models. We will therefore also have to embrace quantitative phenomenological approaches that model emergent properties of disease mechanisms across multiple scales.

I sincerely hope that such insights coming from fundamental systems biology research will help the new initiative succeed and enable its research to accelerate. Similarly, I believe that the organizational structure that was set up by SystemsX.ch, enabling a unique Swiss-wide research approach to be implemented and adopted in a very rapid manner, will also be very useful for future nation-wide research and development initiatives.

Lucas Pelkmans
Chairman of the Scientific Executive Board, 2013-2018

EXECUTIVE SUMMARY

The proposal to establish a Swiss-wide initiative to foster systems biology was motivated by the reality that major advances in this scientific field require the pooling of competences and resources across disciplines and institutions. The Swiss government dedicated Federal funds amounting to CHF 120 million for 2008-2012 to set up SystemsX.ch, the Swiss Initiative in Systems Biology. The vision of SystemsX.ch was to position Switzerland's researchers at the forefront of systems biology research.

SystemsX.ch was established in the form of a simple partnership, comprising twelve participating research institutions by 2012. SystemsX.ch funded a number of different research project types to launch the Swiss systems biology community. For the second phase (2013-2016), the government approved a further CHF 100 million to consolidate and expand the Swiss systems biology community and to perpetuate the systems biology approach within the involved institutions. During this time, three new partner institutions joined the initiative.

The main way SystemsX.ch established and sustained systems biology research in Switzerland at an internationally competitive level was through research funding. In the first phase, five calls for proposals were organized, encouraging large-scale consortium research projects, the development of cutting-edge technologies, interdisciplinary education programs and collaboration projects with industry. In 2010, the Swiss National Science Foundation (SNSF) advised SystemsX.ch to concentrate the funding on research projects rather than technological developments. Consequently, the support for development and technologies was reduced, but not completely abandoned. The SNSF suggested setting up special postdoc and translational project types, which were implemented in the form of Transition Postdoc Fellowships (TPdF) and Transfer Projects (TF).

Between 2008 and 2015 SystemsX.ch conducted a total of twelve calls for project proposals, out of which 248 projects were approved after rigorous review processes. More than 401 different research groups, involving approximately 2100 researchers, contributed to SystemsX.ch. Over the years a clear shift from fundamental research towards translational projects, including medically/clinically relevant research took place. The call for Medical Research and Development (MRD) projects in 2014 was an important step towards extending the systems approach into medicine.

SystemsX.ch successfully supported partner institutions in setting up the organizational, personnel and technological basis necessary to practice sustainable systems biology research:

Funded projects were requested to report matching funds (Own Contributions) of at least the same amount as the SystemsX.ch funding. This influenced the establishment of new organizational structures at the partner institutions: Four new departments or institutes have been created, over 60 faculties and research group leaders hired and ten technology centers implemented. These investments sustainably cemented the systems biology approach at the partner institutions. To support research groups with management, analysis and archiving of huge amounts of scientific data resulting from quantitative systems biology projects, the science IT project SyBIT was established top-down in agreement with the SNSF and supported with CHF 17.5 million. The sustainability of this investment was guaranteed by implementing local data management groups at partner institutions.

SystemsX.ch fostered the development of interdisciplinary research networks between researchers, academic institutions and private partners on a national and international level:

The 43 large, integrated Research Technology & Development (RTD) and Medical Research & Development (MRD) projects, each receiving more than CHF 2 million from SystemsX.ch, allowed the creation of Swiss-wide networks of systems biology researchers, building up structures and dedicated technologies and conducting systems biology research at the highest level. In addition, SystemsX.ch organized networking events including seven All SystemsX.ch Days and three International SystemsX.ch Conferences. Today, a lively and well-connected community of systems biology researchers across Switzerland, including 54% non-biologists, bears witness to the success of these activities. International networking and cooperation was fostered by allowing foreign research groups to act as co-applicants on RTD/MRD proposals. Furthermore, Swiss participation in the European Research Area Network (ERA-Net) ERASysAPP was supported, enabling six Swiss research groups to collaborate in transnational research consortia. Almost half of the RTDs integrated a research group from the private sector in their consortium. However, collaboration and exchange between public and private research groups did not reach the ambitious goals. It turned out that collaboration with university spin-off companies was much easier than with big industry.

SystemsX.ch created an environment that promoted the interdisciplinary education and training of systems biologists:

In total, 118 PhD students and postdocs were educated in a truly interdisciplinary manner in the frame of Interdisciplinary PhD (IPhD) and TPdF projects through training in complementary disciplines. Additional courses organized, co-organized or supported by the initiative on topics such as modeling added to the training of young scientists. Catalyzed by the initiative, educational programs on Bachelor, Master and PhD level were created at the partner institutions or existing ones expanded to meet the changing need for multidisciplinary education.

SystemsX.ch funded interdisciplinary projects of high scientific quality and impact, which contributed to a better understanding of complex biological systems, the modeling of biological processes or the development of new technologies:

SystemsX.ch successfully promoted the shift towards a quantitative research approach in life sciences by means of targeted research funding. Within the SystemsX.ch funded projects, novel insights into a variety of complex biological networks were gained that are of high scientific and societal impact, for example concerning the growth of plants or the pathogenesis of prostate cancer. In addition, technologies, infrastructure and platforms were developed that are available to a wide range of researchers and which advance systems biology research internationally. Output performance as measured by bibliometric studies of SystemsX.ch-acknowledged publications show an increase over the years with a peak in 2012. SystemsX.ch researchers published in high impact journals more than twice as often as the world average. This can, for example, be compared to the UK's score, which is only 27% above the world average. This shows that SystemsX.ch publications are of high impact and that SystemsX.ch researchers are internationally competitive.

Clearly, the Swiss Initiative in Systems Biology was very successful at establishing systems biology approaches across Switzerland in a sustainable manner, and was able to expand their application to the medical sector.

1 INTRODUCTION

To evaluate Switzerland's biggest research initiative to date, the State Secretariat of Education, Research and Innovation (SERI) is carrying out an impact analysis of SystemsX.ch.

The evaluation consists of an internal and external evaluation. In a letter dated September 8, 2015, the SERI mandated SystemsX.ch to conduct an internal self-assessment and summarize the findings in the SystemsX.ch Consortium Report. The concept of the report was jointly developed by SystemsX.ch and the SERI. Based on the consortium report, the Swiss Science and Innovation Council (SSIC) will study the impact of SystemsX.ch with support of an external, international evaluation panel in the next step.

2 HISTORY AND ORGANISATION OF SYSTEMSX.CH

2.1 Introduction and Overview of SystemsX.ch

Between the identification of the basic dogma of molecular biology in the 1960's and the decoding of the human genome in 2001, international life science research was mainly driven by reductionist molecular biology. Technological breakthroughs allowing for high throughput analyses and large data sets, enabled a paradigm shift in the direction of quantitative and predictive research that aims at an integrated understanding of biological processes, the so called systems approach.

In 2007, the Swiss Government decided to support the transition to the systems biology era by providing dedicated funds to public research institutions. Via the Dispatch on Education, Research and Innovation (ERI) 2008-2011, the Federal Council proposed that the parliament set up SystemsX.ch, and allocated it CHF 25 million per year. To ensure commitment and increase impact, institutions receiving such funding had to provide at least the same amount of resources (matching funds). In the following two dispatches (2012, 2013-2016) similar amounts were approved. Over nine years (2008-2016), **the Swiss Initiative in Systems Biology received a total of almost CHF 220 million to foster systems biology research**. The funds had to be allocated to approved projects by the end of December 2015. Research projects can be active until December 2018.

Definition of systems biology

One of the important initial tasks was to define and describe "systems biology". The SystemsX.ch Scientific Executive Board (SEB) phrased it as follows in the call for proposals:

"The primary objective of Systems Biology is to achieve an integral and **comprehensive understanding of the quantitative behavior of biological systems** that arises from the dynamic interplay of its components. It is expected that Systems Biology research projects will culminate in a model (e.g. mathematical) that simulates in silico the system's properties **and predicts its quantitative response to internal or external perturbations**. Frequently, biological systems are represented as networks of interacting elements, whereby the structure and the dynamic behavior of the network determine its phenotypic traits. The study of biological systems in this framework requires interdisciplinary cooperation and a division of labor between biologists, medical scientists, mathematicians, physicists, computer scientists, chemists and engineers. The present Call for Proposals is based on this definition of Systems Biology."

SystemsX.ch was legally set up as a simple partnership (Swiss Code of Obligations, article 530, par 1). In 2007, a management office was put in place to coordinate preparatory work and set up the organization, including committees, procedures and collaboration agreements with the Swiss National Science Foundation (SNSF). At the same time the first call for proposals was composed.

2.2 Preparation Years 2004-2007

Already in 2004, a common program co-funded by the Swiss University Conference called "SystemsX" was launched by ETH Zurich and the Universities of Basel and Zurich. The motivation for such a collaboration was to (a) foster, coordinate and steer research activities, (b) generate synergies in particular for very expensive equipment, and (c) join forces among the institutions. After the partners' legal services and an independent lawyer evaluated various legal forms, the "simple partnership" model was chosen to encourage the identification of partners with the program and keep each partner autonomous at the same time. Meanwhile, the program "Swiss Genomics" was promoted by the EPFL and the Universities of Geneva and Lausanne, which was similar to "SystemsX". In consequence, State Secretary Kleiber proposed in May 2006 to fund one single life science program with the name "SystemsX.ch", to base the organization of the program on "SystemsX" and to include all Swiss public research institutions that contribute to the systems approach in life science on a competitive international level.

> *"Modern research requires institutional and interdisciplinary collaboration. SystemsX.ch is already implementing this in the field of systems biology."*
> *Anita Fetz, State Councillor Basel*

2.3 Organization of SystemsX.ch

When the SystemsX.ch initiative was conceived of in 2006 neither governance nor processes were known in detail. Therefore, it was one of the first tasks to develop and define these boundary conditions.

The preparation work started in January 2007 when the ERI Dispatch 2008-2011 was published: predecessors of the Board of Directors (BoD), the Scientific Executive Board (SEB) and a two-strong Management Office set up all required procedures, documents and communication measures including the SystemsX.ch Partnership Agreement which was signed by seven partner institutions on September 6, 2007. At the same time, the first SystemsX.ch call for proposals was published, which was discussed and approved by the SNSF beforehand. As stated in the SERI decree, an agreement between the SNSF and the SystemsX.ch consortium clarifying (a) branding, (b) scientific reporting, (c) financial reporting, and (d) auditing, was signed.

Each participating institution has equal rights, duties and pays the same fees. In 2017, **the partnership comprised 15 institutions**: ETH Zurich, EPF Lausanne, the Universities of Basel, Bern, Fribourg, Geneva, Lausanne, Neuchâtel and Zurich, the Università della Svizzera italiana, the Friedrich Miescher Institute for Biomedical Research, the Paul Scherrer Institute, the SIB Swiss Institute of Bioinformatics, IBM Zurich Research Laboratory, and the Zurich University of Applied Sciences.

SystemsX.ch developed a model for the governance of large interdisciplinary and inter-institutional research programs within Switzerland. The close collaboration and coordination with the SNSF guaranteed efficient management with a small overhead (cost for the management office amounted to roughly 2%), un-biased proposal reviews and quality assurance.

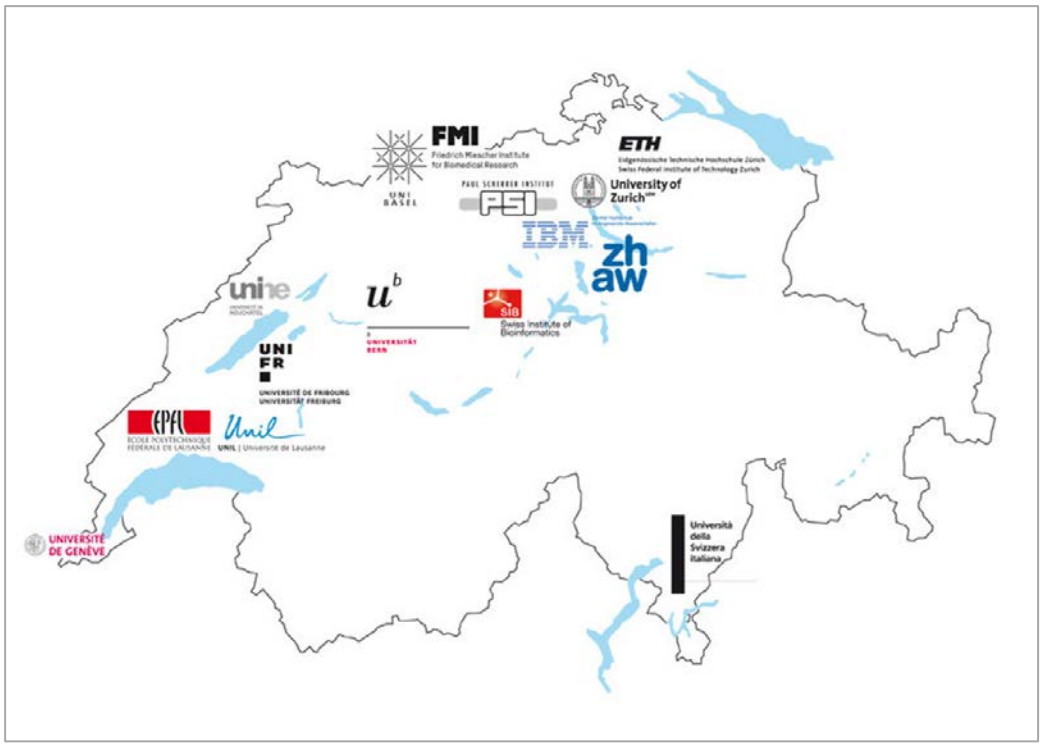

***Figure 1**: The 15 SystemsX.ch partner institutions.*

2.3.1 Committees

The tasks and duties of the various governing bodies are stated in the Partnership Agreement. The BoD covers mainly strategic tasks and was supported by an international Scientific Advisory Board (SAB), which was dissolved in 2012. The SEB met usually about ten times per year to discuss and decide on scientific and operational issues. Its members cover a wide range of disciplines and represent most partner institutions. For the coordination of educational topics across the main universities, the SEB mandated an Education Advisory Board (EAB). All boards are supported and coordinated by the Management Office (MO). The Management Office takes care of the daily business, including coordination with the SNSF, the composition of scientific and financial annual reports, communication, and training measures for the community as well as the representation of Switzerland in the ERA-Net ERASysAPP.

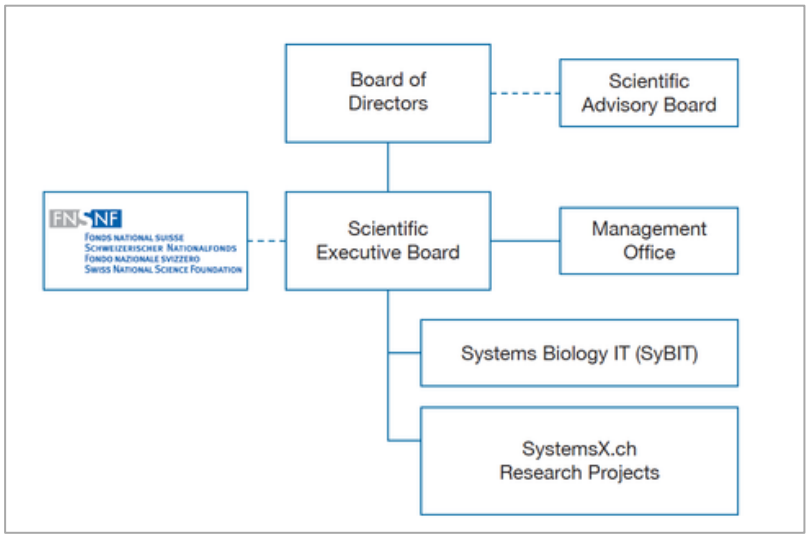

***Figure 2:** Organizational structure of SystemsX.ch.*

2.3.2 Procedures

Call for proposals

SystemsX.ch aimed to create funding categories complementary to those already offered at the SNSF. Each call for proposals was drafted by the SEB and approved by the BoD before it was submitted to the SNSF. The SNSF checked the legal aspects in particular to prevent appeal cases. After SNSF approval, the call texts were published via different channels.

Review of submitted proposals

The main criteria for the selection of research proposals were (1) scientific quality and potential of the proposal and (2) contribution and added value towards systems biology as defined by SystemsX.ch.

The SNSF assembled two panels of international experts, one to evaluate and assess RTD, MRD and TF proposals (2008-2017) and one for TPdF and IPhD proposals (2012-2016). Proposals for those project types were reviewed in parallel: both by the SNSF Review Panel and by the SystemsX.ch SEB. Each committee reviewed and ranked the proposals independently of the other. As a rule, a proposal had to be approved by both committees to be funded. In few cases, the final decision was made after exchange between the SNSF and SEB. According to the SERI decree, the SNSF was to make the final funding decision for the project types RTD, MRD, SyBIT, TF, TPdF and IPhD.

Proposals for BIP, Special Opportunity projects, and High Tech Funds were reviewed by two or three SEB members. In an SEB meeting, all reviewer comments were discussed (conflicted SEB members left the room) and funding decisions taken without the involvement of the SNSF. Requests for sponsorship of events (conferences, workshops, retreats, etc.) and student grants for conferences were decided by a specific core team.

Mid-term review

Each of the large projects (i.e. RTDs, MRDs, SyBIT) underwent a thorough mid-term review approximately two years after the project start. The SNSF panel commented on the progress of the reviewed projects based on written annual reports, oral presentations of the PIs and discussions of posters and gave recommendations for the continuation of the projects.

Reporting

The SystemsX.ch annual scientific report is submitted every September to the SNSF and SERI. Its structure was defined in the agreement between SNSF and SystemsX.ch. Each report is drafted by the Management Office and approved by the SEB. The main part consists of an overview of the whole initiative while Appendix B presents the individual annual reports of each running project.

The annual financial report, structured as defined in the agreement between SNSF and SystemsX.ch, is produced as a separate report for each calendar year. Partner institutions return their reports by the end of February each year to the Management Office, where all reports are checked, consolidated and a final report produced. An external, private company audits the report before the end of May, after which it is approved by the BoD and then submitted to the SNSF and the SERI before the end of June.

Good governance

As a public initiative, SystemsX.ch uses taxpayers' money. It is therefore necessary to apply implicit and explicit attitudes and rules that comply with the expectations of society. An example of such standards is "The Nolan Committee's First Report on Standards in Public Life" that states "The Seven Principles of Public Life"[1] (Selflessness, Integrity, Objectivity, Accountability, Openness, Honesty, Leadership). The Boards and the Management Office of SystemsX.ch defined a frame for good governance, agreed upon with the SNSF, and since 2010 the external auditor has examined and commented in particular on the good governance of SystemsX.ch. In general, this means the application of best practice, e.g. that procedures and roles are transparent, that checks and balances are established, and that areas of potential high risk are known and managed appropriately. Details can be found in the financial report of SystemsX.ch.

2.4 Finances

2.4.1 "Currencies": Various Sources

As stated by law, SystemsX.ch Funds had to be matched by at least the same amount in partner institutions' resources to underline their commitment to systems biology research (Own Contributions). In addition, SystemsX.ch was asked to assess how much funding from competitive public funding agencies (e.g. SNSF, CTI, EU) SystemsX.ch research groups acquired, which provide "collateral benefit" (2nd Party Funds). Finally, SystemsX.ch reported on resources provided by the private sector (SMEs, industry, etc.) through collaborative projects (3rd Party Funds).

2.4.2 Allocation of SystemsX.ch Funds 2008-2018

As Table 3 shows, more than three quarters (77%) of all SystemsX.ch Funds were used for 34 RTDs, nine MRDs and SyBIT. Each project lasted for at least 3 years and most received more than CHF 2 million. For 119 projects supporting young researchers (87 IPhDs and 32 TPdFs), 13% of the SystemsX.ch funds were spent. Another 7% were allocated for various types of research project (with private partners, pilot, international) and technology support (HT Funds, SpecialOpps). This means that more than 96% of SystemsX.ch Funds were used in research groups and labs.

[1] http://webarchive.nationalarchives.gov.uk/20140131031506/http://www.archive.official-documents.co.uk/document/parlment/nolan/nolan.htm

Table 1: *Allocated SystemsX.ch Funds per category.*

Expenses 2008-2018	allocated by 2015		paid out by 2015	to pay 2016-2018
RTD	131'858'113	60.2%	111'606'193	20'251'920
MRD	18'587'695	8.5%	6'701'930	11'885'765
SyBIT	17'549'500	8.0%	14'749'500	2'800'000
TPost-doc [a)]	8'970'426	4.1%	5'661'212	3'309'214
IPhD [a)]	18'739'688	8.6%	13'345'966	5'393'722
Special Opportunity	3'097'335	1.4%	1'939'555	1'157'780
Transfer Project	2'097'716	1.0%	1'707'402	390'314
Internat Activities	2'997'528	1.4%	1'014'109	1'983'419
IPP	3'455'702	1.6%	3'455'702	-
BIP	1'865'904	0.9%	1'865'904	-
High Tech Funds	1'440'087	0.7%	1'440'087	-
SNSF	1'796'400	0.8%	1'596'400	200'000
Event/Workshops/Conf [b)]	1'669'746	0.8%	1'269'746	400'000
Management Office [b)]	4'830'271	2.2%	3'518'271	1'312'000
Total	***218'956'110***	***100%***	***169'871'977***	***49'084'133***

Income 2008-2018				
Source	income total		income until 2015	income 2016-2018
SERI (ETH domaine & CUS	218'498'800	99.8%	193'998'800	24'500'000
Interests	486'258	0.2%	486'258	-
Total	***218'985'058***	***100%***	***194'485'058***	***24'500'000***

Balance 2008-2018		
Item		
Total expenses	218'956'110	100.0%
Total income	218'985'058	100.0%
Difference	***28'948***	***0.0%***

[a)] subject to changes in salary and social taxes

[b)] plan; changes may occur due to event approval of the SEB and MO personnel fluctuation

According to the SERI decree, there are four categories of expenditure: categories I (overheads, management costs and events) and II (central services) were to be allocated by the SystemsX.ch boards (BoD and/or SEB), and categories III (education) and IV (research and technology projects) were to be allocated by the SNSF. Table 2 gives an overview of the originally planned and actual allocations within these categories. It shows that:

- overhead costs (management, events etc.) were 16% lower than initially planned,
- special projects approved by SystemsX.ch (RTD-HT, IPP, BIP and Special Opps) were cut by almost 40% for the benefit of larger projects to be decided by SNSF
- for IPhD and TPdF projects (category III), only three-quarters of the planned amount was spent (mainly due to the fact that the review boards of the SNSF and SystemsX.ch agreed to fund only highly convincing proposals),
- funds that were not allocated in one of the four categories above were moved to large RTD and MRD projects, and
- the SystemsX.ch boards decided to transfer roughly CHF 9,897,027 (categories I and II) to category IV for the SNSF to allocate.

Table 2: *Overview of planned and actual allocations according to the "SERI categories".*

SERI categories	**plan 08-16**	**actual 08-16**	**delta 08-16**	**%**
I (overhead)	9'900'000	8'296'417	-1'603'583	-16%
II (central service)	21'150'000	12'856'556	-8'293'444	-39%
III (education)	36'300'000	27'710'113	-8'589'887	-24%
IV (research)	152'125'000	170'093'024	17'968'024	12%
Total	***219'475'000***	***218'956'110***	***-518'890***	***0%***

3 OBJECTIVES OF SYSTEMSX.CH

"It is the vision of SystemsX.ch to generate the know-how, technical, financial and intellectual resources and the facilities to develop one of the world-wide leading systems biology research initiatives…" This ambitious goal, as written in the SystemsX.ch business plan 2007, was to be reached by combining Switzerland's strength in genomics and biomedical research with chemistry, mathematics, physics and engineering. Furthermore, the initiative was meant to advance the paradigm shift from the "reductionist molecular biology" of the 20th century towards more "holistic and predictive life science research". This involved the evolution of life science research from a qualitative discipline to a quantitative, predictive research approach.

Original objectives

The original objectives of SystemsX.ch were described as follows in the 2007 business plan[2]:

i. To provide the organizational and technological basis to enable systems biology research at the partner institutions;

ii. To foster the ongoing design, development and application of advanced technology and the training of scientists and engineers in the special skills required to understand biological systems;

iii. To develop, build and implement advanced technology platforms for the generation and management of the data required for systems biology projects;

iv. To initiate and nurture partnerships between the projects associated with the program and with other academic entities, industry and society;

v. To carry out substantial projects that impact on and bring together the national and international systems biology research communities;

vi. To develop and coordinate curricula in systems biology at Swiss universities in order to educate a new generation of bioengineers and natural scientists for research and industry.

Changes in the years 2010/2011

In 2010, the SNSF Review Panel evaluated not only the scientific progress of the eight RTD projects of the first call, but also the achievement of objectives of the whole initiative. In its recommendations, the panel advised SystemsX.ch to focus less on the development of technological infrastructure, but more on research, including the identification of new scientific questions[3]. Furthermore, the SNSF suggested refraining from setting up and running central technology platforms managed nationally by SystemsX.ch, as the continuation of implemented structures would represent a huge challenge after the termination of SystemsX.ch.

The panel recommended expanding existing large-scale RTD projects in order to give them time to mature and gain maximum profit from the investments made, rather than launching new ones in the second phase. Furthermore, the panel suggested creating smaller scale alternative project types and welcomed the idea of projects with industry involvement. With regards to training, the SNSF Review Panel proposed the creation of additional training opportunities in general, and in particular at the postdoctoral level. The international visibility of SystemsX.ch was also to be strengthened.

[2] SystemsX.ch Business Plan, June 2007
[3] SystemsX.ch Review Panel Report, 22.10.2010

Extension of the original objectives during the initiative

In the plan for the second phase of SystemsX.ch (2013-2016), the original objectives remained largely unchanged, since the establishment of a cultural shift in the scientific community requires time and continuity. However, the *scale* of selected objectives was altered slightly, according to the requests of the SNSF Review Panel. In particular, the importance of interdisciplinary PhD projects in addition to the continuation and expansion of large-scale RTD projects, was emphasized. With regard to educational measures, postdocs were explicitly included as a target group. Additionally, collaboration with the private sector was to be further strengthened. The completely new aspect of sustainability in research was added to the initiative's original list of objectives.

Adjustment of measures

Although the initiative's goals themselves were not changed significantly, the measures to reach them had to be adjusted to meet the new orientation. As the SNSF Panel recommended focusing less on building up infrastructure and centrally managed technology platforms, but more on research, it was consequently decided to primarily fund bottom-up research projects. For this reason, it was up to the SystemsX.ch partner institutions to build up local infrastructure necessary to perform systems biology research. As a result, research consortia composed themselves in a way that allowed access to locally implemented technologies crucial for the project. Thus, a positive side effect of the Swiss-wide networking was achieved, even if not initially intended in that way.

Unfortunately, the decision to focus on funding research also affected the collaboration with industry. Industry was mainly interested in new technologies, and as the focus changed in favor of basic research questions, the engagement and interest of industry in SystemsX.ch projects decreased. Aiming to attract industry partners and to give the private partner more influence in the projects, the existing project types IPP and BIP were exchanged for more application-oriented Transfer Projects.

With the creation of the Transition Postdoc Fellowship program (TPdF), which supports young scientists with innovative project ideas, along with the newly implemented Postdoc Workshops, the request to set up additional educational measures on the postdoc level was met.

As for the large, integrated RTD projects, the emphasis of the second phase was on (1) elaborating theory, modelling and simulation (i.e. the predictive part), and (2) translational (e.g. medically relevant) rather than pure basic research. This was clearly communicated in the calls.

4 SYSTEMSX.CH ACHIEVEMENTS AT A GLANCE

The main way SystemsX.ch established and sustained systems biology research in Switzerland at an internationally competitive level was through research funding. SystemsX.ch conducted twelve calls for project proposals between 2008 and 2015. Altogether **248 SystemsX.ch projects** were approved, involving a total of **401 research groups**.

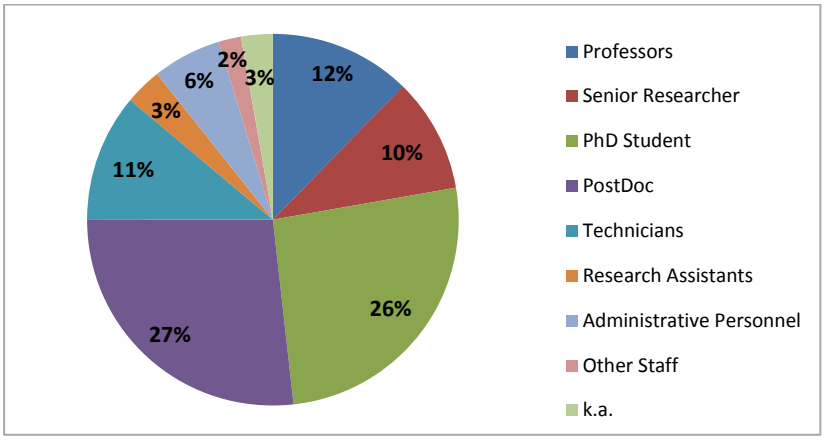

Figure 3: *Functions of personnel contributing to SystemsX.ch projects.*

Each year, approximately 1000 researchers contributed to SystemsX.ch projects. In total **more than 2'100 people were involved in SystemsX.ch funded projects** (Figure 3): 234 professors, 213 senior researchers, 575 postdocs, 237 technicians, 557 PhD students, 69 research assistants, 128 administrators and 42 other personnel. The information on the function of 59 people was not available.

Looking at the distribution of research groups and the amount of SystemsX.ch funding allocated to the different partner institutions, large differences can be seen (Figure 4). As anticipated, the number of SystemsX.ch research groups located at a partner institution directly influences the magnitude of the funding received by the respective institution. Although at first glance the distribution seems to be unbalanced, the picture changes if the success rates of the calls as well as the size of each institution are considered: Some partner institutions that received only a small share of the available funding had a higher success rate than those who received a major part of the funds (*for details see Appendix A, Table A1*).

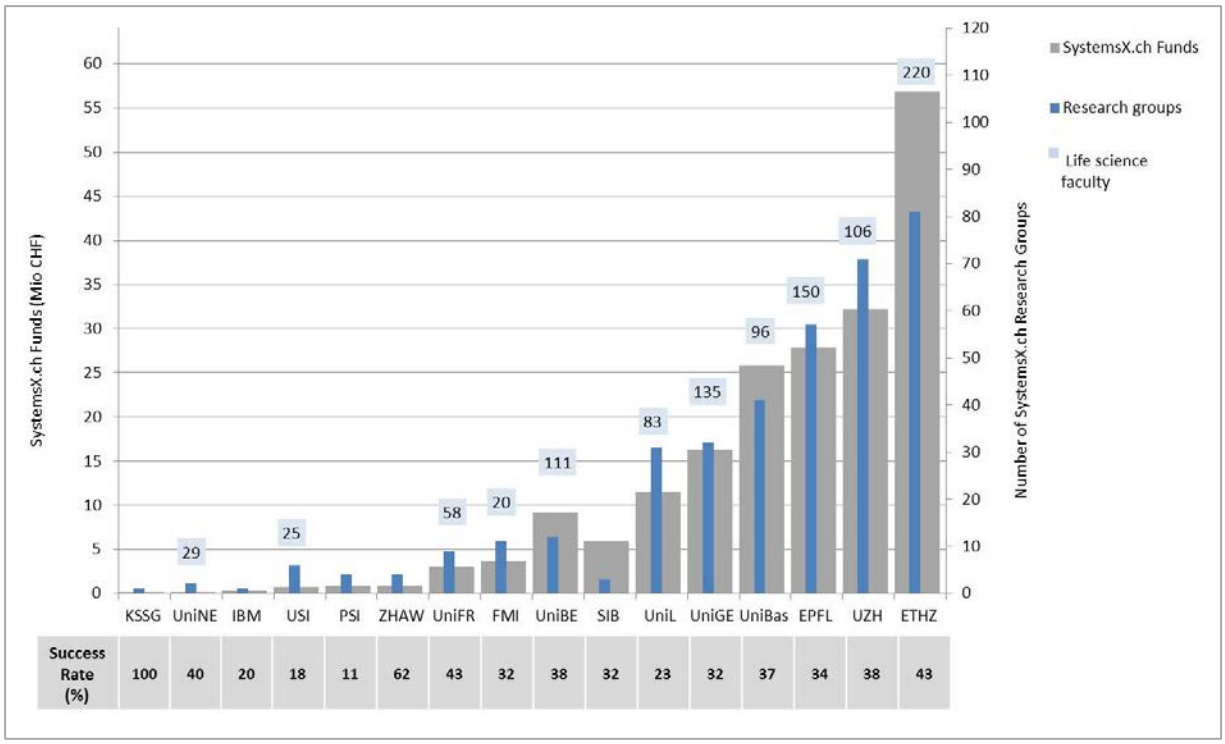

Figure 4: *Number of research groups funded by SystemsX.ch and share of funding for each partner institution.*

Explanation: The numbers in the blue box indicate the number of life science faculty based on information from the Federal Statistical Office (personnel 2015, disciplines 4.1, 4.2 and 4.3).
Note: SyBIT funds were not considered due to the fact that all institutions benefit from the IT-backbone;

Different project types were defined to reach the initiative's goals:

RTD and MRD: Build up interdisciplinary research networks to conduct top-science

As nearly 70% share of the funding volume already indicates, the **34 RTD projects** and **9 MRD projects** were the main instruments to reach the initiative's goals: Building up a lively systems biology community by encouraging the composition of interdisciplinary, inter-institutional research consortia that conduct internationally competitive top science. Scientists from disciplines that formerly did not carry out research in life sciences at all, such as computer sciences, engineering, physics, mathematics and medical science were brought together with biologists. These community-building efforts were supported by events organized for the SystemsX.ch community (All SystemsX.ch Days, diverse retreats, annual PI meetings, International SystemsX.ch Conferences). By granting nine MRD projects in 2015, a major step towards personalized medicine in Switzerland was launched.

SyBIT: IT-backbone, science support IT

In order to support scientists to deal with and make sense of big data resulting from systems biology projects (in particular RTDs and MRDs), the **science IT project SyBIT** was granted. The SyBIT team (66 people) developed tools and offered assistance in the fields of science IT and data management. Local platforms and expertise that were installed at partner institutions ensuring sustainability of research results and investments.

ERASysAPP, FAIRDOM: International outreach

To foster transnational research collaboration on an European level, SystemsX.ch supported six Swiss research groups to contribute to ERASysAPP projects and granted funding to the European FAIRDOM project, which was co-initiated by SystemsX.ch.

IPhD, TPdF: Education of future systems biologists

To raise a new generation of researchers that is experienced in cross-disciplinary thinking and working in interdisciplinary teams, doctoral students were supervised by mentors from two different disciplines. By 2018, almost **90** young scientists will have obtained **their inter-disciplinary doctorates**. In addition, through the support of young researchers in a complementary discipline, **32 postdocs completed a TPdF project.** The skills they gained are an asset in multi-disciplinary life science research and increase their chances on the job market. In addition to the education the young scientists received via their projects, SystemsX.ch offered self-organized or co-organized complementary training.

IPP, Special Opportunity: Promoting innovation and developments

Innovation and development was promoted by granting **45 IPP projects and Special Opportunity projects** to investigate high-risk topics. A considerable number of cutting-edge methods, approaches and technologies resulted for systems biology research in Switzerland and beyond.

BIP, TF: Fostering public-private partnerships

The **24 BIP and TF projects specifically** promoted the exchange between academia and industry partners, aiming to establish the systems approach at private institutions. In addition, young scientists gained insight into industrial research, an attractive option for their future careers.

Out of these **248 projects**, an impressive publication record resulted with a total of **more than 1400** reported publications, more than 120 of them in high-ranked journals such as Cell, Nature, Science and PNAS. Novel insights into a variety of biological networks were gained that are of high scientific and societal impact. Together with newly invented and improved techniques and infrastructure, they cement Switzerland's position as one of the top countries in systems biology research worldwide.

An overview of all funded projects can be found in the Scientific Report 2015-2016, Appendix D, Table D3 through Table D35.

Table 3: *Overview of SystemsX.ch project types and funded projects (2008-2016).*

Project type	Allocated SystemsX.ch funds	Description
RTD Projects (34 projects; 2008-2018)	CHF 131'858'113	**Research, Technology and Development** (RTD) projects are large interdisciplinary research projects carried out by consortia of more than three research groups; RTD projects focus either on the in-depth analysis of a particular biological system, and/or on the development and implementation of a new technology. *Duration: 4 years; Funding: CHF 2-8 million per project (average success rate 32%)*
MRD Projects (9 projects; 2015-2018)	CHF 18'587'695	**Medical Research and Development** (MRD) Projects are large, interdisciplinary projects concerning medically, and ideally clinically, based research *Duration: 3 years; Funding: 1.3-2.4 million per project (average success rate 30%)*
IPhD Projects (87 projects; 2008-2018)	CHF 18'739'688	**Interdisciplinary PhD** projects foster interdisciplinary collaboration in system biologically relevant disciplines and interdisciplinary education *Duration: 3 years, with optional one-year extension; Funding: salary plus CHF 40.000 (average success rate 47%)*
IPP Projects (30 projects; 2008-2012)	CHF 3'455'702	**Interdisciplinary Pilot Projects** jump-started the exploration of new research directions and ideas. And brought together research teams from different disciplines to address "seed" or "high-risk" topics critical for systems biology. *Project duration: 1 year; Funding: CHF 120.000 (average success rate 47%)*
TPdF Projects (32 projects; 2012-2018)	CHF 8'970'426	**Transition Postdoc Fellowships** foster and support young scientists with new ideas; prerequisite is that the researcher works his way into a new discipline (transition) *Duration: 2 years, with optional one-year extension; Funding: salary plus CHF 30.000 (average success rate 30%)*
BIP (16 projects; 2010-2013), **TF** (8 projects; 2012-2018)	CHF 1'865'904 CHF 2'097'716	Projects to promote collaboration with industrial partners (e.g. industry, SME, hospitals): **Bride-to-Industry Projects (BIP):** *Duration: 1 to 2 years; Funding: CHF 120.000 (average success rate 84%)* **Transfer Projects (TF):** *Duration: 2 years; Funding: CHF 300.000 (average success rate 47%)*
SpecialOpps (15 projects; 2012-2018)	CHF 3'097'335	**Special Opportunities Projects** are highly innovative projects that don't qualify for other traditional sources of funding. *Duration: 1-2 years; Funding: CHF 200.000 (average success rate 27%)*
SyBIT (2 phases; 2009-2018)	CHF 17'549'500	Systems Biology IT project **SyBIT** was established as the central Bioinformatics and IT support service for all SystemsX.ch funded research projects. Duration: 8 years; Funding: approx. 2 million per year
HT Funds (9 grants; 2008-2012)	CHF 1'440'087	**High Tech Funds** were granted to consortia of approved RTD projects to grant access to state-of-the art technologies that could not be considered in the initial proposal *Funding: range between CHF 88.000 to CHF 240.000 (average success rate 53%)*
International activities (7 projects; 2014-2018)	CHF 2'997'528	**ERASysAPP projects** aimed to foster trans-national collaborations with European researchers; *Duration: 3 years; Funding: CHF 300.000 to 500.000 (average success rate 35%)* **FAIRDOM project** to promote standardized data and model management on an European level; *Duration: 2.5 years; Funding: CHF 660.000*

5 SELF-EVALUATION OF THE SYSTEMX.CH CONSORTIUM

5.1 Evaluation Approach

The SystemsX.ch self-evaluation report demonstrates to which extent the aims of the initiative have been met. Therefore, the activities were structured into four dimensions:

- **Structural impact** on the SystemsX.ch partner institutions (structural changes)
- **Impact on interdisciplinary and inter-institutional collaborations** (networking and partnerships)
- **Educational impact** (promoting young talents)
- **Scientific impact** (excellence in science)

For each of these dimensions, a set of key statements (KS) was defined. Based on objective parameters, the key statements are analyzed as to whether they have been fulfilled. Wherever possible, a comparison between the state of the art before 2008 and in 2016 will be demonstrated. The influence of the evaluation results from phase 1 (2008-2012) on phase 2 (2013-2016) will also be described.

As SystemsX.ch was set up as a partnership intended to result in catalytic effects, it is necessary to also mention the "indirect" effects (effects that did not directly result from specific measures) of the initiative. However, the assessment of the "direct" impact will be at the center of the analysis. It has also to be considered that excellence in science cannot be assessed exclusively based on quantitative parameters, such as the number of publications of a research project or citation indices, and that impact can often only be judged years after the results have been published or the program came to an end.

Relevant data, data acquisition, methods and analysis

The impact analysis is mainly carried out on the basis of data and information identified in the established monitoring procedures (Financial and Scientific Reporting). For some key statements, multi-methodological approaches combining quantitative and qualitative parameters, were used to highlight different aspects.

To be able to draw a holistic picture of the SystemsX.ch initiative and its achievements, **a set of questionnaires** was set up in 2016 to retrieve additional facts and to give several stakeholders a "voice" in the assessment. Whereas SystemsX.ch partner institutions were asked to answer questions that mainly related to the structural development of systems biology research and education of their institution, the questionnaires for PIs and co-PIs of RTD and MRD contained questions regarding the collaboration, results and benefits of SystemsX.ch projects. To assess the educational impact of IPhD and TPdF projects, online questionnaires were sent to students, postdocs and their supervisors. All of the SystemsX.ch partners returned the partner questionnaire and reported their lessons learned. The online survey for PIs and co-PIs was sent out to 39 Principal Investigators and 154 co-PIs of RTD and MRD projects. In total a representative number of 87 questionnaires were filled in, 30 of them from PIs. The received feedback was integrated in the report, also in the form of testimonials, to support the discussion of the achievement of objectives.

Based on a **bibliometric analysis** of publications acknowledging SystemsX.ch as a funding source, the scientific impact was studied and compared to the results of two major European players in systems biology research, Germany and the UK. The international comparison was intended to determine the position of Swiss systems biology research in Europe. Through a co-authorship analysis of publications of selected RTD projects, collaboration networks that resulted from SystemsX.ch were illustrated.

Furthermore, those who can evaluate SystemsX.ch best in an unbiased manner are the members of the **SNSF Review Panel**. These experts accompanied SystemsX.ch and the RTD and MRD research projects for several years. Thus, the feedback and statements from SNSF Review Panel reports were also considered.

Finally, it has to be mentioned that this self-evaluation report is a snapshot at this moment in time, as scientific results are only considered up to the end of 2016. Many projects will be running until 2018, which is why further scientific achievements can be expected. Both, existing and future publications may have their highest impact in the years to come.

5.2 Assessment of the Initiative's Activities

5.2.1 Structural Impact

The following chapter intends to assess if SystemsX.ch succeeded in supporting partner institutions to establish the organizational and technological frameworks for sustainable systems biology research. Besides classical research structures, supporting services, such as Science IT are also considered.

5.2.1.1 KS 1: SystemsX.ch has catalyzed the establishment of new research directions, through new faculty positions and enabling technologies

Situation

In order to perform systems biology research at a competitive level, this new approach needed to become an integral part of the partner's portfolio. This called for new organizational and technological structures at the partner institutions. At the personnel level, existing faculty members needed to be attracted to the systems approach, or even undergo a reorientation of their research direction, and new experts had to be hired. SystemsX.ch couldn't and didn't want to interfere in the institutions' organizational set-up or recruiting processes as each partner acts autonomous.

In addition, cost-intensive technologies that enable the generation of novel data types had to be purchased or developed. In the beginning of SystemsX.ch, it was envisioned that the initiative would support the set-up and use of cutting-edge technologies and make them accessible to the Swiss research community (see also KS 11). Early RTDs, like CINA, are good examples of this. However, the SNSF commented in 2010 that the responsibility to provide technological infrastructure lay first and foremost with the partner institutions.

Measures and results

SystemsX.ch influenced the strategic alignment of the partner institutions mainly through targeted funding of large, inter-institutional RTD and MRD projects. The matching funds rule for SystemsX.ch projects stipulated in the ERI dispatch 2008-2011 states that partner institutions need to match at least 50% of the total project costs in the form of "own contributions" (OCs), meaning that SystemsX.ch funds had to be matched 1:1 by resources from the receiving institutions. This concept was intended to demonstrate their commitment to the sustainable implementation of the systems approach. As a consequence, partner institutions invested their own funds in personnel and equipment in addition to the funds provided by SystemsX.ch. Some institutions (e.g. the Universities of Basel, Lausanne and Zurich) even reorganized their internal budgets to be able to add 'cash' funds as OCs for research groups receiving a SystemsX.ch grant. Thus, the partner institutions were primed to invest their own funds, in cash or in kind, into systems biology research, which in turn helped extend the adoption of systems approaches to life science research in the institutions.

> *"A key achievement of CellPlasticity was the installation of next generation sequencing within academia in Basel. This crucial genomics technology unit is meanwhile a joint facility between the University of Basel and the ETH department D-BSSE, and will be sustained post-SystemsX.ch."*
> *Prof. Susan Gasser, Friedrich Miescher*

The structural impact on partner institutions became obvious through the answers to the questionnaires: **12 out of 15 institutions established new departments (4), units (4), facilities or competence centers (10) with a focus on systems biology.** Examples are the "Département de biologie computationnelle" at the University of Lausanne or the new "Proteomics and Imaging Facility" at the University of Basel. *For more information on newly implemented structures, see Appendix A, Table A2.*

More than 60 new research groups in the field of systems biology were created at the partner institutions, led by 24 full professors, 11 associate professors, 15 assistant professors, 8 SNF professors and 9 group leaders. About half of them were educated as non-biologists (i.e. in computational biology, bioinformatics/modeling, scientific computing, bioengineering, mathematics/statistics, physics or analytics). Christian von Mering and Lucas Pelkmans are two cases in point who, after their non-tenure-track assistant professorships, both got faculty positions within the University Research Priority Program for Systems Biology of the University of Zurich.

> *"Swiss universities have created new systems biology professorships, whereby the initiative will leave behind a lasting footprint."*
>
> *Prof. Ralph Eichler, Chairman of the SystemsX.ch BoD (2007-2014)*

For details on new personnel see Appendix A, Table A3.

SystemsX.ch institutions reported **investing more than CHF 75 million in equipment and devices enabling systems biology research**. More than 80% of the invested infrastructure and equipment is made accessible to other research groups within the home institution, and more than half is offered to researchers outwith. Those numbers impressively reflect the spirit of sharing limited resources between the partners. *Details on investment can be found in Appendix A, Table A4.*

5.2.1.2 KS 2: SystemsX.ch has enabled sustainability of research assets by supporting science IT and data management services

Situation

When the SystemsX.ch initiative was launched in 2007, the need for computational support for systems biology research was generally acknowledged. New technologies generated huge amounts of data, but the specific tools and knowledge regarding the management and analysis of data were largely missing. Thus, it was agreed that it was necessary to develop an efficient, integrated and scalable computing infrastructure comprised of hardware and software tools and applications. At the time, local computational resources (for high performance computing and storage) existed at different institutions. Vital-IT from the SIB provided support for the institutions of the Arc Lémanique, and the Center for Information Sciences and Databases (C-ISD) from ETHZ intended to similarly overarch several institutions. Originally it was suggested that Vital-IT and C-ISD would provide IT support to RTD projects, but eventually the decision was made to propose a centralized IT support project to the SNSF.

Measures and results

At first, a bottom-up project was developed and proposed twice to the SNSF. After the second rejection in August 2008, the SEB defined a SyBIT structure, which was proposed to and approved by the SNSF top-down. A project manager was hired in January 2009.

Governance of SyBIT

The project has a clear governing and task structure that is overseen and implemented via a project manager. SyBIT was established with a fixed budget that was initially defined at the beginning of each phase. The project duration is from 2009 to 2018, having been granted an extension in 2015, with a total budget of CHF 17.5 million. SyBIT submits yearly financial and scientific reports.

The SyBIT structure involves 6 partners that collaborate both directly and via the Swiss Institute of Bioinformatics:

- EPF Lausanne – Bioinformatics and Biostatistics Core Facility BBCF
- ETH Zurich – Science IT Support unit of the IT Department ID-SIS
- Friedrich Miescher Institute FMI in Basel – IT Group
- SIB Swiss Institute of Bioinformatics– Vital-IT in Lausanne
- University of Basel – Center for Scientific Computing sciCORE
- University of Zurich – Service and Support for Science IT S3IT

Goals of SyBIT

To bridge the gap between applied biology and information technology, SyBIT aimed to:

- support SystemsX.ch scientists in their data-rich biology workflows: from data production and validation to data analysis and publication,
- provide tools and standards to the SystemsX.ch community: enabling end-to-end integration of digital workflows; facilitating reproducibility of workflows through automated provenance information and metadata; guaranteeing reusability, modularity, openness and visibility of programs developed by the community for the community; and facilitating communication and collaboration,
- actively promote information and knowledge exchange within SystemsX.ch and for life sciences in general by supporting existing technology-oriented communities or creating new ones where necessary,
- provide education to scientists and bioinformaticians and provide support for the usage of tools and standards,
- provide support for the usage of the available IT infrastructure for data and computing, and assisting in the coordination and planning of IT resources.

The decision was made for SyBIT to follow an external integration model for the consolidation of the different projects. All project data were kept and managed individually, mostly directly where they were created. Each project was responsible for its datasets, their maintenance and provisioning to others. The integration happened externally, so SyBIT provided a linking facility, which gathers the most relevant data from projects on a high level.

Developments & supporting services

SyBIT created long-term valuable technical assets for the management, sharing and analysis of life-science research data, built a tool box and offered accompanying services:

- openBIS: research data management platform (www.openbis.net),
- Software that is actively used in the research community, e.g. CIFEX (cifex.ethz.ch), applicake github.com/lcb/applicake), EPPIC (www.eppic-web.org/ewui) and GDV (github.com/bbcf/bbcfutils).
- Large-scale data analysis efforts in SystemsX.ch projects, including development of technical assets useful beyond any particular project, e.g. EASE for RNA-seq data analysis.
- Support for data publication by offering assistance in uploading data to existing portals or by developing bespoke data publication portals, such as www.infectome.org

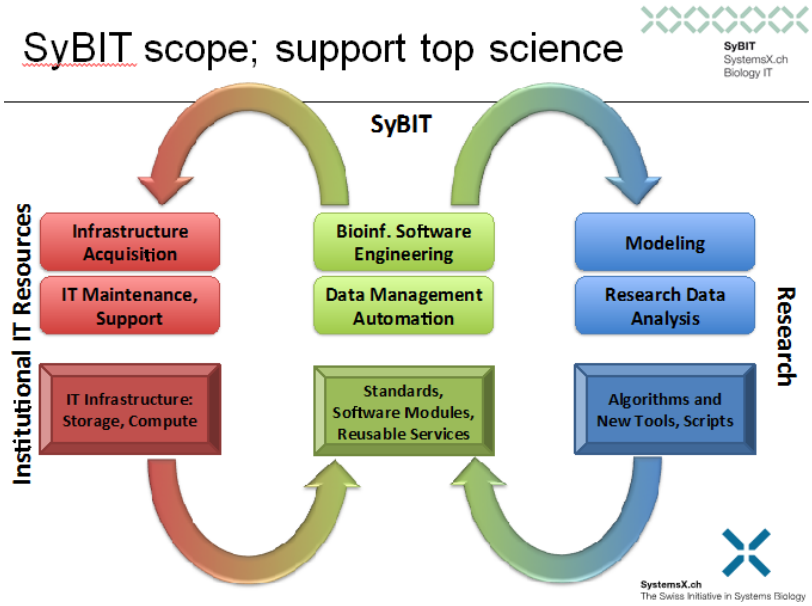

***Figure 5**. Scope and activities of SyBIT.*

In particular, the **development of the openBIS platform has played a central role in enabling the scale-up of data management and analysis pipelines** for a set of OMICS technologies used in in systems biology projects, such as next-generation sequencing (transcriptomics) data, proteomics data, metabolomics data and imaging data. openBIS is used by an international community of labs, research projects and scientific facilities in Switzerland and Europe (see KS6 – FAIRDOM) as well as pharmaceutical companies for managing laboratory information, documenting experiments, large-scale management of digital research assets and as a backbone of data analysis pipelines. Today, more than 40 local installations of the Open Source Software are known and an estimated 1000 users regularly work with it. Large installations manage more than 350 TB of research data.

SyBIT has organized **15 'tech days'**, retreats and technical workshops among its partners to this date, not counting bilateral training sessions. These efforts increased partners' knowledge of one another and created a collaborative setup, which will continue within the frame of the SIB.

Science IT services provided by SyBIT have been valued as good or very valuable by almost 80% of PIs asked. The service that has been most used by RTD and MRD projects was software development, followed by infrastructure for storage and analysis of data. However, several PIs noted that either local structures suitable for their needs were already in place, or that the necessary expertise was already present within the consortia, rendering SyBIT's services unnecessary. In one case it was argued that a less centralized structure would be more useful, although most PIs valued precisely the centralization of services.

Sustainability

Local science IT groups

From early on it was clear that the efforts made to establish science IT support should move gradually towards structures that guaranteed the sustainability of these activities beyond the funding period of the SyBIT project. It can be said that **SyBIT kick-started the development and establishment of competences.** Besides the previously existing Vital-IT (University of Lausanne, EPF Lausanne, University of Geneva, University of Bern, University of Fribourg – coordinated by Ioannis Xenarios), similar services now exist at the University of Zurich (S3IT, Marcel Riedi), University of Basel (sciCore, Torsten Schwede) and ETH Zurich (Scientific IT Services, Bernd Rinn). In addition, SyBIT stimulated the University of Bern, which was not a

SyBIT partner, to create a science IT unit in 2017. The institutional adoption of science IT helps sustain supporting activities implemented by SyBIT, such as publication support, software support, operational support and data storage and archiving.

> *"SyBIT was truly enabling in the beginning. Now it has been taken over by many more local organizations"*
> *Prof. Uwe Sauer, ETH Zurich*

Cultural change

SyBIT catalyzed a cultural change towards more collaboration both between life-science researchers and scientific IT support groups as well as between scientific IT support groups from different institutions. In addition, SyBIT brought together groups from institutions which did not work together regularly before, including those from the Arc Lémanique and the Zurich/Basel area. Today, newly created science IT groups are aware of the needs of the life science community. In addition, researchers became aware of the possibilities, importance and challenges of scientific computing and improved their knowledge on it.

Continued collaboration and international outreach

The collaboration and synergies between the two clusters (ZH/BS and Arc Lémanique) became evident during the formation of the e-Science Support Coordination Team (eSCT eSCT", new: "EnhanceR) of the CRUS 'scientific information' program and other projects and programs, including the upcoming Swiss Personalized Health Network (SPHN) which started in late 2016. International outreach and continued collaboration between SyBIT partners was facilitated by the participation in the European projects CHARME (coordinated jointly by Vital –IT and ETH Zurich) and FAIRDOM (University of Zurich and ETH Zurich are contributing).

By setting up SyBIT, SytemsX.ch sustainably influenced science IT and research data management in Switzerland. **The organizational, technical and social impact of SyBIT will be of continued value to the research community and paved the way for future projects**, such as a national computational infrastructure for the Swiss Personalized Health Network.

A more detailed description of SyBIT achievements can be found in the Appendix C.

5.2.1.3 Conclusion "Structural Impact"

By promoting the systems approach and setting financial incentives that respect the autonomy of each partner institution, SystemsX.ch indirectly caused a structural re-orientation of both faculty (including research group leaders) and infrastructure at most institutions.

While those changes were initiated directly by the partners and in alignment with their institutions' strategies, the central service project SyBIT was implemented top-down. Several partners built upon the SyBIT model and set up their own science IT units. SyBIT not only created long-term valuable technical assets for data management, sharing and analysis of life-science research data. It also catalyzed a cultural change towards more collaboration both between life science researchers and scientific IT support groups, and between scientific IT support groups from different institutions.

***Table 4**: Overview of personnel and organizational changes at partner institutions relating to SystemsX.ch.*

Institution	# New Research Groups (including replacements)	# New Organizational Units	New Science IT Support Unit	Total Infrastructure Investments (CHF)
ETHZ	23	1	Scientific IT Services	26'805'838
EPFL	5	2	(Vital-IT)	3'320'000
UZH	10	3 (incl S3IT)	S3IT	6'727'504
UniBS	9	4 (incl sciSCORE)	sciCORE	17'527'191
UniBE	7	1	Vital-IT*	2'600'000
UniNE		1	Vital-IT*	2'400'000
UniL	4	1	(Vital-IT)	526'650
UniGE			(Vital-IT)	not reported
UniFR	2		Vital-IT*	900'000
USI	2	2	Institute for comput. sciences (with CSCS)	5'240'000
ZHAW				400'000
PSI	1	2	Science IT	700'000
FMI	3	3	IRIS (Integrated Resource Information System)	2'533'823
SIB			(Vital-IT)	no investment
IBM	4	1		1'000'000
Total	**70**	**19**		**75'420'856**

(Vital-IT): affilitated with Vital-IT previous to SystemsX.ch

**: Partners joined Vital-IT during SystemsX.ch*

For the future, it will be crucial to build upon the established structures and ensure continuity to research groups that have in the meantime got used to working in an interdisciplinary manner using high-tech equipment and relying on science IT support. Most of the reported changes will be sustainable, as the partners reported that the majority of the investments would be continued after the end of SystemsX.ch. For example, professorships will be maintained using institutional funds. A number of novel facilities plan Service Level Agreements, e.g. the proteomics and metabolomics platform at the University of Fribourg, to offer continued services. Nevertheless, additional funding vessels will be needed.

5.2.2 Collaboration Networks

The complexity of modeling biological functions and network interactions calls for large collaborative project consortia, as no single academic institution would be able to provide the required expertise or financial means for the multidisciplinary framework needed to unravel multilayered biological networks. Whether the SystemsX.ch program succeeded in fostering the development of interdisciplinary research networks between scientists, academic institutions and private partners on a national and international level will be discussed in the following.

5.2.2.1 KS 3: SystemsX.ch systematically initiated and funded interdisciplinary, inter-institutional research collaborations between the partner institutions

Situation

One of the top priorities of SystemsX.ch was to stimulate inter-institutional interactions between research groups in different scientific domains to pool expertise and to build up an internationally competitive community of Swiss systems biology researchers. The SIB has paved the way in training bioinformaticians since the early 2000's by building up a network of computational research groups at numerous Swiss institutions.

Measures and Results

Project funding

The funding activities of SystemsX.ch, in particular the calls for large RTD and MRD projects, became the main driving force to foster interdisciplinary, inter-institutional collaborations. As written in the call texts, projects with an interdisciplinary character that linked research groups from traditionally separated disciplines were encouraged to apply in order to attract non-biologists. Furthermore, consortia were required to be composed of research groups from at least two partner institutions."[4] As some of the early RTD projects involved more than 12 research groups, the maximum number of groups was limited to eight in the second phase to avoid overly time-consuming coordination efforts. In addition, the projects were required to integrate at least two disciplines relevant to systems biology.

"The RTD greatly increased opportunities for trans-disciplinary research that would be impossible for any single group on their own."
Prof. Dirk Bumann, University of Basel

Beside RTD and MRD projects, IPhD projects also fostered interdisciplinary collaboration, as the students had to be supervised by two investigators from separate scientific domains such as computer science, engineering, physics, mathematics, chemistry, biology or medicine.[5]

Interdisciplinarity of research consortia

In the 248 approved SystemsX.ch projects, a total of 401 different research groups added to the success of the projects. Looking closer into the funded RTD and MRD projects, PIs reported up to six different scientific disciplines represented in their projects. Not surprisingly, all RTD projects reported biology as one of the main disciplines, whereas only five out of nine MRD projects referred to biology. Computer sciences were mentioned by 76% of the RTD projects as the second important discipline, which perfectly reflects the integration of experimental and theoretical sciences. Only 44% of MRD projects mentioned computer sciences as part of their project portfolio.

[4] 1st SystemsX.ch Call for Proposal, September 2007
[5] 2nd SystemsX.ch Call for Proposal, September 2008

The dominance of biology also becomes evident in the composition of research consortia. Based on the topic and discipline of their (first) doctoral thesis, 46% of the PIs/co-PIs were biologists. In contrast, this also means that **SystemsX.ch succeeded in attracting 54% of non-biologists to contribute to systems biology projects** (see Figure 6).

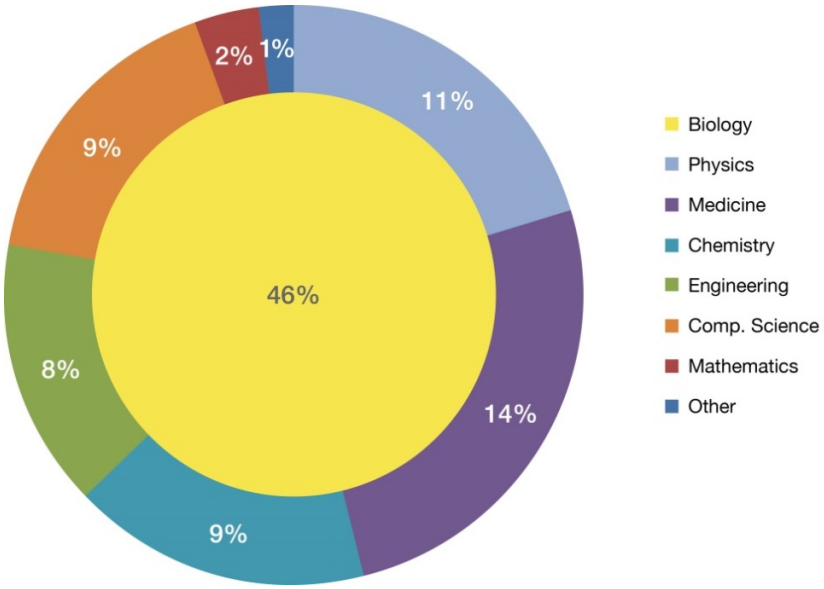

Figure 6: *Share of disciplines in all SystemsX.ch funded research project types (401 PIs and co-PIs in total).*

> *"Our participation in AneuX further widened our interactions with other disciplines, for example computer sciences."*
> *Prof. Brenda R. Kwak, University of Geneva*

Although biology is the principal discipline within the SystemsX.ch community, its relative share has decreased over time from 55% in 2008 to 46% in 2015. The remaining shares did not change significantly over the past few years with physicists, chemists, computational scientists and engineers representing about 10% each. However, the 10th call caused a remarkable increase in the proportion of MDs, from 10% to 14%, a good example of steering research through the use of funding instruments. *Further information on the development of disciplines in SystemsX.ch funded research groups is given in the Scientific Report 2015-2016, p. 36-37.*

Inter-institutional research consortia

Since 2008, collaborations between systems biology researchers have increased significantly, thanks to the implemented funding measures: **80% of the interviewed PIs and co-PIs of RTD and MRD projects answered that they gained new research partners they had never worked with before through their RTD or MRD project**. On average, three new cooperation partners were given.

The 43 RTD and MRD projects also succeeded in initiating truly **Swiss-wide collaboration networks** that combined the expertise of partners in the eastern and western parts of Switzerland:

- **21 RTD and MRD research consortia brought together scientists from both parts of Switzerland**
- **18 research consortia** only involve research groups from the **eastern part** of Switzerland
- **4 research consortia** only involve research groups from the **west**

According to the survey up to 74% of these newly established networks resulted in subsequent publications, new joint project proposals, the exchange of personnel or sharing of technologies. Further outcomes of the newly encouraged collaborations were jointly organized symposia, training courses or even the joint purchase of equipment.

Interdisciplinary, inter-institutional research consortia facilitated especially the integration of young scientists into the Swiss systems biology community. An increased awareness of the expertise and infrastructure available in Switzerland was accomplished as well as a better understanding of complementary disciplines. Both added to a transparent systems biology landscape in Switzerland: The resulting exchange of competences and technologies between research groups contributed to high-impact outcomes that would not have been possible without the SystemsX.ch network.

Collaborations between RTD projects

Close collaborations also took place between funded RTD projects. Examples are HostPathX, MetaNetX, TbX and SwissLipids, which share data and coordinating efforts on metabolism representation and modeling. The MorphoGraphiX software, whose development was started under the first phase RTD Plant Growth, was further developed as a collaborative effort between PlantGrowth2, WingX, MorphogenetiX and SyBIT. In addition, several IPhD students and TPdFs have contributed to RTD projects. These interactions enable the young scientists to intensify their exposure to different scientific domains, as well as to expand their network, while the RTDs profit from the young researchers' interdisciplinary training. Some examples are the TPdFs Julien Limenitakis with GutX, Hartland Jackson with MetastasiX, and IPhD student Sunil Kumar with MetastasiX.

"We can build on these new collaborations for both ongoing and new projects."
Prof. Sebastien Gagneux, University of Basel

Co-authorship analysis

To verify the above statements, the Center for Science and Technology Studies (CWTS) at University Leiden carried out a **co-authorship analysis of selected RTDs.** Since an evaluation of the whole of SystemsX.ch was considered too work-intensive, a subset of publications from selected RTDs (LipidX1&2, PlantGrowth1&2, InfectX/TargetInfectX, PhosphoNetX/ PhosphonetPPM, Neurochoice) was chosen to investigate the collaboration patterns between PIs/co-PIs.

For 59 PIs and co-PIs involved in those projects, publications were collected for the period under study. In order to investigate the effect of SystemsX.ch funding on the collaboration network, the period 2008-2015 was compared to the situation in the period 2000-2007. The resulting networks are displayed on the following page.

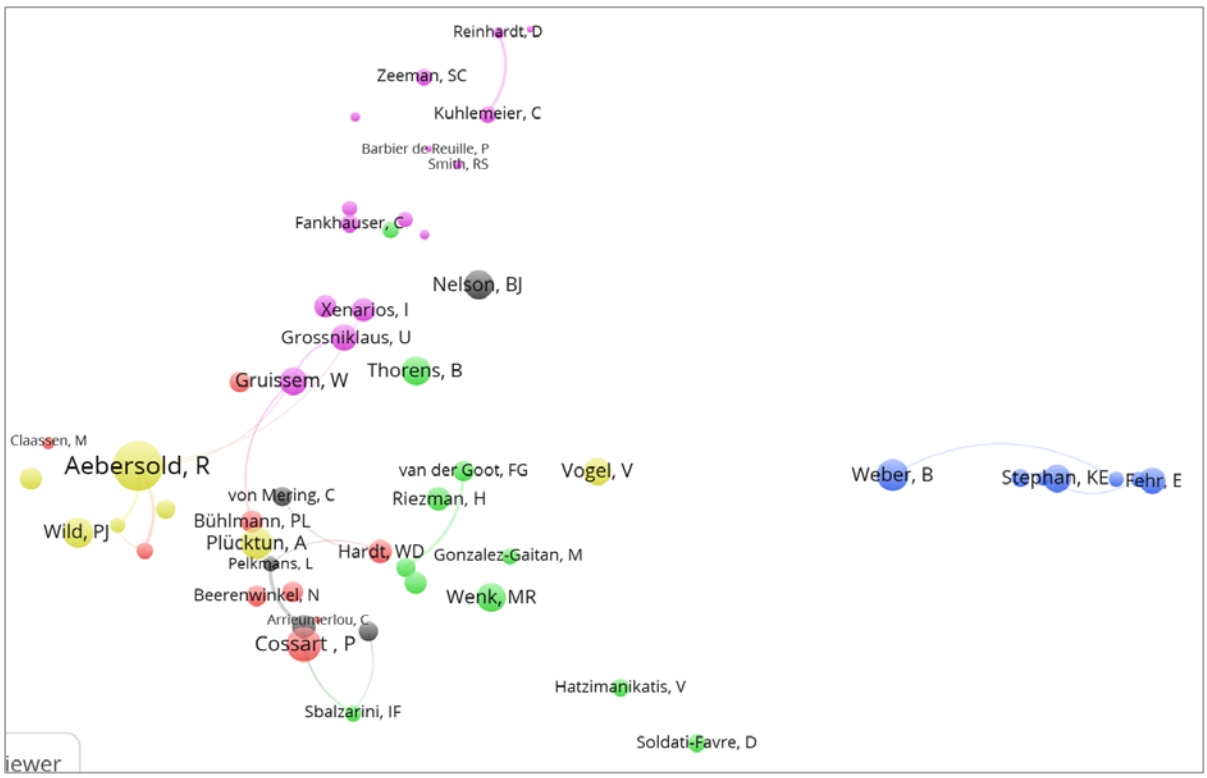

Figure 7: *Collaboration map for a subset of SystemsX.ch researchers based on a co-authorship analysis over the period 2000-2007.*

Explanation Figure 7 and 8: Each (co-)PI is characterized with a color to indicate the project she/he belongs to (green: LipidX1&2; yellow: PhosphoNetX/PhosphonetPPM, pink: PlantGrowth1&2, blue: Neurochoice, red: InfectX/TargetInfectX). Those who are active in more than one program are colored in grey. The closer two labels appear, the closer the collaboration. The bigger the circle, the more publications and the broader the connections, the more joint publications.

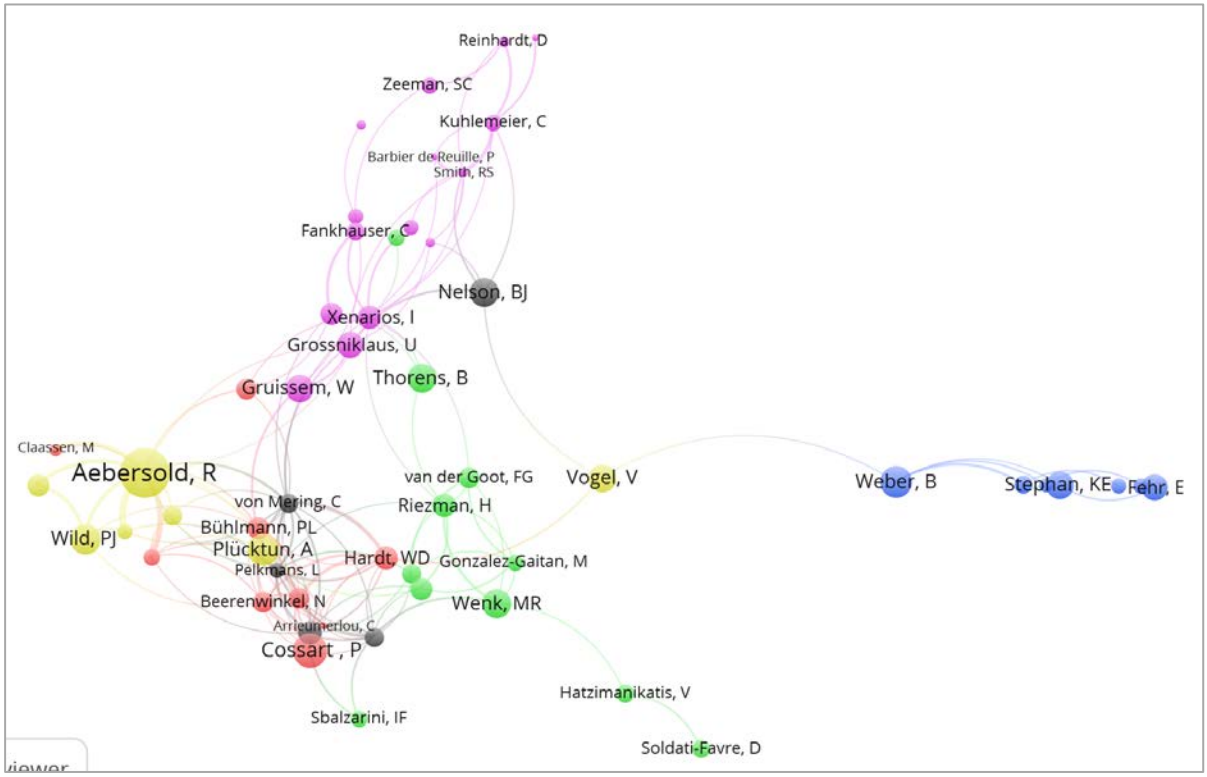

Figure 8: *Collaboration map for a subset of SystemsX.ch researchers based on a co-authorship analysis over the period 2008-2015.*

Comparing the two resulting networks, a clear acceleration of connections can be seen since 2008: up **until 2007, only 17 connections** between PIs/co-PIs can be identified, while in the period **since** 2008 the connections amount to 144. This number includes all co-authorships, regardless of whether the analyzed publications were funded by SystemsX.ch or not. If only SystemsX.ch publications are considered, 116 out of those 144 connections remain, which demonstrates the influence of targeted SystemsX.ch funding on the development of national collaboration networks (Figures 7 and 8).

When zooming in on the details of the collaboration network on the level of single RTD projects (Figure 9 and 10) it can be seen that a **lively interaction between researchers of different discipline and institutions** evolved over the running time of SystemsX.ch. Exemplarily, the cooperation network of two projects (Plant Growth1&2 and LipidX 1&2) are displayed in the following:

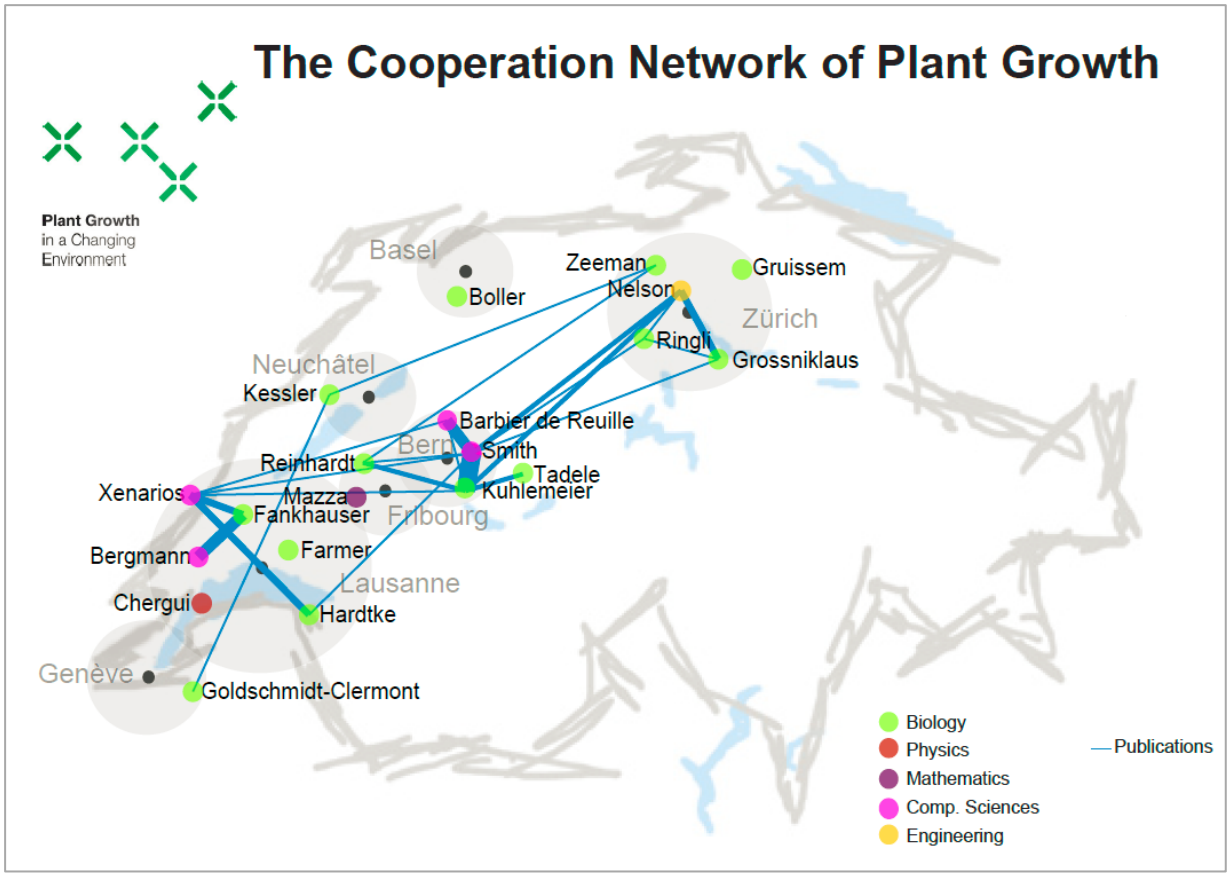

Figure 9: *Cooperation Network of PlantGrowth 1&2 based on a co-authorship analysis (2008-2015).*

Explanation: The broader the lines the more joint publications.

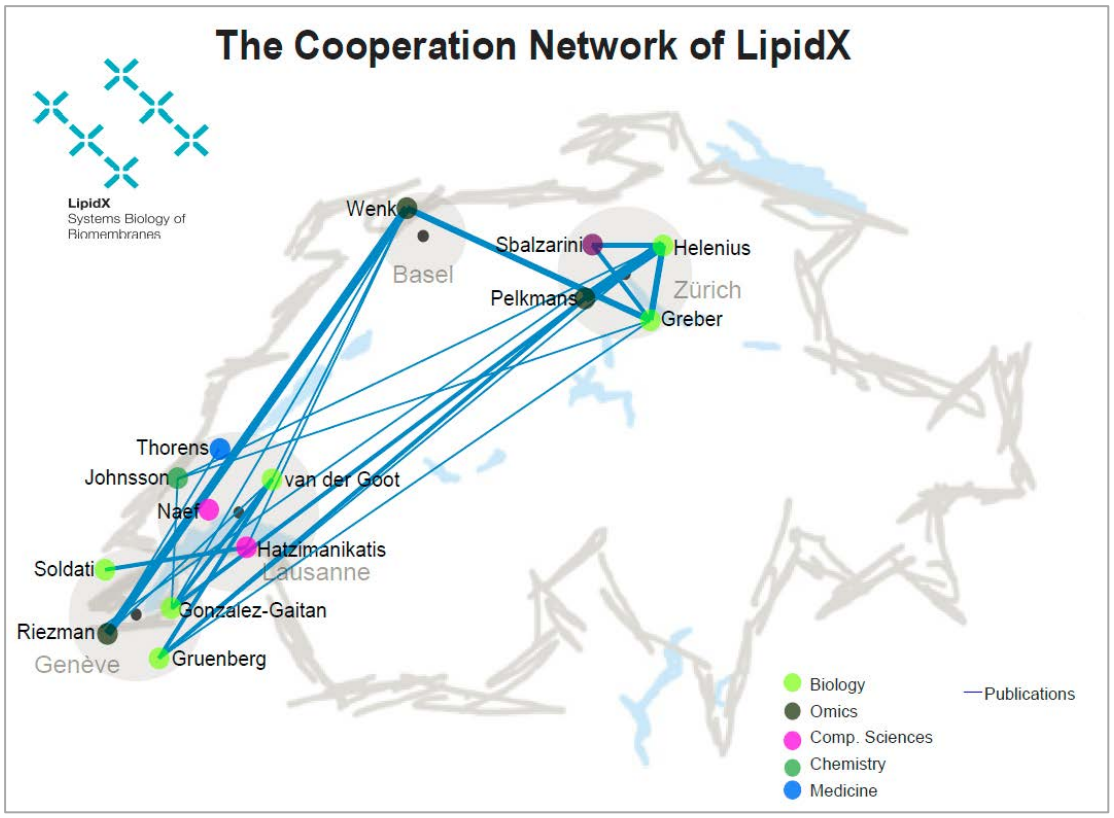

Figure 10: *Cooperation Network of LipidX 1&2 based on a co-authorship analysis (2008-2015).*
Explanation: The broader the lines the more joint publications .

For more information on approach and results of the co-authorship analysis please see Appendix B.

Measures to support community building

> *"For me as a young PI the interactions with other Swiss universities and senior groups has been extremely important for networking, to become known and to exchange ideas, strategic concerns, etc."*
>
> *Prof. David Gatfield, University of Lausanne*

To promote a lively systems biology community in Switzerland, a variety of supporting measures were taken: Scientific events such as **seven All SystemsX.ch Days** and **three International SystemsX.ch Conferences** (Basel 2011, Lausanne 2014 and Zurich 2017) as well as more than ten annual PI meetings, intended to offer researchers a meeting point for scientific discussions, networking and knowledge exchange. After the termination of SystemsX.ch, community building efforts will be continued in the frame of the annual meeting of Life Science Switzerland (LS2). A specific systems biology session will be integrated into the program in 2018 and the subsequent annual meetings will offer SystemsX.ch researchers a meeting platform. Supported courses and conferences that were also open to non-SystemsX.ch researchers have added to an expanded Life Science Network in Switzerland beyond SystemsX.ch**.** Non-scientific efforts supporting community building include the "SystemsX.ch trademark" and diverse communication tools, such as the SystemsX.ch webpage, newsletters, the X-Letter magazine, and since August 2016 a SystemsX.ch Twitter account. The film about SystemsX.ch and some of its projects, currently in production, intends to report on the achievements in research.

5.2.2.2 KS 4: SystemsX.ch has reached out towards the private sector to facilitate the implementation of system biology approaches in industry and SMEs[6]

Situation

Partnerships with industry, and thereby 3rd party funding, were one of the priorities of the initiative, especially in the beginning. In the precursor program between 2004 and 2007, several research activities between private and public institutions were initiated. As an example, ETHZ and Roche started a new project in 2005 called "Systems biology of pancreatic beta-cells", which involved a financial investment of more than CHF 10 million by Roche, including up to 10 postdocs.

Based on former large-scale investments by industry partners, the initial interest of industry in the preparatory phase as well as the proximity of some SystemsX.ch partners to industry (e.g. FMI is core funded by Novartis Foundation, Syngenta supported renovation of D-BSSE in Basel), collaboration in particular with big pharma was expected to be intense. Also, both federal authorities and industry expressed interest in a collaboration between academia and the private sector during the Federal ERI Dispatch 2008-2011: representatives from industry (Novartis: Paul Herrling; Roche Pharma: René Imhof) were invited to meetings of the parliaments committees for science, education and culture (of both chambers).

The private sector was especially interested in academic know-how (transferred via well-educated scientists) for translational research and advanced technologies. However, no technology-heavy project was among the funded RTD projects of the 1st call. Most of them incorporated technology development within scientific milestones instead (e.g. PhosphoNet).

> *"As one of the large pharma companies we are mainly interested in cutting-edge technologies and the latest developments when collaborating with academic institutions."*
> *Dr. René Imhof, Roche Pharma AG*

Measures and results

SystemsX.ch partners and committees

In both SystemsX.ch committees, BoD and SEB, two representatives from industry were invited as guests to ensure that public-private-partnerships were efficiently implemented. In addition, the FMI, which is core-funded by the Novartis Foundation and academically affiliated with the University of Basel, became one of the earliest SystemsX.ch partners in 2007. All of the FMI projects had collaborative links to Novartis. In 2015, IBM Zurich Research Laboratory joined SystemsX.ch as a partner. The participation of industry in SystemsX.ch proved that the private sector was interested in the systems biology approach.

Promotion of public-private partnerships

In order to foster collaboration between academic and private research groups, SystemsX.ch organized several events (e.g. Industry Day, SME Workshop), participated actively at biotech fairs (MipTec), connected to the Swiss Biotech Association (SBA) and visited numerous companies right from the beginning. For example, the **SME-SystemsX.ch workshops** were held jointly with the SBA and local university tech-transfer offices to present both sides with their needs and requests. Similar events with industry were organized but did not take place due to the low number of registrations. In 2012, an "**Entrepreneur in Residence"** (Michael

[6] Data Source: Calls for Proposals #1 to #12 (especially BIP, IPP, TF Projects), Scientific Reports 2008-2016, lists of events with industry involvement, FMI and IBM Zurich Research Lab as SystemsX.ch partner institutions
Parameters: number of applications, approved projects and interaction with the private sector per project type; industry events organized by SystemsX.ch

Dillhyon) visited various SystemsX.ch research groups as an innovation scout to find appropriate private partners. As the interest of the private sector was vague, the decision was made to **concentrate on supporting spin-off companies**, as can be seen in Table CC.

Table 5: *Spin-off companies which either (a) evolved out of a SystemsX.ch research group or (b) collaborated in a project.*

Name Spin-off	Year	SystemsX.ch project	Type
Biognosys	2008	PhosphoNetX	(a)
ProteoMedix	2010	PhosphoNetX	(a)
Microduits GmbH	2010	CINA	(a)
Genohm SA	2011	CycliX	(a)
BioDataAnalysis GmbH	2015	InfectX, TargetInfectX	(a)
Lunaphore	2014	IPhD Project Ciftlik	(a)
Lyncée tec S.A.	2003	BIP	(b)
Science Visuals	2007	BIP	(b)
FemtoTools AG	2007	MecanX	(b)
Nebion AG	2008	BIP	(b)
BioVersys AG	2008	TbX	(b)

For a complete list of measures undertaken to promote collaboration with the private sector see Appendix A, Table A5.

Projects

After the approval of the first RTD projects, several companies were visited and the projects' contents presented. It transpired that most of these RTDs were either 'too upstream' (basic research) or not within the thematic scope of the companies. Consequently, fewer collaborations were realized than initially anticipated. Also, some scientists were concerned about private influence on research when collaborating with industry.

In order to meet the interests of industry and promote public-private research cooperation, specific project types (BIP and TF) were established, allowing private partners to act as co-PIs. Thus, private partners were involved from the outset to help shape the proposals. From 2012 onwards, private research groups were invited to be part of the proposal consortia of all project types with the restriction that they could not receive SystemsX.ch funding but had to cover their expenses themselves. With this, it was clear that contributions from the private sector were in-kind.

"Through SystemsX.ch Novartis gained easy access to an established network of academic research groups."
Dr. Hans Widmer, Academic Liaison and Knowledge Management Novartis

"SystemsX.ch jump-started the industry collaboration between C-CINA and Roche Basel, as well as several other smaller companies (CovalX, LeadXPro)."
Dr. Christian Sengstag, University of Basel

In total, **29 private co-PIs contributed to SystemsX.ch projects** *(for a complete list see Appendix A, Table A6).* Almost 50% (13 out of 30 PIs) of all large projects (RTDs, MRDs) reported that at least one co-PI of the consortium was a private partner (i.e. receiving no SystemsX.ch money but providing expenses via the company). Their main motivation was the access to advanced methods and technology, as well as access to relevant data. Half of the PIs are of the opinion

that the industry partner definitely benefitted from the collaboration and that the expectations were met (public -> private), while 40% stated that their own research group benefitted from the collaboration (private -> public). Only in one case did the research group cease collaboration with the respective private partner.

Despite a variety of measures aimed at initiating public-private partnerships, there is a large discrepancy between the planned and realized 3rd Party Funding. Nevertheless, a considerable number of collaborations kicked-off by SystemsX.ch turned out to be sustainable: no fewer than 77% of the collaborations continued after SystemsX.ch funding ended *(see PI questionnaires for details).*

5.2.2.3 KS 5: SystemsX.ch has created the basis for international research collaborations

Situation

As a European center of research and innovation it is essential for Switzerland to attract renowned experts and build up international research collaborations. These help to guarantee excellence in science and enhance the ability to translate Swiss innovation into industry and to ensure international competitiveness long-term. Throughout the initiative, SystemsX.ch has taken a variety of actions to create the basis for international research collaborations.

Measures and results

Invitation of foreign research groups to Swiss research consortia

A direct influence on international research collaborations has been made from the beginning by allowing foreign research groups to act as co-applicants on proposals for SystemsX.ch projects. “Under certain circumstances (e.g. no Swiss research group can provide the respective know-how), it is possible to include research groups located in a foreign country. However, SystemsX.ch funds can only be provided to the Swiss research groups involved”[7]. To strengthen Swiss-German collaboration, a **Consortial Agreement between the German Ministry for Education and Research (BMBF) and SystemsX.ch was signed in 2013**. This agreement ensured that German research groups could team up with Swiss researchers and become partners in a SystemsX.ch RTD or MRD consortium. In case the joint proposal was funded, the German research group received funding from BMBF. Currently, German research groups are involved in four RTD projects. The open-mindedness towards foreign research groups lead to a total of 29 foreign co-applicants, many of them located at leading systems biology research centers such as MIT, USA or the University of Cambridge, UK, on proposals submitted to SystemsX.ch. Eight of these projects were chosen for funding, involving **nine international research groups from Germany, France, the UK, the USA and the Netherlands**. Mainly the large, integrated RTD and MRD projects receive international support: 14% of the RTDs and MRDs include foreign co-applicants who receive funding from their home countries. Thus, in-kind contributions from foreign countries to SystemsX.ch projects were secured.

A list of research groups contributing to SystemsX.ch RTDs can be found in Appendix A, Table A7.

[7] 10th SystemsX.ch Call for Proposal,

Swiss participation in ERA-Net ERASysAPP

"Through SystemsX.ch we were able to successfully apply for the second ERA-SysAPP call. The resulting Rootbook project gained a lot of visibility and led to new international interactions."
Prof. Manfred Claassen, ETH Zurich

With the participation of SystemsX.ch in the European Research Area Network for Applied Systems Biology, ERASysAPP, the initiative took another important step towards fostering pan-European research collaboration. Altogether, 16 partners from 13 different European countries joined forces to encourage scientists of the participating countries to collaborate, exchange knowledge and share existing resources.

In order to set up research networks beyond national boundaries, the consortium launched two joint transnational calls for proposals in November 2013 and October 2014**.** Altogether twelve project proposals were selected for ERASysAPP funding, involving more than 70 research groups from twelve European countries. **Swiss researchers contribute to six of those projects**: SysMilk (Uwe Sauer, ETHZ), SysVirDrug (Niko Beerenwinkel, ETHZ), SysMetX (Igor Pivkin, USI), MetAPP (Julia Vorholt, ETHZ), RobustYeast (Vassily Hatzimanikatis, EPFL) and Rootbook (Manfred Claassen, ETHZ). SystemsX.ch is supporting the Swiss research groups with a total amount of CHF 2.34 million for projects lasting 36 months. In total, the ERA-Net granted nearly 16 million Euros in research funding. The Swiss participation in half of the funded projects clearly shows that Switzerland is a key player in systems biology research in Europe.

"Professor Vorholt and her group at ETHZ are known worldwide for their strong scientific skills in systems biology on methylotrophic bacteria, and their participation has been crucial for our ERASysAPP project. I am well aware of other very strong systems biology groups in Switzerland that I would be most happy to collaborate with in the future."
Prof. Trygve Brautaset, Coordinator ERA-SysAPP project MetAPP, NTNU Norway

Call statistics of both calls can be found in Appendix A, Table A8. For a complete list of funded projects and Swiss partners see Appendix A, Table A9.

Funding of European data management project FAIRDOM

In spring 2014 the data management project FAIRDOM was launched. This project is funded by the UK (BBSRC), Germany (BMBF), Switzerland (SystemsX.ch) and the Netherlands (NWO). The mission of FAIRDOM is to support researchers in Europe in managing, sharing and archiving their scientific data through FAIR (= **F**indable, **A**ccessible, **I**nteroperable, **R**eusable) management of data, models and operating procedures to simplify transnational research collaborations and guarantee sustainable research investment.

"openBIS is an important component of FAIRDOM. Six of the twelve ERA-SysAPP projects use it for managing their local proteomics and NGS data and through FAIRDOM two of the six Synthetic Biology Centres in the UK have adopted openBIS."
Dr. Carole Goble, University of Manchester, FAIRDOM Coordinator

SystemsX.ch supported the participation of the Swiss Science IT and Data Management project SyBIT in FAIRDOM with an amount of CHF 660,000 for 2.5 years. **SyBIT not only provides know-how in data management, but contributes the Swiss data management platform openBIS.** To set up a central infrastructure for standardized data, model management and archiving the existing platforms, openBIS (Switzerland) and SEEK (UK) were integrated to a central

platform, openSEEK. This integration was a **major step in closely linking the Swiss research community to the European research landscape** and simplifying international research collaborations. Furthermore, Swiss users benefit from the integration, as they now have access to a user interface that provides social networking functionalities, integration with bioinformatic tools and model management. The participation in FAIRDOM allows Switzerland to take part in the current development of tools, standards and procedures for the management of scientific data in Europe.

"The collaboration with FAIRDOM was an integral part of the ERASysAPP proposal. As biologists we were skeptical, but the FAIRDOM team was very user-oriented and provided solutions tailored to the need of our consortium. The FAIRDOMHub is easy to use and very helpful. "
Dr. Marco Binder, project member SysVirDrug, DKFZ

Currently, six ERASysAPP projects (SysMilk, SysVirDrug, SysMetEx, IMOMESIC, MetAPP and RootBook), receive data management support from the FAIRDOM team. With a growing number of users, the importance and influence of FAIRDOM will increase over the next few years.

Organization and support of international conferences and courses

To foster networking and increase the visibility of Swiss systems biology research internationally, a variety of measures that sow the seed for future trans-national collaborations have been conducted. SystemsX.ch has been very active in supporting international conferences and events. By organizing international conferences in Switzerland (International SystemsX.ch Conferences 2011, 2014 and 2017) and inviting renowned foreign speakers, the international recognition of Swiss systems biology research was boosted and Swiss researchers received the opportunity to network with world-leading scientists. For example at the **2nd International SystemsX.ch Conference on Systems Biology** in 2014 in Lausanne, 376 researchers from seventeen different countries registered and met to exchange their experiences, among them twelve world-class speakers from the USA, UK, Germany, Austria, Canada and France.

Sponsorship of foreign events and travel grants for Swiss researchers were also important tools for fostering international visibility and networking. The bi-annual **Advanced Lecture Course on Systems Biology in Innsbruck, Austria** (co-organized by Prof. Uwe Sauer, ETH Zurich) was supported four times (2009, 2011, 2014 and 2016). When the main sponsor of the course, FEBS, withdrew in 2013, SystemsX.ch stepped in to guarantee the continuation of this well-known educational event and took over organizational tasks. Thus, SystemsX.ch was instrumental in sustaining the course that attracts 120 young researchers and 35-40 renowned speakers from all over the world. In 2016, a total of 18 young researchers from Switzerland participated. With the sponsorship of the **Conference on Systems Biology of Human Diseases (SBHD),** which has been supported yearly since 2012, SystemsX.ch not only promoted Swiss systems biology research internationally, but also awarded up to 20 travel grants overall.

In total SystemsX.ch approved more than 60 travel grants to students between 2013 and 2016 to enable Swiss researchers to participate in courses and events. Furthermore, the mobility of IPhD students was promoted by granting CHF 2'000 to cover participation in courses and conferences so they could present their own work.

Additional measures

Funding of high-impact research projects itself added to continued international recognition of Swiss systems biology research and led to international collaborations: 45% of the PIs and co-PIs of SystemsX.ch projects, who stated that their participation in SystemsX.ch opened up new opportunities, referred to international collaborations, be it new foreign research partners, EU funding of follow-up projects or increased international visibility.

Finally, various collaborations and activities of SystemsX.ch scientists and members of the SystemsX.ch Management Office contributed to the international recognition of SystemsX.ch. This is also reflected in the **invitation to the Managing Director of SystemsX.ch to advise the new Norwegian biotechnology initiative, Digital Life,** on establishing a new research initiative.

5.2.2.4 Conclusion "Collaboration Networks"

In summary, it can be stated that SystemsX.ch was very active in promoting cross-disciplinary research networks on national and international levels.

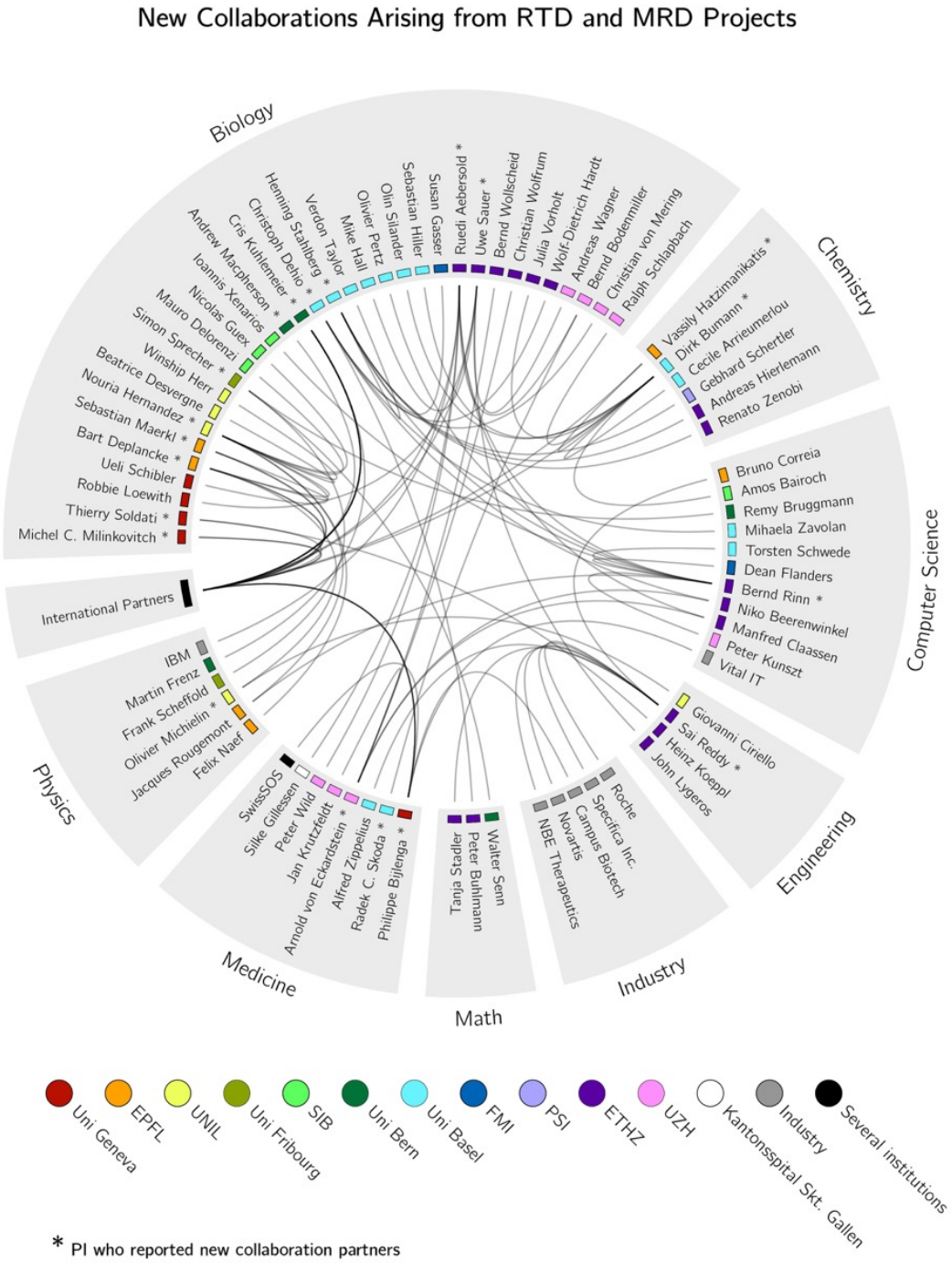

Figure 11: *Novel interdisciplinary, inter-institutional collaborations of Swiss research groups as reported in the SystemsX.ch questionnaire for PIs.*
(Disciplines have been determined based on the topics the PIs' doctoral thesis)

With the combination of tailored funding measures and the support of community building efforts, SystemsX.ch not only sped up the development of Swiss-wide collaboration networks and attracted new disciplines to systems biology, but also established the financial and technological basis for simplified international research collaborations and implemented valuable connections to industry. As Figure 11 shows, **multiple new collaborations arose from SystemsX.ch projects, connecting researchers from different institutions, disciplines and countries.** Although cooperation with industry players did not reach the intended level, nevertheless a number of lasting partnerships evolved. An active, well-connected systems biology community resulted which will live on after the termination of SystemsX.ch, and which will be an important success factor for future systems biology research. In fact, the establishment of a **Swiss-wide systems biology research network is seen as the most important legacy of SystemsX.ch**, as many of the statements from researchers and partners indicate (see SystemsX.ch questionnaires).

5.2.3 Impact on Education and Training

One of the main limitations in the early days of systems biology was that most interdisciplinary research approaches relied on the collaboration between experts in individual fields (e.g. biologists and mathematicians), each with limited knowledge and understanding of the other field. Therefore, it was deemed essential for young scientists to gain expertise in diverse scientific fields, as an interdisciplinary education influences the way researchers think, approach biological questions and set up experiments and adds to more efficient collaboration. The following chapter evaluates whether SystemsX.ch successfully created a framework for strengthening the cross-disciplinary education and training of the next generation of systems biologists.

5.2.3.1 KS 6: SystemsX.ch has triggered the development of educational programs at Masters and PhD level at partner institutions to educate the next generation of systems biology researchers

Situation

Academic education is under the direct control of each university. SystemsX.ch, as an impermanent initiative, should not and could not have intervened in academic curricula on three Bologna levels (Bachelor, Master, PhD). Instead of establishing “a Swiss-wide graduate school for PhD students” as was stated in the 2007business plan, SystemsX.ch acted mainly through participants (PIs, co-PIs and SEB and EAB members) to embed systems biology education steadily in the portfolio of the partner universities. It also has to be considered, that the continuation of a centrally organized program would not have been guaranteed after the termination of the SystemsX.ch initiative.

Measures and Results

In Switzerland, systems biology education became an inherent part of academic education over the last nine years, be it through new Master- and PhD programs specialized in systems biology or the integration of systems biology aspects in existing curricula. Although these programs were not directly launched by SystemsX.ch, the majority of universities stated that **SystemsX.ch had a catalytic effect on the development or expansion of their systems biology curricula** and “kick-started” the process. This effect was mainly achieved by funding systems biology research projects and PhD fellowships, which led to an increase in public recognition of systems biology and its potential. Furthermore, it revealed deficiencies in

existing traditional curricula in the education of scientists in a truly interdisciplinary manner, which prompted universities to create new educational programs or refine existing ones.

"SystemsX.ch did not directly implement new educational programs, but they were created under the same spirit as SystemsX.ch and benefitted indirectly from the increased public awareness for computational biology thanks to SystemsX.ch."
Prof. Christian Mazza, University of Fribourg

To date, the academic partners have reported **nine PhD and nine Masters programs with a focus on systems biology** (a new one will be offered by the ZHAW as of 2017) and a total of 8 lectures, courses and practicals in systems biology which are embedded in Bachelor curricula. A variety of additional lectures, courses, summer schools and symposia for Masters and PhD students as well as postdocs complement the undergraduate and graduate study programs *(see Appendix A, Table A10 and A11).*

At the University of Lausanne, for example, a new specialization in bioinformatics was introduced as part of the "**Master in Molecular Life Sciences"**. Conversely, systems biology approaches became an integral part of bioinformatics, biotechnology or engineering curricula, as the **"Master in Biotechnology"** at the ETH's D-BSSE in Basel shows. In addition, new programs were developed bottom-up, such as the Master program **"Bioinformatics and Computational Biology",** which has been jointly offered by the Universities of Bern und Fribourg since 2013 and was encouraged by researchers, who faced the need for interdisciplinary educated researchers in their SystemsX.ch projects.

"SystemsX.ch facilitated the implementation of the bioinformatics specialization of the Master in MLS, as more and more professors felt the need to provide better training in computational methods to our students".
Dr. Renzo Restori, University of Lausanne

An example of newly established PhD programs is represented by the **Systems Biology PhD Program**, which was jointly launched by SystemsX.ch researchers from the Institute of Molecular Systems Biology, IMSB at ETH Zurich and the ETH Department of Biosystems Science and Engineering in Basel (D-BSSE) within the frame of SystemsX.ch. Since 2010, the PhD program, which is jointly organized by ETH and University of Zurich under the umbrella of the Life Science Zurich Graduate School, has offered an interdisciplinary education to students with different scientific backgrounds. The **Doctoral Program StarOmics**, which is jointly organized by the Universities of Bern, Fribourg, Geneva, Lausanne and Neuchâtel, was also launched in 2010. PhD students learn how to integrate quantitative and experimental methods in research projects.

As interdisciplinary education and systems thinking should be nurtured from the beginning, universities also started to modernize existing curricula on the Bachelor level. Biology curricula were enhanced by quantitative analytical methods as well as with the computational and mathematical concepts necessary to interpret big data, for example from genome sequencing or the analysis of microbial communities. One example is represented by the **Bachelor in Biology at ETH Zurich**, which offers not only lectures in bioinformatics and systems biology, but also a systems biology practical course.

5.2.3.2 KS 7: SystemsX.ch implemented new funding instruments to promote interdisciplinary education and training for the next generation of systems biology researchers

Situation

Although expertise in more than one discipline is an important asset for systems biology research, the appropriate funding for interdisciplinary fellowships was largely missing. Consequently, the Interdisciplinary PhD project (IPhD) was launched by SystemsX.ch in 2008, as proposed by the Advisory Board of the predecessor SystemsX. Postdocs with innovative project ideas who wished to work their way into a complementary discipline, also had difficulties obtaining funding. This fact, together with the SNSF panel's recommendation to create new training possibilities for postdocs, motivated SystemsX.ch to introduce the Transition Postdoc Fellowships in 2012. These newly established formats became the main instruments for promoting education and training at the interface of different disciplines.

Measures and results

SystemsX.ch fostered the interdisciplinary training in SystemsX.ch funded research projects through different measures:

- Participation of young scientists in RTDs and MRDs
- Newly established formats for PhD students (IPhDs) and postdocs (TPdFs)
- Support of the SIB PhD fellowship program

Training in RTD and MRD projects

Young scientists working in RTDs and MRDs, were exposed to interdisciplinary projects in their daily life. Joint meetings and retreats of these large consortium projects further impinged on this, beside bringing them together with junior and senior researchers from other institutions. SystemsX.ch retreats and conferences also facilitated these contacts.

Interdisciplinary training in IPhD projects

IPhD projects have enabled **87 students** to carry out their PhDs in two (or in some cases three) host labs. The characteristic of the IPhD projects is that students with a certain scientific background are trained and educated in complementary disciplines. This is achieved mainly through the joint supervision principle. While this program allows students to gain very valuable interdisciplinary experience in at least two scientific domains during their doctoral studies, it is also a format with a certain potential for conflict. This is shown by the fact that in several IPhD Projects the PhD student left prematurely and the PI and co-PI had to find another student who could continue the project.

The number of proposals received per call throughout the initiative remained high and quite constant ranging from 18 to 41 submitted proposals, which suggests that the format of these projects is valued by the community, and that it addresses an important need.

"Overall the SystemsX.ch IPhD funding scheme has been a good and valuable source of funding for systems biology-related projects that would otherwise have had a difficult time competing for funding in the normal track of SNSF funding."
Prof. Sebastian Maerkl, EPFL

As would be expected, in 90% of the IPhD projects one of the scientific disciplines was biology, with engineering, computer science, mathematics and bioinformatics being the main complementary fields. Perhaps surprisingly, biology was the new discipline for almost 35% of the IPhD students.

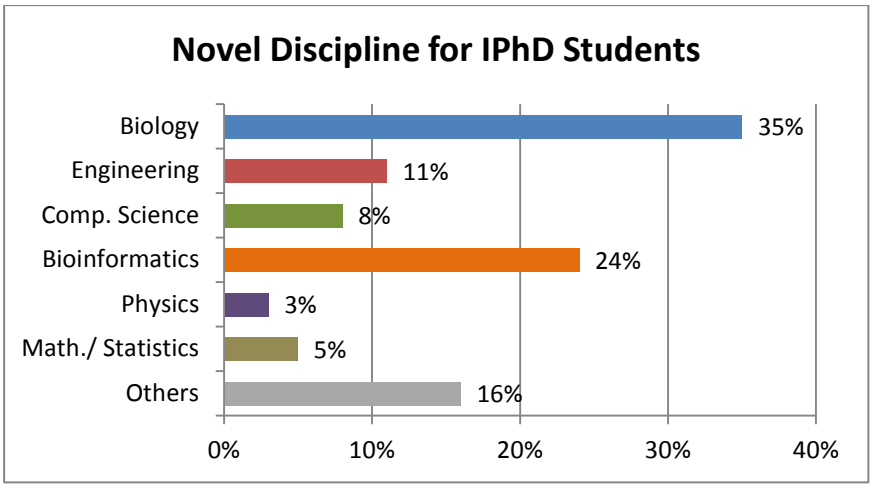

Figure 12: *Disciplines in IPhD projects that are novel to the IPhD student.*

IPhD students reported **many different advantages** of this project type: it promotes creativity, provides a broader perspective, and stimulates the researcher to look for new points of view. Most students also greatly appreciated being part of a network and community. Among the disadvantages of IPhD projects, students mentioned that they potentially get to know each field less in depth than a student focusing on only that field. Moreover, students often remarked that different interests or expectations of the PIs can be a challenge. However, the feedback was very positive, with students stressing that the advantages largely outweighed the challenges.

"The wide range of the IPhD Project was challenging, but mastering the skills over time made me a more skilled and wider positioned researcher. The funding of SystemsX.ch was instrumental to succeeding in this challenge."
Philipp Ihmor, IPhD Student at ETHZ

IPhD supervisors agreed with the students on the risk of gaining less profound knowledge in each field. They also noted that IPhDs required an increased effort in terms of supervision, and that the funding might have been too short for such projects. Nevertheless, they all agreed in considering the program to be a very useful and necessary tool for training young, interdisciplinary scientists. Many supervisors also declared that these projects had allowed them and their labs (and not only the IPhD student) to learn much more from the other field, and in several cases the IPhD Projects paved the way for future collaborations with the co-PI's lab, thus being an important tool in the establishment of networks within the systems biology community.

"I have gained better appreciation for the challenges one is faced with in experimental biology. I had and still have more exchange with my co-PI thanks to our common IPhD student. There is less asymmetry in interest than if both PIs had their own separate student".
Prof. Vartan Kurtcuoglu, IPhD Supervisor, University of Zurich

TPdFs to support transition to complementary field

TPdFs were introduced with the aim of enabling young systems biology postdocs to acquire competences in a scientific domain complementary to the one they had been active in so far. These transitions allow the Transition Postdoc fellows to become real interdisciplinary scientists, mastering at least two disciplines of high relevance for systems biology research. There have been four calls for TPdF proposals, through which **32 fellowships** were approved. The

increase in proposals since the 5th call (17-28-28-33) suggests that there is a strong demand for this type of funding.

The backgrounds of the postdoc fellows were varied, with nearly 38% having completed their PhDs in biology, and 17% in bioinformatics or computer sciences. Most transitions were towards biology.

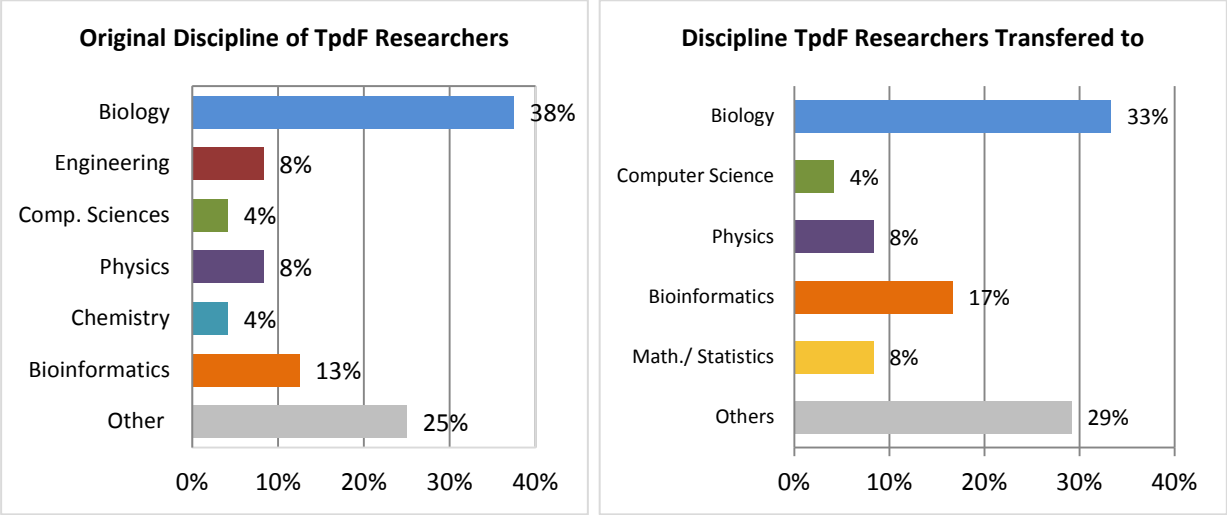

Figure 13 *Original and new disciplines as reported by TPdFs.*

The feedback received from both Transition Postdoc Fellows and from their host lab PIs is extremely positive: **the postdocs greatly appreciated the unique opportunity that this funding provided to work in a field in which they had limited previous expertise**. TPdFs remarked that interdisciplinary training is key towards becoming an independent systems biology researcher. Furthermore, and as in the case of IPhDs, the sense of belonging to a community and having chances to network and interact was mentioned as a great advantage. The main disadvantages that postdocs mentioned is that the actual transition is challenging, that it takes more time to publish, and that communication with scientists from other domains can be difficult. All agree that advantages greatly compensate for these disadvantages.

> *"It has been an enriching experience to have been awarded a TPdF as it has allowed me to expand my knowledge by carrying out a project in a different field of research. This is an important aspect of this project type, given that not all other postdoc fellowships fund research in areas where the applicant has no expertise."*
> *Dr. Maria Eugenia Zaballa, TPdF at EPFL*

The host lab PIs remarked that transition postdocs impacted the way the whole lab did research in many cases (e.g. quantitative approaches in labs that were thus far more biology-centered, or development of software or techniques that the whole lab uses). PIs also stressed the advantage of interdisciplinarity being embedded in the lab vs. being achieved through collaborations with other labs. Of all PIs that answered the questionnaire, none stated any disadvantages of this program.

Importantly, it has been remarked that the actual format of IPhD Projects and TPdFs has been a major and successful innovation of SystemsX.ch. To our knowledge, there had been no comparable funding instruments for promoting the interdisciplinary training of young scientists in Switzerland prior to SystemsX.ch. Several different members of the community have reported plans to create similar fellowships within different programs (national research initiatives, e.g. PHRT; institutional programs, e.g. at EPFL).

SIB PhD Fellowship Program

SystemsX.ch further promoted the interdisciplinary training of systems biologists by supporting the SIB PhD Fellowship Program. This program addresses the fast growing need for bioinformaticians specialized in analysis, visualization and interpretation of the massive amounts of data being generated in life science projects, and has awarded fellowships to ten graduate students since 2012. Two of the fellowships granted in 2012 were funded by SystemsX.ch. Both students carried out their PhDs at ETH Zurich. Other collaborations between SystemsX.ch and the SIB in the domain of training and education are detailed in Key Statement 8.

5.2.3.3 KS 8: SystemsX.ch has supported the training of scientists and engineers in special skills required to understand biological systems as well as in skills that are crucial for carrying out interdisciplinary research

Situation

The initiative implemented further training activities outside the frame of SystemsX.ch projects to cover the following objectives:

1) Reach PhD students and postdocs not affiliated to SystemsX.ch projects,
2) provide further training to the larger systems biology community in specific skills, both scientific and soft skills, that are complementary to academic education,
3) offer additional training measures for postdocs, as requested by the SNSF Panel,
4) promote networking among young scientists.

Measures and results

SystemsX.ch has organized and co-organized numerous educational activities since 2008. These training activities have focused on developing the interdisciplinary skills of PhD students and postdocs. To that end, different formats and subjects have been approached, as well as diverse collaborations with other institutions. The subjects were in many cases scientific, but SystemsX.ch has also organized retreats and workshops aimed at improving the researchers' soft skills since 2012. The main initiatives in training have been:

- **Joint Summer and Autumn schools with the SIB Swiss Institute of Bioinformatics**. The three joint schools organized with SIB have addressed the following topics: "From data to models in biological systems" (Summer 2011), "Systems medicine and its applications" (Summer 2014), and "Modelling" (Autumn 2015). A final joint Autumn School in Machine Learning will take place in November 2017.
- **Annual SystemsX.ch retreats** (since 2009, except for 2014): the format of the retreats was changed in 2012. Since then, they have focused on developing the soft skills necessary for science such as communication, scientific presentations, diversity management or career development.
- Courses in **Leadership and Management Skills for Postdocs** (February 2015, February 2016 and November 2016).

In addition, a number of international training courses have been supported (see also Key Statement 5):

- Joint **modelling courses and summer schools** with the CRG Barcelona: June 2013, June 2014 and June 2015,
- **Advanced Lecture Course on Systems Biology**: February 2009, February 2011, March 2014 and February 2016,
- **Summer School in Computational Biology:** Summer 2010 (Split, Croatia).

Travel grants awarded by SystemsX.ch enabled young scientists to attend international systems biology-related courses and conferences.

> *"Being part of the program enables the student to take part in various SystemsX.ch activities which I would certainly class as fantastic learning opportunities."*
>
> *Ariel Bensimon, IPhD student at ETH Zurich*

Most courses, workshops and schools organized and co-organized by SystemsX.ch have been fully booked. The feedback received from the participants has been steadily positive. This feedback has also influenced the design of further educational activities, which have tried to adapt to the evolving needs of young scientists. The general feedback received from students and postdocs of the network is that they greatly appreciate the training opportunities offered by SystemsX.ch, as well as the numerous possibilities to interact with other young systems biologists. Those courses also offered a much-appreciated chance to meet and network with other young scientists

Furthermore, SystemsX.ch has financially supported many scientific events, from student-organized retreats or seminar series to large international conferences. These efforts aim to support the exchange of knowledge between different scientific disciplines involved in systems biology, as well as contributing to the establishment of an interdisciplinary scientific community in the field of quantitative life sciences in Switzerland. Among the events supported by SystemsX.ch are international conferences such as the annual Systems Biology of Human Diseases conference (held alternatively in Heidelberg and Boston, supported since 2012) or the International Conference on Systems Biology (supported in 2016), as well as conferences co-organized by several different PIs of the SystemsX.ch network, such as the Physics of Biology meetings (Geneva, 2013 and 2016), or the Systems Biology of Infection symposia (Ascona 2012 and 2015).

The complete list of events organized, co-organized or supported by SystemsX.ch can be found in Annex A, Table A 12.

5.2.3.4 Conclusion "Impact on Education& Training"

To provide young scientists and engineers with opportunities to develop their skills in complementary disciplines, SystemsX.ch created new funding instruments and offered additional training courses. Together with the education offered at academic partner institutions, young scientists received a comprehensive education that influenced the way they will carry out their own future research and address complex questions in systems biology.

The profile of PhD students and postdocs has clearly become more interdisciplinary throughout the course of the initiative, with many young scientists currently displaying expertise in at least two scientific domains. This is a strong contrast with the situation in 2008, when most students were trained in one discipline, which made collaborations much more labor-intensive and less efficient. SystemsX.ch has played a key role in promoting this shift in education, through its project types as well as through the organization and support of educational activities for young scientists. Together with new or adapted educational programs offered at SystemsX.ch partner institutions, the next generation of systems biology researchers is being successfully trained. The next career steps of alumni from SystemsX.ch projects provide evidence for the success of the educational programs that the initiative has been part of or collaborated with:

- The majority of students and postdocs who received training in the frame of a RTD project and left their lab before July 2016 continued their career in academia, most of them as postdoctoral fellows. Fifteen professorships and ten group leader positions were reported. Approximately 100 scientists work in the private sector (including three who started their own companies) and 19 are employed in the public sector (including hospitals). *Details on the career tracks of students that have been reported to SystemsX.ch are summarized in Appendix A, Table A13.*

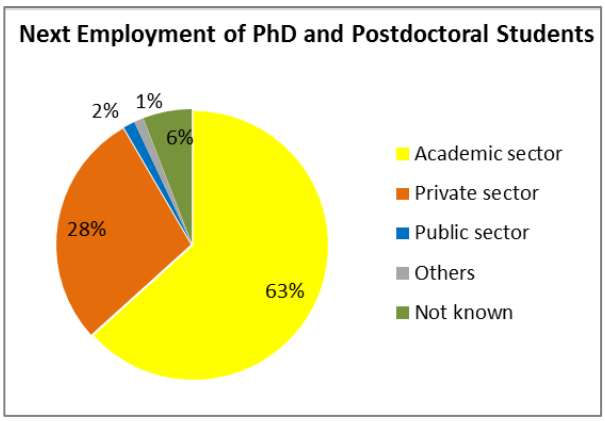

Figure 14: *Subsequent employment of PhD and postdoctoral students after leaving their SystemsX.ch RTD project as reported in the Scientific Reports 2008-2016.*

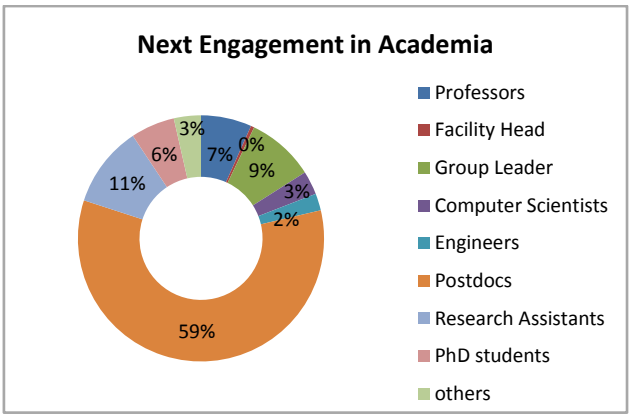

Figure 15: *Position of PhD and postdoctoral students in academia after leaving their SystemsX.ch RTD project as reported in the Scientific Reports 2008-2016.*

- Former TPdFs have moved on to lead their own groups (e.g. Markus Basan at Harvard Medical School and Christoph Zechner at the Max Planck Institute for Molecular Cell Biology and Genetics (MPI-CBG) and the Center for Systems Biology Dresden (CSBD) in Dresden)

Young systems biologists are aware of the advantages of having an interdisciplinary education. They view interdisciplinarity as an essential quality for carrying out research in the life sciences. For the large majority, working in an interdisciplinary manner is self-evident, independent of what the next stage in their careers might be (academy, industry, policy, research support services, administration, etc.).

5.2.4 Impact on Science

With the aid of focused funding, SystemsX.ch intended to establish the systems approach at the partner institutions and to support research projects of high impact that have the potential to place Switzerland among the world leaders in this domain. This goal could not have been reached without changing the way biological research questions were addressed: the reductionist view of molecular biology needed to be extended to incorporate a comprehensive understanding of biological systems. Based on examples, the following chapter will depict how SystemsX.ch succeeded in fostering scientific research and technological innovation in order to address research questions of high relevance for society, in particular health.

5.2.4.1 KS 9: SystemsX.ch has initiated a shift in biological sciences from a reductionist, qualitative science to a quantitative, predictive science

Situation

The paradigm shift towards a holistic, quantitative understanding of biological systems was an important prerequisite for the sustainable implementation of systems biology research in Switzerland. By routinely embedding bioinformatics, computational analyses and modelling in interdisciplinary projects, awareness of the potential of the systems approach was to be raised.

Measures and results

Definition of systems biology

The definition as phrased by the SystemsX.ch SEB (see also chapter 3, History and Organization of SystemsX.ch) explicitly mentioned the role of mathematical models and *in silico* predictions and contributed to a common understanding of systems biology in Switzerland.

Integration of quantitative aspects in research proposals

As clearly described in the call texts, **incorporating bioinformaticians, modelers and/or computational scientists in research consortia was a prerequisite for funding**. In the initiation phase, most projects still focused on data acquisition and data processing; modelling was not integrated in all RTDs with the expected depth. Therefore, in the 2nd phase emphasis was placed explicitly on modeling and theoretical aspects. In the preparatory phase of the 6th call, SystemsX.ch organized two **workshops for mathematicians, computational scientists and (bio)informaticians** (November 2011 in Fribourg with 16 participants and another 31 who could not attend but received documents; June 2012 with 34 participants) with the aim of attracting them to join consortia and to contribute their knowledge to the proposal-writing process. The 6th call for proposals stated: "*Scientists not previously associated with SystemsX.ch, scientists focused on the development of mathematical models of biological processes […] are particularly encouraged to apply*" and "*In this call RTD projects will be prioritized that: (i) focus on quantitative modeling of biological processes and the integration of large, complementary datasets describing dynamic biological systems, (ii) develop new theoretical tools*".

> *"SystemsX.ch boosted computational biology in general and elevated the collaboration and understanding of bioinformatics and experimental biologists."*
> *SIB partner questionnaire*

From 2008 to 2013, RTD proposals became more consistent with respect to these requirements. In the beginning, the integration of the experimental and theoretical parts was often lacking. Later on, proposals were written in a more coherent way, reflecting that the systems approach was being embraced. The SNSF Review Panel report from 2017 underlines this statement: "In the starting phase of the RTDs, the reviewers often commended the biological and experimental work, but criticized the modelling parts. It took some time until the RTDs fully integrated the quantitative aspects into their projects."

Supporting measures

In addition, **summer schools and courses co-organized by SystemsX.ch focused on topics like modelling or machine learning** (see also KS 8), lending further support to the paradigm shift. Today, 11 out of the 15 SystemsX.ch partner institutions reported that systems biology has become an integral part of their institution's portfolios.

Successful paradigm shift

47 out of 87 PIs and co-PIs confirmed systems biology to be one of the disciplines that best describes their current research (see questionnaires). As statements of SystemsX.ch researchers attest, SystemsX.ch accelerated the acceptance of novel technologies and quantitative approaches in experimental laboratories and enabled computational groups to efficiently enter the field of systems biology research. Various groups mention that they completely changed their research approach towards systems biology. This has influenced the way research questions are now approached and studied.

> *"The collaborative projects changed the strategic direction of my laboratory to a more systems biology type of approach. We now routinely use bioinformatics and computational analyses and interact with experts in computational analysis and modelling."*
> *Prof. Gerhard Christofori, University of Basel*

The successful shift towards an integration of experimental and theoretical aspects in systems biology research also becomes obvious when looking at publication records: The research profile of SystemsX.ch publications (see Annex B) shows that **the category with the highest number of publications (162) is "Multidisciplinary Sciences"** with an average MNCS of 2.98 (i.e. three times more cited than the world average), and more than 60 of them are among the top 10% cited publications. This indicates that most papers are published in journals of multidisciplinary character, such as PLoS, PNAS and Nature.

Table 6: *Categories of journals SystemsX.ch researchers publish in.*

Category	P	MNCS	PP[top10]
MULTIDISCIPL SC	162	2.98	0.40
BIOCHEM&MOL BIOL	156	3.25	0.39
CELL BIOLOGY	134	2.67	0.43
BIOCHEM RES METH	108	2.48	0.31
NEUROSCIENCES	58	2.89	0.45
PLANT SCIENCES	49	1.75	0.18
GENETICS&HEREDIT	46	2.17	0.30
BIOTECH&APPL MIC	41	1.79	0.25
MATH&COMPUT BIOL	38	1.10	0.12
MICROBIOLOGY	37	3.02	0.39
DEVELOPMENT BIOL	32	1.62	0.29

P=number of publications; for more details see Appendix B

5.2.4.2 KS 10: SystemsX.ch has funded interdisciplinary research projects that had a high- impact output

Situation

The vision of SystemsX.ch was to position Switzerland among the world leaders in systems biology research. To reach this ambitious goal, SystemsX.ch funded large, bottom-up research projects with the potential to generate scientific insight or technological innovation of high significance. Project proposals were selected mainly based on the excellence of the research approach and their potential to advance systems biology in Switzerland. The scope of the calls was intentionally not limited to specific scientific topics in order to attract a broad range of researchers and to give them the opportunity to apply the systems approach in the field of their expertise.

Measures and results

Large, integrated **RTD and MRD projects were SystemsX.ch's main tools for promoting first-class research**. These projects aimed to provide new insight into particular biological questions using the systems biology approach. While in the first phase of SystemsX.ch, the structural and technological basis for systems biology research was set up, the goal of the second phase was to build upon the achievements of the first phase, to consolidate and expand research in those areas and in particular to promote modelling and translational projects. This aim was underlined by the SNSF panel recommendation to give existing RTD projects the option to extend the project and integrate new research groups in the second phase, instead of calling for new large projects. As a consequence, the RTD projects LipidX, PlantGrowth, InfectX and PhosphoNetX were extended in the second phase to give their research and resources time to mature. To guarantee a high quality output a controlling mechanism was implemented: The SNSF Review Panel performed mid-term reviews (2010, 2011, 2015 and 2016) of RTD and MRD projects to monitor the progress of the projects and to advice research consortia for the second project period.

> *"For our consortium the midterm review was very useful: as we prepared for it and got a perfect overview of where we stood and where we were going. This was highly motivating, as it showed us the great progress we had made, allowed us to re-evaluate our priorities and further improve our organization. So it was really useful, aside from the actual monitoring aspect."*
>
> *Prof. Patrick Matthias, Friedrich Miescher Institute*

In addition, major insights into biological systems were achieved through other project types, which often collaborated with and/or supported RTD projects – another indication of the close-knit network of researchers in Switzerland.

SystemsX.ch funded research

Within SystemsX.ch projects, new scientific insight into a variety of biological systems was gained. As SystemsX.ch aimed to fund proposals based on their excellence and did not limit the scope of research projects, a broad variety of research topics were funded: While some projects focused on broadly available infrastructure and computational methods to advance systems biology research (see also Key Statement 11), others aimed to unravel specific pathways, understand the interactions in microbial communities or study the mechanics of growth. Advances in proteomics and metabolomics opened the door to applications in the medical field.

Detailed descriptions of single projects and their progress can be found in the annual Scientific Reports 2008-2016.

Examples of RTD projects

To show the broad range of research topics, a selection of outstanding RTDs and their influence on systems biology research in Switzerland are highlighted.

Plant Growth

Because plant cells don't move relative to each other, they provide excellent opportunities for studying problems of geometry and mechanics on the level of tissues and organs. The project "Plant Growth in a Changing Environment" (PG) integrated molecular genetics with computational modeling and mechanics. The project started in the first phase of SystemsX.ch (PG1) and was renewed in the second phase (PG2). A major goal was to develop a mechanistic model of phyllotaxis, the regular arrangement of leaves around a plant's stem. Early on a computational model was produced that integrated signaling events at the surface with processes in the underlying cell layers (Bayer et al., 2009). In the next stage, a complete 3D geometry of the *Arabidopsis* embryo at successive developmental stages was modeled. During this process, the project team acquired new insight into the mechanisms of morphogenesis, resulting in computationally much more complex mechanistic 3D models of phyllotaxis, implemented on a realistic cellular template (Yoshida et al., 2014; de Reuille et al., 2015). To investigate the dependence on environmental factors, the light-dependent development was studied with a combination of genetics, high throughput transcriptomics, biochemistry and mechanics (de Wit et al., 2016; Kohnen et al., 2016). PG2 further addressed an old question in plant stem cell biology (Kierzkowski et al., 2012): why do stem cells fail to engage in organogenesis even when the appropriate signaling molecules are externally applied? The answer came from fairly simple experiments interpreted using complex mechanical modeling. Stem cells are strain-stiffened, that is, they are stretched to an extent that prevents any further expansion.

Cell Plasticity

Differential activation of genes is the key process that underlies the acquisition of the distinct cell types that arise from a single fertilized oocyte through cellular differentiation. This regulation relies on the interplay between DNA binding transcription factors and the packaging of DNA into chromatin. Like DNA, the epigenetic status of chromatin can be inherited through cell division. The epigenetic state of chromatin is thus a key component of transcription regulatory networks in higher eukaryotes, and one that plays a crucial role in developmental and cell differentiation processes. The overarching scientific goal of Cell Plasticity was to connect both the genetic and epigenetic regulation of genes across multiple systems of differentiation. The underlying assumption was that combining chromatin and TF binding and activity in computational modeling and experiments would provide new insight into gene regulation during differentiation at the systems level. By comparing several differentiation paradigms of normal development and disease, we aimed to determine how well the principles of interaction could be generalized across distinct tissue/cell types. This goal has clearly been achieved, as evidenced by 99 publications that have been catalyzed by SystemsX.ch funding, including many publications in high-impact journals, such as Nature or Cell. The high-impact papers arose from cross-disciplinary synergies: epigenetic mapping technologies from the FMI were applied to differentiation systems from the University of Basel Medical faculty, and analyses were aided by the theoretical bioinformaticians of the Biozentrum Basel.

The efforts also included fruitful collaborations with industrial partners, in particular with Novartis. The (previously nonexistent) publication of co-authored publications between Cell Plasticity members from the University of Basel Medical faculty, the FMI and the Biozentrum testify the intense networking that took place. The joint hiring of postdocs and a joint progress report series maintained the interaction throughout the funding period. The outstanding productivity of CellPlasticity is evidence for a functional network and shows that the approach

addressed questions that were relevant and timely. The close interaction between theoretical and experimental groups was efficiently enhanced through the joint funding scheme.

PhosphoNetPPM

The PhosphoNet Personalized Precision Medicine project aimed to generate precise clinical treatment decisions based on the computational integration of multilevel omics data from a well-defined prostate cancer clinical cohort. Integration of the different data types identified molecular pathways and informational networks that are perturbed in cancer tissue. The project built on the findings of the predecessor PhosphoNetX[8], which analyzed the phosphorylation-mediated informational networks in cells. Specifically, the goal of the PhosphoNetPPM project was to provide precise diagnoses and more efficient, tailor-made treatments to prostate cancer patients, based on individualized analyses of tumor tissue on the level of the genome, expressed genomic information and proteome profiles. The researchers of PhosphonetPPM used advanced genomic, proteomic and computational techniques to understand how genotypic variation changes the molecular patterns in the tissue of individual prostate cancer patients. To determine the characteristics of the tumor's genome and protein composition, samples of prostate tissue were analyzed with the aid of cutting-edge high-throughput methods, such as next-generation sequencing, or PCT-SWATH, a mass spectrometry-based technology developed by Ruedi Aebersold's group (see also key statement 11), which is able to quantify a sample's protein profile with a high degree of accuracy and reproducibility. The resulting data, together with information from medical histories, was integrated into a computational model, which predicts the course of cancer development in each individual patient. Novel methods based on those findings could not only provide more precise treatments, but also avoid unnecessary prostate operations and their related risks.[9] This project can be used as template for further research projects on different types of cancer, as it strives to provide personalized treatment to cancer patients.

AntibodyX

AntibodyX aimed to use and optimize systems biology-based methods for the quantitative molecular analysis of antibody responses that develop in response to vaccination and pathogenic infection. This ambitious goal could only be accomplished by uniting a team of scientists with expertise in biotechnology, bioengineering, immunology, virology and computational modeling. AntibodyX has led to discoveries in basic immunology on how chronic viral infection (e.g. HIV) impacts the diversity of an antibody response. In addition, an advanced method for sequencing and analyzing antibody responses was developed, which is now being utilized by several industry partners (Roche, Novartis, UCB-Celltech, Specifica, NBE Therapeutics) for applications in vaccination and monoclonal antibody engineering.

Publication record of SystemsX.ch projects

Although often discussed controversially, publication records in high-impact journals are one of the main indicators for measuring the research performance. To be able to quantify the performance of SystemsX.ch researchers, the publications resulting from projects funded by the initiative were analyzed in detail by CWTS Leiden (see Appendix B). Out of the 248 SystemsX.ch funded projects, **an excellent publication record of 1419 publications** resulted. This number includes all publications that have been reported up to July 2016 and only includes publications that acknowledge SystemsX.ch explicitly and joint publications authored by at least two groups involved in SystemsX.ch projects. Publications with minor

[8] Vaga S, Bernardo-Faura M, Cokelaer T, Maiolica A, Barnes CA, Gillet LC, Hegemann B, van Drogen F, Sharifian H, Klipp E, Peter M, Saez-Rodriguez J, Aebersold R. (2014) ***Phosphoproteomic analyses reveal novel cross-modulation mechanisms between two signaling pathways in yeast.*** **Mol Syst Biol,** 10(12): 767. doi: 10.15252/msb.20145112.

[9] Haldrup C, Lynnerup AS, Storebjerg TM, Vang S, Wild P, Visakorpi T, Arsov C, Schulz WA, Lindberg J, Grönberg H, Egevad L, Borre M, Ørntoft TF, Høyer S, Sørensen KD. (2016) *Large-scale evaluation of SLC18A2 in prostate cancer reveals diagnostic and prognostic biomarker potential at three molecular levels*. **Molecular Oncology** 10 (6): 825-37. doi: 10.1016/j.molonc.2016.02.001

contributions from SystemsX.ch not acknowledging SystemsX.ch are not listed. Although major scientific impact was achieved in the RTD and MRD projects, scientists of IPhDs, TF, IPP, BIP, SpecialOpps and TPdF projects also published over 400 articles and conference papers, in many cases in co-authorship with RTD projects.

The remarkable numbers of publications in high ranked international journals, such as Cell, Science and Nature prove the high impact of Swiss research in the field of systems biology:

Table 9: *Publications in high-impact journals.*

Journal	Number of reported publications
Nature	28
Science	26
Cell	31
Molecular Cell	9
Cell Host & Microbe	4
Molecular Systems Biology	21
Nature Methods	26
Nature Genetics	3
Nature Biotechnology	12
PNAS	40

In the following a short list of highly regarded publications of SystemsX.ch projects has been put together by the SystemsX.ch Scientific Executive Board:

1. Wu Y, Williams EG, Dubuis S, Mottis A, Jovaisaite V, Houten SM, Argmann CA, Faridi P, Wolski W, Kutalik Z, Zamboni N, Auwerx J, Aebersold R. (2014), *Multilayered genetic and omics dissection of mitochondrial activity in a mouse reference population.* **Cell 158 (6),** 1415-1430, 10.1016/j.cell.2014.07.039, *AgingX*
2. Battich N, Stoeger T, Pelkmans L. (2015), *Control of Transcript Variability in Single Mammalian Cells.* **Cell. 163 (7)**, 1569-610, 10.1016/j.cell.2015.11.018, *PhosphoNetX, PhosphoNetPPM, InfectX, LipidX, PrionX, MorphogenetiX*
3. Kierzkowski D, Nakayama N, Routier-Kierzkowska AL, Weber A, Bayer E, Schorderet M, Reinhardt D, Kuhlemeier C, Smith RS. (2012) *Elastic domains regulate growth and organogenesis in the plant shoot apical meristem.* **Science 335 (6072)**, 1096-1099, PlantGrowth
4. Picotti P, Clément-Ziza M, Lam H, Campbell DS, Schmidt A, Deutsch EW, Röst H, Sun Z, Rinner O, Reiter L, Shen Q, Michaelson JJ, Frei A, Alberti S, Kusebauch U, Wollscheid B, Moritz RL, Beyer A, Aebersold R. (2013), *A complete mass-spectrometric map of the yeast proteome applied to quantitative tranalysis.* **Nature, 494(7436)**, 266-270, *PhosphonetPPM*
5. Stadler MB1, Murr R, Burger L, Ivanek R, Lienert F, Schöler A, van Nimwegen E, Wirbelauer C, Oakeley EJ, Gaidatzis D, Tiwari VK, Schübeler D. (2011), *DNA-binding factors shape the mouse methylome at distal regulatory regions.* **Nature 480 (7378)**, 490-495, 10.1038/nature10716, *MetastasiX, Cell Plasticity*

In addition, SystemsX.ch researchers contributed a number of review papers.

A list of 20 highly recommended publications can be found in Appendix A, List A1. The complete catalogue of publications from SystemsX.ch projects can be requested from the SystemsX.ch Management Office.

Bibliometric analysis of SystemsX.ch-acknowledged publications

To measure not only the output but also the impact of research funded by SystemsX.ch, the CWTS in Leiden was mandated to conduct a **bibliometric performance analysis of all publications captured in Web of Science (WoS)** that explicitly acknowledge SysytemsX.ch funding. In total, 1245 acknowledged publications were identified in Web of Science, from which 1145 qualified for analysis.

From 2009 onwards, a continuous increase in publications was observed, with the highest number of 210 publications in 2012. This peak reflects the publications generated by the RTDs of the first phase. In the following years the totals dropped slightly. Over the next few years, a new peak is to be expected as the running RTD and MRD projects publish their results.

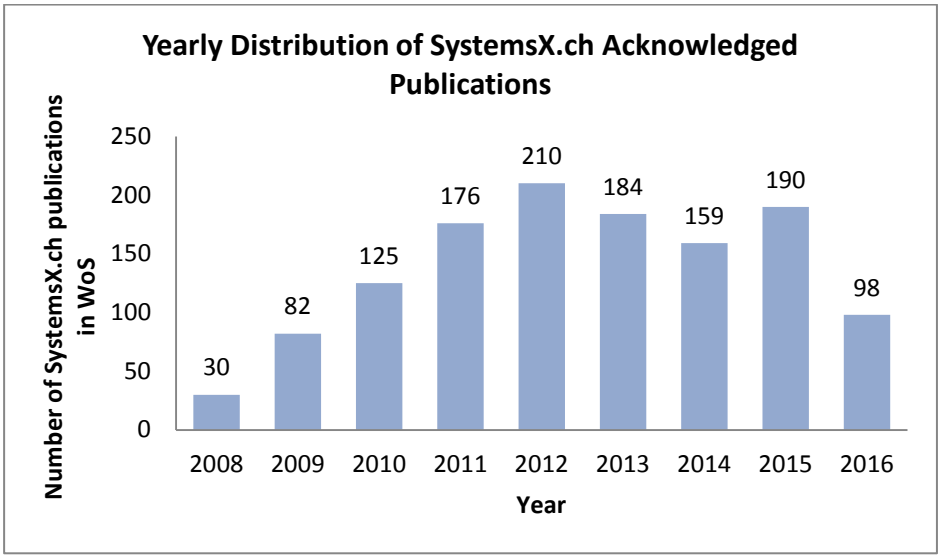

Figure 16: *Distribution of SystemsX.ch publications per year.*
Please note: In 2016 publications are only considered up to the end of July.

Performance

With the aid of normalized performance indicators, the impact of SystemsX.ch publications was analyzed.

Table 8: *Normalized performance indicators for the whole SystemX.ch sample as well as for selected RTDs; the description of each indicator can be found in Appendix B.*

Unit	P	MNJS	TCS	MCS	MNCS	PP (top10)	PP UIC	PP collab	PP Intl collab
SystemsX.ch	1,143	2.14	24,432	21.37	2.35	0.32	0.04	0.75	0.55
InfectX/ TargetnfectX	54	2.39	2,342	43.37	4.53	0.37	0.09	0.76	0.46
LipidX 1&2	165	2.28	3,865	23.42	2.38	0.34	0.01	0.65	0.53
NeuroChoice	81	2.24	2,420	29.88	2.74	0.43	0.00	0.80	0.78
PhosphoNetX/ Phosphnet-PPM	52	4.29	2,959	56.63	5.07	0.63	0.08	0.87	0.66
PlantGrowth 1&2	93	1.70	1,736	18.67	1.89	0.28	0.02	0.82	0.61

MNJS, MNCS: 1= world average

As the mean normalized journal score (MNJS) shows, **SystemsX.ch researchers have their results published in high impact journals**. The MNJS for the whole sample is 2.14 – more than two times the world average, and in the case of PhosphoNetX/PhosphoNetPPM even four times the world average. Furthermore, 75% of SystemsX.ch publications involve collaboration between at least two institutions, and 55% involve international collaboration.

Also, the impact is high, as a mean field normalized citation score (MNCS) of 2.35 indicates: **For the whole sample, the impact is more than two times the world average**, and for two of the projects it is even four to five times world average. The PPtop10 indicator, which is less sensitive to outliers, confirms the high impact: 32% of SystemsX.ch publications (i.e. 366 publications) rank in the top 10% of highly cited publications, which is more than three times the expected 10%.

When looking at the organizations that are citing SystemsX.ch publications, it can be seen that internationally leading players in the field of systems biology research, such as Harvard University, MIT or the Max Planck Society reference SystemsX.ch publications. This is a clear sign of the appreciation and recognition of SystemsX.ch research.

International comparison

With the aid of benchmarking analysis, an international comparison of the performance of Swiss researchers was conducted. Based on the profile of SystemsX.ch publications, a "SystemsX.ch field" was defined, in which approx. 50% of the acknowledged Systemsx.ch publications can be found. The performance metrics for this subset of SystemsX.ch publications is representative of the entire set. Based on the predefined "SystemsX.ch field", data from the UK, Germany and the whole of Switzerland was collected.

***Table 9**: International benchmarking of performance indicators.*

Unit	P	MNJS	TCS	MCS	MNCS	PP (top10)	PP collab	PP Intl collab
SystemsX.ch (selection)	580	2.13	14,293	24.63	2.48	0.31	0.77	0.59
Germany	14,781	1.15	183,562	12.42	1.20	0.13	0.74	0.54
UK	13,338	1.27	193,706	14.52	1.38	0.15	0.72	0.61
Switzerland	4,424	1.52	76,519	17.29	1.76	0.20	0.80	0.68

MNJS, MNCS: 1= world average

Comparing SystemsX.ch results to the selected benchmarks Germany and the UK, large differences in output can be seen. These can be explained by the differences in funding volumes: Up to 2021, the German BMBF will have spent EUR 560 million[10] on building up systems biology centers, supporting young scientists and financing 161 research consortia. In UK the investment in systems biology relevant areas are estimated to be approximately EUR 400 million.

Although it has to be considered that high impact scores can be more easily reached with smaller numbers of publications, it can be seen that that **the impact of SystemsX.ch publications is more than two times world average (MNCS of 2.48**), **compared to 20% above world average in Germany or 38% in UK:.** To estimate the impact scores considering the large difference in output, the whole of Switzerland was taken into consideration. Although the output is still smaller, it can be seen that the impact is still considerably higher due to the high impact of SystemsX.ch publications. SystemsX.ch was also quite active in publishing, as the comparison of 180 publications of SystemsX.ch funded researchers with 250 publications of BMBF funded researchers in the year 2011 shows. *The comprehensive bibliometric study of CWTS Leiden is attached in Appendix B.*

[10] Source : systembiologie.de (issue December 2016)

5.2.4.3 KS 11: SystemsX.ch has fostered the design, development and application of advanced technologies enabling systems biology research

Situation

Novel technology and approaches, e.g. for data acquisition and analysis, are of vital importance for enabling new discoveries in the field of systems biology. Therefore, SystemsX.ch encouraged and supported the development and application of novel methods, technologies, and computational platforms at all times.

When the business plan was written in early 2007, the establishment of so-called “Glue Projects” was envisaged. Within these projects, cutting-edge technologies for topics such as proteomics, genomics, imaging or computational sciences would have been developed and made accessible to all SystemsX.ch partners. These “Glue Projects” were planned to be funded 75% by SystemsX.ch funds and to be coordinated nationally via newly created professorships. In addition, research projects known as “Scientific Nodes” were planned to be funded up to 50% by SystemsX.ch, using technologies from the “Glue Projects”.

However, when formulating the first call for proposals, it became obvious that a stringent distinction between “Glue Projects” and “Scientific Nodes” was not feasible. Hence, both project types were combined in the RTD project category. Technological developments were explicitly encouraged in the call texts. In 2010, the SNSF discouraged the implementation of centrally organized technology platforms, as the continuation of established structures after the termination of SystemsX.ch would have been a great challenge. Instead, the necessary infrastructure was built up locally and mainly funded by the partner institutions.

SNSF recommendation to focus on research rather than on technological infrastructure also influenced the scale of technology development: RTD projects of the first phase drove the development of novel methods, approaches and technologies, whereas RTD projects of the second phase focused more on research questions. However, the extension of first-phase RTD projects allowed novel techniques to mature in the second phase, bringing forth major innovations of high impact. To fill the gap in technology funding in the second phase, SystemsX.ch created High-Tech Funds (phase 2008-2012) and Special Opportunity projects (phase 2012-2016).

Measures and results

To foster technological and methodological innovation, SystemsX.ch made use of its funding tools, mainly RTD projects, High Tech Funds and Special Opportunity projects, and customized them accordingly.

The main driving force for innovation were large, integrated RTD projects. As the “T” for “Technology” already indicates, this project type encompassed not only interdisciplinary projects focusing on biological processes, but also projects with a technological focus or a mixture of both. In the second call for proposals in 2008, special preference was given to proposals in the field of technology development. Consequently, a number of technology-oriented projects resulted, such as CINA or MetaNetX. With the **High Tech Funds**, which the consortia of funded RTD projects were able to apply for, SystemsX.ch provided access to cutting-edge technology, which PIs could not have foreseen and budgeted for in their initial proposal, and which were crucial for the progress of the funded projects. In total 15 proposals asking for additional funding were received. Nine of them were approved by the Scientific Executive Board, granting CHF 1,388,521, which enabled the application of advanced technologies.

Furthermore, the “matching funds” rule also influenced the implementation of new technologies and infrastructures, contributing to the establishment of high-tech centers that are accessible to the Swiss systems biology community (see also KS1).

Examples of technological developments

In the following, selected technological developments that resulted from SystemsX.ch projects will be introduced to give an idea of the broad range of technological innovations.

RTD projects

A textbook example for technology innovation is represented by the **PCT-SWATH mass spectrometry technology**, a method for quantitative analysis of biological samples such as tissues and cells. This technology was developed by Ruedi Aebersold's group at ETH Zurich as part of the **PhosphoNetPPM RTD project**. This method converts small tissue or cell samples into one digital file that represents the mass-spectrometry measurable proteome. *In silico*, the resulting proteomic maps can be analyzed, re-analyzed and compared to identify specific proteins and accurately quantify them across multiple samples. The advantage of the technology includes compatibility with small (biopsy level or below) sample sizes, a high degree of reproducibility, high sample throughput and relatively low cost. Because small clinical samples can't be reproduced, the conversion of the samples into perpetually readable digital files offers the possibility of generating "digital biobanks" in which sample cohorts are represented in a generally accessible data format, thus supporting unprecedented opportunities for *in silico* cross-sample, cross-study or cross-cohort queries. This highly innovative technology is at the core of the recently opened ProCan Center in Sydney, Australia and will be used to measure the precise levels of proteins in about 70,000 samples of all types of cancer. Protein data will then be compared to already available data for each cancer (clinical records, genetic analyses, genome sequencing, etc.) using computer analysis techniques. This approach will accelerate the search for cures. ProCan, as well as the SystemsX.ch PhosphoNetPPM project are also part of former US Vice President Joe Biden's recently established Cancer Moonshot Initiative to drive forward cancer research.

Also in the frame of the PhosphoNetPPM project, Bernd Bodenmiller's group at the University of Zurich significantly advanced an approach for single cell proteomics based on mass cytometry (**CyTOF^{TM}**). With the latest developments of the technology, the quantities of over 100 types of molecules, including proteins and their modifications, can be measured simultaneously on the single-cell level. In combination with computational methods developed by Manfred Claassen's group at ETH, who was also a project member, cell phenotypes and model regulatory systems on the single-cell level can be identified. This approach is currently used to unravel the regulatory systems on the level of single cells that influence cancer development.

Another impressive example for successful technology development is the **RTD project CINA**, which was approved in 2009. With support from this SystemsX.ch project, the "Center for Cellular Imaging and NanoAnalytics" (C-CINA) has been established at the Biozentrum of the University of Basel to provide measuring and imaging techniques for nanoscale cell biology to advance the understanding of biological systems. Within the project, an **imaging platform** was set up to visualize and manipulate single cells and their constituents at nanometer to atomic scale resolutions. Different types of optical and electron microscopes were combined in a way that allow the characterization of the 2D or 3D structure of samples of various sizes at high resolution. A second method developed within this project is the groundbreaking "**Visual Proteomics Technology**". Within seconds, this patented method gently breaks up the cell membrane, sucks up the unharmed cell components with a fine needle and sends the material to be analyzed through a series of modules that can optionally purify certain proteins out of the single cell's cytosol, or prepare the entire cytosol in a loss-less manner for visualization. In this case, the entire contents of a single, hand-picked cell are vitrified on an electron microscopy grid, which is then imaged by the worlds most advanced cryo-transmission electron microscope. With the aid of this state-of-the-art technology, scientists can study disease processes or test the efficacy of drugs. The facility offers its tools and services to SystemX.ch members as well as international collaborators. Companies like Roche are very interested in developments at C-CINA, as collaborations demonstrate. Besides the

study of membrane proteins employing high-resolution electron microscopy and single cell visual proteomics, the center also develops algorithms and software for the analysis of electron microscopy data and investigates neurodegeneration.

The website **MetaNetX.org,** developed within the **RTD project MetaNetX** is a user-friendly portal for accessing, analyzing and manipulating genome-scale metabolic networks (GSM) and biochemical pathways. Researchers worldwide can access this freely available platform and use it to develop top-quality models within hours. The platform has been available since 2013 and currently has more than 1,000 users per month. A comprehensive dataset that includes a large share of the known data on metabolic processes builds the backbone of this novel tool. Scientists can draw on already supported information and, with the aid of specifically developed algorithms, gather required data and build a new model, for example, starting from a newly sequenced genome. The automatically generated model needs to be fine-tuned later on. In comparison to previous work in this area, MetaNetX.org tries to focus on the accuracy of models. The more comprehensive and systematic the approach, the more accurate the predictions, the principal investigator of this project, Jörg Stelling (D-BSSE, ETH Zurich), is convinced. SystemsX.ch funding for MetaNetX enabled developments that are currently being taken up by other projects such as the TbX RTD or the GutX MRD. Current and future developments of the platform are also supported in the ELIXIR (European Bioinformatics Infrastructure) network.

The range of developments that resulted from the **RTD project Plant Growth 1&2** comprises new microscopy techniques as well as software for visualization. **Cellular Force Microscopy** (CFM), developed by Anne Lise Routier-Kierzkowska combines the versatility of classical microindentation techniques with high automation and resolution, and has established itself as a valuable alternative to Atomic Force Microscopy (AFM). It can be used to reveal the feedback between mechanics, genetics, and morphogenesis.[11] The recently developed **Automated Confocal Micro Extensometer** (ACME; S. Robinson, submitted) allows the measurement of mechanical properties of tissues with cellular resolution. The **MorphoGraphX software**, developed by Richard Smith and Pierre Barbier de Reuille is an open source application for the visualization and analysis of 4D biological datasets and available on www.MorphoGraphX.org. It's development was a collaborative effort of several RTDs. Labs around the globe use it to quantify cellular parameters from confocal images in 3D.[12] The recent extensions MorphoDynamX and MorphoRobotX make it possible to construct a variety of computational and biomechanical models on tissue templates with biologically realistic geometries.

Special Opportunity projects

In order to endorse innovative, high-risk projects that promote systems biology research, and in particular technology development, but do not qualify for traditional funding, **Special Opportunity (SpecialOpp) projects** were created. Between 2012 and 2015 a total of 16 SpecialOpps were granted, including for example those that aim to develop new approaches for affinity proteomics or a high-throughput platform for systems immunology and protein engineering.

[11] Routier-Kierzkowska, A.L., et .al. (2012). Cellular Force Microscopy for in Vivo Measurements of Plant Tissue Mechanics. Plant Physiology 158, 1514-1522.

[12] de Reuille, P.B. et. al. (2015). MorphoGraphX: A platform for quantifying morphogenesis in 4D. Elife 4.

An example of a Special Opportunity project that generated a novel platform with an impact for the international systems biology community is the **SwissLipids** project. Based on the work of the LipidX RTD, a **freely available source to interpret lipid and lipidomic data (www.swisslipids.org)** was launched in March 2015. It is a comprehensive library of over 300,000 known and theoretically possible lipid structures, enriched with expert-curated information on lipid metabolism, protein interactions, and occurrence in organelles, cells, tissues and organs. SwissLipids structures are mapped to analytical outputs from LipidX and other lipidomics platforms, facilitating the integration of lipidomic data with biological knowledge. The platform is interlinked with further databases, such as ChEBI, LIPID MAPS, UniProtKB, neXtProt and the MetaNetX resource for genome-scale metabolic models. An active and growing user community reflects the impact of SwissLipids, with more than 4,000 users recorded in the first year following publication. Known users of SwissLipids data include the Innovative Medicines Initiative projects for diabetes IMIDIA (www.imidia.org) and RHAPSODY (www.imi-rhapsody.eu). SwissLipids can be extended to support any multidisciplinary project that requires the integration of lipidomic data with biological knowledge and models, and has the potential to become one of the leading references in lipidomics. The continued development and maintenance of SwissLipids is currently supported by the SIB.[13]

> *"SwissLipids …could not have been created without the unique opportunities for interaction provided by SystemsX.ch and the financial support of the special opportunities funding scheme."*
>
> *Dr. Alan Bridge, SIB*

Further project types

Moreover, the design and application of new devices and approaches was also supported within other project types. An impressive example is the **IPhD project of Ata Tuna Ciftlic** (EPF Lausanne), who developed a **microfluidic tissue processor (MTP**) for rapid, low-cost tumor diagnostics during his four-year project and filed a patent in 2012, together with his advisor Prof. Martin Gijs (EPF Lausanne). Subsequently, the EPFL spin-off company Lunaphore was established, aiming to build tissue-processing platforms for breast cancer diagnostics. SystemsX.ch supported the promising development by granting additional Special Opportunity projects.

In his **TPdF project, Kyle M. Douglass** resolved the issue of highly constrained fields of view in single-molecule microscopy techniques. With the newly developed flat illumination for field-independent imaging (FIFI), which is a low-cost microlens array-based epi-illumination system, researchers are now able to image multiple cells at once with single molecule resolution. Thus, the FIFI system enables uniform, high-quality fluorescence imaging on nanometer scales while still capturing large-scale cell-to-cell variability. Several labs at EPFL (e.g. Pierre Gönczy's and Joachim Lingner's labs) started using this **high-throughput super-resolution microscopy method**, as it opens up the possibility to answer questions in structural and systems biology that could not be addressed before. In particular, it has helped researchers at the EPFL understand how sheltering proteins regulate telomere structure and what this means for DNA damage response mechanisms.[14]

Beside the highlighted techniques, further developments of SystemsX.ch researchers can be found in the Scientific Report 2015-2016, Appendix A, pages 17-18 (patents and licenses) and pages 18-24.

[13] Lucila Aimo, et.al. (2015) *The SwissLipids knowledgebase for lipid biology***. Bioinformatics**. 31(17): 2860–2866

[14] Kyle M. Douglass, , Christian Sieben, Anna Archetti, Ambroise Lambert and Suliana Manle. *Super-resolution imaging of multiple cells by optimized flat-field epi-illumination*. **Nature photonics** 10, 11/2016, p. 705ff

Access to enabling technologies

New developments and cost-intensive devices that were installed by a partner institution have been made available to other SystemsX.ch partners (see also KS1 and partner questionnaires). Examples include technologies of the RTD CINA, the transmission electron microscope at the University of Basel or devices and services of the Functional Genomics Center Zurich. Thus, investment in cutting-edge technology was efficiently used, inter-institutional collaboration was further strengthened and the spirit of sharing existing resources was fostered.

"The inter-institutional consortium enabled access to metabolomics technology that was not locally available at that time."

Prof. Robbie Loewith, University of Geneva

In conclusion, the development of innovative methods and techniques in the frame of SystemsX.ch projects, together with the investment in enabling technologies lead to scientific insight and advanced systems biology research nationally and internationally.

5.2.4.4 KS 12: SystemsX.ch has contributed to steering the funded research towards current social needs and has created a landscape that facilitates/enables the new SPHN initiative

Situation

The application of the systems approach to medical/clinical questions provides a promising concept for the more effective diagnosis and treatment of patients and has the potential to lead to personalized, preventive medicine in the future. As stated in the 2007 SystemsX.ch business plan, research was to be steered from basic biological questions towards translational research over the course of the initiative, in particular towards medical/clinical applications. Thus, at all times medically/clinically relevant research has been promoted, although the initial focus was more on basic biological research questions.

Measures and results

Research projects

In the 2nd call for RTDs in 2008, **special preference was given to systems biology proposals at the interface with medical research**. This priority was maintained, and in the second phase SystemsX.ch called for RTDs that "focus on systems biology approaches to clinical questions". An example of a funded RTD with medical relevance is the AntibodyX project (see also KS10).

To meet the increasing interest of medical researchers in the systems approach, SystemsX.ch launched the **new MRD project** (Medical Research and Development Projects) category with its **10th call in March 2014**. Nine MRD Projects that "develop or apply a systems approach to the study of disease in a medical, or ideally clinical, setting" were approved and are now funded by SystemsX.ch with a total amount of CHF 18.5 million for three years. *For a full list of funded MRDs please see the Scientific Report 2015-2016, Appendix A, Table A33.*

In the following, two selected MRD projects are introduced. As most of these projects only started in 2015, it is too early to fully assess the impact of this project type.

GutX

The GutX project, coordinated by Prof. Dr. med. Andrew Macpherson, Inselspital Bern, aims to understand what is happening in the bowels of patients suffering from acute of chronic intestinal inflammation. The inflammation is caused by immune cells in the intestine's mucous membranes that react aggressively to the body's own microorganisms. Researchers are now investigating how intestinal bacteria interact with one another and to what extent the host organism plays a part in these processes. To this end, the scientists are employing methods that simultaneously measure many of the different biochemical substances within the intestine. They then look at how these substances are passed from the bacteria to the host, and develop models that simulate these processes in a healthy and diseased organism. The ultimate goal of the study is to vindicate microbiota manipulation as therapy to treat intestinal bowel diseases.

MelanomX

Drugs that inhibit the BRAF-oncogene (a protein that promotes tumor growth) are used in the treatment of advanced melanoma. Unfortunately, affected patients experience resistance to the drugs after about six months. The MelanomX project team, headed by Prof. Dr. med. Olivier Michielin, University of Lausanne, is searching for the cause of this resistance and is examining the mechanisms employed by cancer cells in order to develop better therapies. To decipher the resistance to BRAF inhibition on the single-cell level, researchers have developed a way of determining the complete mutational landscape of thousands of single cells from metastatic melanomas. They are studying samples taken from patients before and during BRAF inhibition, as well as patients whose therapy failed or led to disease progression. In this way, the scientists want to understand the dynamics of resistance. After analyzing thousands of single cells, the team has managed to describe the cellular composition of melanoma in great detail, and has already identified a number of potential targets for therapy.

For details on all MRD projects please see the Scientific Report 2015-2016, Appendix B, p. 300-381.

In conclusion it can be said that only a few SystemsX.ch RTDs of the first phase contained translational aspects. In the second phase of SystemsX.ch topics became clearly more medically relevant and some projects envisaged concrete applications.

Swiss Personalized Health Network (SPHN) initiative

Based on the knowledge and experience gained throughout SystemsX.ch, the BoD established a Working Group in 2012 to explore and put forward suggestions for a new national research initiative from 2017 onwards. The interdisciplinary, interinstitutional working group, organized and managed by SystemsX.ch, produced a report on "Personalized Health" to discuss the options and frame for a new initiative, and presented it to the BoD in June 2014. The Federal Council proposed to implement the SPHN initiative under the lead of the Swiss Academy for Medical Sciences (SAMS) in its ERI Dispatch 2017-2020.

"The research infrastructure established in SystemsX.ch projects as well as the research experience gained will be crucial for understanding interactions between diverse pathogens and individual human patients. In addition, SyBIT provided good grounds for SPHN."
Dr. Christian Sengstag, University of Basel

In fact, all but two SystemsX.ch partner institutions reported in the SystemsX.ch partner survey the intention to participate in SPHN. Most of them intend to make use of existing resources (scientific personnel and technological/computational infrastructure) built up during SystemsX.ch. Metabolomics platforms and bioinformatics expertise are just two examples that were mentioned.

ERA-Net for Applied Systems Biology Research

With the participation in ERASysAPP SystemsX.ch also fostered translational projects, as international ERA-Net funding predominantly targeted applied systems biology research. Some of the proposals were even rejected due to their proximity to basic research, even though their quality was admittedly high. *For more details on funded ERASysAPP Projects see Appendix A, Table A8 and A9.*

5.2.4.5 Conclusion "Impact on Science"

To summarize, it can be stated that SystemX.ch successfully fostered first-class systems biology research, leading to an increased appreciation and application of a quantitative, predictive research approach. This ongoing paradigm shift, combined with high-impact research results also paved the way for systems medicine in Switzerland. S**wiss researchers are undoubtedly internationally acclaimed,** as the international recognition of Swiss research results shows. Not only has high-impact scientific insight in the life sciences resulted, but SystemsX.ch also prompted the design, further development and application of groundbreaking technologies to the advantage of the international systems biology community.

> *"The NeuroStemX RTD was instrumental for my group in completely changing the way we think about our projects, how we use new technologies and develop interdisciplinary projects."*
> *Prof. Verdon Taylor, University of Basel*

The excellence of the science is also reflected in the **high number of ERC (European Research Council) grants SystemsX.ch scientists have been awarded.** Up to 2016, SystemsX.ch researchers had received 26 ERC Starting Grants, 48 ERC Advanced Grants, three Consolidator Grants and one Synergy Grant. For the period 2007-2013, SystemsX.ch researchers were awarded an impressive 19% (68) of the total number of 364 ERC Grants awarded to Swiss researchers. As the scientific quality of the project proposal is the only criteria for awarding an ERC Grant, this clearly shows the outstanding performance of SystemsX.ch scientists. The ERC Synergy Grant awarded to the MERiC team (Michael Hall, Gerhard Christofori, Markus Heim and Niko Beerenwinkel) must be mentioned in particular, since the grant application was based on the RTD MERiC and enabled the consortium to complement and scale up their research plans. The highly remunerated grant of EUR 11.2 million is funding cancer research until 2020. *A full list of all SystemsX.ch researchers who have been awarded ERC grants since 2007 can be found in Appendix A, Table A14.*

In addition, **Swiss participation in the PrECISE project**, which received funding from the European Union's Horizon 2020 research and innovation program, attests the high reputation and scientific excellence of SystemsX.ch scientists. Researchers from ETH Zurich, the University of Zurich and IBM Zurich Research Laboratory are contributing to the Pan-European and American cooperative research project that officially started on 1st January 2016 with a set duration of 36 months. The project aims to develop a predictive computational technology that can exploit molecular and clinical data to improve the understanding of disease mechanisms of prostate cancer, and to inform clinicians about optimized treatment strategies.

Another indicator for the high international recognition of SystemsX.ch researchers are numerous **collaborations with prestigious systems biology centers worldwide,** such as MIT in Boston, Stanford University, the Max Planck Society in Germany or University College in London.

Furthermore, the fact **that internationally renowned experts were attracted** to take over faculty positions (see key statement 1) proves that Switzerland provides an excellent environment for world-leading systems biology research. Here, two SystemsX.ch researchers should be explicitly mentioned: Bernd Bodenmiller (UZH) and Manfred Claassen (ETH), who both completed their PhDs within SystemsX.ch RTD projects and went to one of the top systems biology centers in Stanford, USA as postdocs, finally returning to Switzerland to secure faculty positions.

"When I started to scout for group leader positions, it became clear that Switzerland offered the best fit for my research needs, which bridge experimental and computational work. SystemsX.ch was a key element in creating this worldwide unique environment".

Prof. Bernd Bodenmiller, University of Zurich

The **impressive number of SystemsX.ch scientists who received SNSF professorships** can also be seen as an indicator for excellence in science. Between 2007 and 2016, 24 current and former SystemsX.ch scientists received SNSF professorships. Furthermore, young assistant and SNSF Professors involved in SystemsX.ch projects have been tenured or moved on to full professorships at different institutions. Examples include Robbie Loewith (full professor at University of Geneva), Jörg Stelling (full professor at ETH) or Olivier Pertz (associate professor at University of Bern).

In conclusion, it can be said that SystemsX.ch successfully strengthened Switzerland's position as one of the leading countries in the field of systems biology over the last nine years.

5.3 Overall Conclusion

With SystemsX.ch, a successful framework to promote the implementation of the systems biology approach at Swiss research institutions has been established, which has become a role model on the national and international level.

Over nine years, SystemsX.ch played a central role in forming, unifying and strengthening the systems biology community in Switzerland. A common understanding and definition of systems biology was promoted. The flexibility of the funding scheme allowed SystemsX.ch to rapidly adapt to scientific progress, new challenges and changing requirements, thus enabling Swiss researchers to be up to date and make significant contributions to emerging topics. Major progress has been achieved in many directions, from a fundamental understanding of metabolic networks to new approaches to data acquisition or modeling and the establishment of unique technology platforms. Through recognized research and contributions to many unsolved scientific questions, SystemsX.ch has established a strong reputation in the international community. These outstanding accomplishments are the result of highly committed scientists, a lively interaction between researchers of different disciplines and the culture of sharing limited resources between partner institutions all across Switzerland. Efficient management of the initiative, supported by close collaboration with the SNSF and the scientific advice of the SNSF Review Panel facilitated the successful implementation of the systems approach in the Swiss research landscape.

"SystemsX.ch has been a major financial and intellectual support for truly transdisciplinary studies in Switzerland. It helps us to stay at the forefront of these 'interface' disciplines and to remain highly competitive with the best universities in the world."
Prof. Michel Milinkovitch, University of Geneva

"The SystemsX.ch review process set up by the SNSF was very well structured and extremely efficient and flexible compared to other countries."
Prof. Peter Sorger, Harvard Medical School and Member of the SNSF Review Panel

By educating the next generation of systems biology researchers, who are experienced in working at the interface between different disciplines, the scientific foundation for future quantitative studies of biological systems on an internationally competitive level was laid.

SystemsX.ch also had a positive impact on the partner institutions. The allocation of matching funds led to the reorientation of a number of professors at partner institutions as well as the recruitment of renowned scientists. The latter were often attracted by the high reputation of the SystemsX.ch initiative. In this way the systems biology community in Switzerland was enriched and further strengthened. Furthermore, partner institutions (supported by SystemsX.ch funds) made major investments in technologies and infrastructure, resulting in a number of high-tech research facilities accessible to all members of the Swiss systems biology community. The growing number of educational programs that integrate systems biology in their curricula bears witness to the catalytic effect of the initiative, as they were often inspired by the SystemsX.ch approach. Overall, these observations show that systems biology became an integral part of the partners' portfolio over the last decade, which will leave a lasting impact on the scientific domain of systems biology, well beyond the lifetime of SystemsX.ch.

"SystemsX.ch has fostered excellent cross-disciplinary research, and has opened up many opportunities that would not have existed without this initiative. "
SNSF Review Panel report, October 2010

6 LESSONS LEARNED AND RECOMMENDATIONS

Over the nine years of the initiative, partner institutions, researchers and management collected a list of various do's and don'ts in different areas. Selected lessons learned that could be of benefit for further initiatives like SystemsX.ch will be discussed in the following.

Funding

Targeted funding was experienced as an efficient tool to steer funding and jump-start a novel research domain. Promoting a research approach bottom-up that can be applied to a variety of questions, rather than forcing a specific subject, gave researchers the freedom to pursue their own topics while exploring new ways and methods of doing so. This strategy opened up room for innovation and unforeseen, groundbreaking ideas of high scientific impact.

Although the matching funds rule of SystemsX.ch proved to be very effective in supporting the implementation of new, sustainable structures at the partner institutions, it was also a challenge, especially for smaller research groups and young, (almost) independent scientists who had no or only very limited endowment resources. Own Contribution budgets and policies varied a lot from one SystemsX.ch institution to another and obviously, there is a large difference between e.g. experimental and theoretical groups. After realizing these constraints, SystemsX.ch tried to solve this issue by allowing the projects to provide matching funds not on the level of single research groups, but also on the level of whole projects and/or institutions. In this way, smaller research groups and theoretical groups were still able to participate, as some of their funds could be matched by those of larger research groups that have a higher volume of expenses.

Furthermore, in collaborative projects it is advisable to limit the number of participating research groups. Although a bigger number of research groups can assure broad expertise in different disciplines, the communication and coordination effort increases tremendously, leaving less resources for research activities. Consequently, it was generally noticed that larger consortia are less focused, and tend to support already ongoing research in the participating labs, rather than invoking a new research direction and creating synergies that lead to findings that would not have come out of any of the labs individually.

As stated by the SNSF Review Panel, computational groups have not grown fast enough to comprehensively satisfy the needs of research consortia, despite efforts to train researchers in computational aspects, new faculty staff and new educational programs in this domain. To attract a sufficient number of theoretical groups, an appropriate measure could be to fund small-scale, inter-institutional projects that focus mainly on the theoretical aspect, e.g. the creation of new biological models. Thus, this domain would be further strengthened and groups could compete for the most exciting approaches. This might lead to an improved network and consequently to easier access to integrated research consortia.

Service projects

The only exception to the very successful bottom-up approach was the funding of the service project SyBIT, which was granted top-down in order to support the systems biology IT needs for large RTD projects. For several RTD projects the support offered by SyBIT was beneficial to reach their goals. Many RTD projects however never benefited from SyBIT, partly because they did not know the portfolio of SyBIT well enough, or because they were not offering the services that they needed. The latter directly shows the biggest flaw of top-down funding. It cannot be known *a priori* what the needs for research will be, and so any central service project must be implemented in a highly flexible manner that carefully monitors and pro-actively reacts to emerging needs in the ongoing research. It should **never** become an entity that

develops tools for the sake of developing tools, which has been the impression that SyBIT at times has given. When implementing central service projects, a clear communication of the role, services, infrastructure, their usage and benefits needs to be guaranteed from the beginning on. An early involvement of researchers is recommended to (a) get researchers onboard right from the beginning and make them participate in key decisions, (b) develop solutions that are not restricted to a discipline and (c) can easily be tailored to the users' different requirements.

Public-private partnerships

A clear lesson learnt has been that the contribution that the private sector would make to SystemsX.ch was overestimated. One explanation is that systems biology started at the basic science level. It involved the development of new methods in the areas of –omics, imaging, computer vision, single-cell measurement technologies, mathematical modelling, and graph theory, which were not immediately recognized as being important by some of the established companies in Switzerland. Interestingly, several start-ups from SystemsX.ch projects which did see the potential early on are now very visible and highly successful. To some extent this reflects the inertia amongst the established private sector to embrace new approaches early on. Furthermore, scientific concepts such as network biology, quantitative single-cell biology, complexity, emerging phenomena, and collective behavior were not immediately recognized as being important for the applied life sciences such as in biotechnology and in the medical sector. While biotechnology has adopted some of these concepts faster, the medical sector still lags behind. It can be expected that a new initiative which applies systems biology in the medical sector, such as in personalized health and precision medicine, will benefit to a greater extent from the private sector.

As a recommendation, it is paramount that in any project that involves a public-private partnership, all partners have the same understanding of the project, the planning and its aims. This should be thoroughly discussed already in the proposal design phase, and agreements should be made on the expectations on the cooperation. Like this, unrealistic expectations can be avoided. A model for efficient negotiations regarding inventions and product development could prove useful to prevent conflicts between the parties.

Interdisciplinary education

Although education at the interface of several disciplines (e.g. in IPhD or TPdF projects) allows students to gain interdisciplinary experiences, it is also challenging for students and supervisors alike. First, supervisors with expertise in two scientific domains who can teach students in an interdisciplinary manner are still scarce. Here, efforts should be made to train the next generation of systems biology lecturers.

Dual supervision by two persons coming from different fields bears also a certain potential for conflicts. Awareness and understanding for the student's situation, a well-planned organization of the project, clear communication of milestones and goals, as well as regular physical meetings with all project members could help improve the situation.

Last but not least, becoming familiar with two disciplines requires significantly more time from the student or postdoc and the host than with a single discipline, and it is very likely that it takes longer until results can be achieved. This fact might also discourage research groups from offering interdisciplinary education. Specific funding categories that promote interdisciplinary training are therefore required. Clear communication of the benefits for the host lab as well as longer funding periods or the possibility for project extensions could contribute to overcome these issues. This should alleviate some of the problems emerging at short-term and allow the greater benefits to be realized at long-term.

ABBREVIATIONS

BIP	Bridge to Industry Project
BMBF	German Ministry for Education and Research (Bundesministerium für Bildung und Forschung)
BoD	Board of Directors (all Presidents and Rectors of SystemsX.ch partner institutions)
CWTS	Centre for Science and Technology Studies University of Leiden, Netherlands
DKFZ	Deutsches Krebsforschungszentrum (German Cancer Research Center)
E(A)B	SystemsX.ch Education (Advisory) Board
EiR	Entrepreneur in Residence
ERASysAPP	European Research Area Network for Applied Systems Biology
ESF	European Science Foundation
EU	European Union
FEBS	Federation of European Biochemical Societies
HTF	High Technology Service Funds
IPhD	Interdisciplinary PhD Project
IPP	Interdisciplinary (high risk and seed) Pilot Project
ISA	Industrial Sabbatical in Academia
KS	Key Statement
MO	SystemsX.ch Management Office
MRD	Medical Research and Development Project
PI	Principal Investigator
RTD	Research, Technology and Development Project
SBFI	Staatssekretariat für Bildung, Forschung und Innovation
SEB	Scientific Executive Board (Scientists of different Systems Biology fields & partner institutions)
SERI	State Secretariat on Education, Research and Innovation (German: SBFI)
SNSF	Swiss National Science Foundation
SpecOpp	Special Opportunity Project
SPHN	Swiss Personalized Health Network
SUC	Swiss University Conference (today swissuniversities)
SyBIT	SystemsX.ch Initiated Project*:* IT-support for RTDs
TF	Transfer Project
TPdF	Transition Postdoc Fellowship
WoS	Web of Science

APPENDIX A

Tables and lists complementing the SystemsX.ch Consortium Report 2008-2016

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Overall Output SystemsX.ch

Table A1: Number of research groups funded by SystemsX.ch and distribution of SystemsX.ch funds per institution

Institution	No. Research Groups	Allocated SystemsX.ch Funds*	% Research Group	% SystemsX.ch Funds	Success Rates
Kant.Spit_SG (KSSG)	1	Fr. 63'000.00	0.00%	0.03%	100.00%
UniNE	2	Fr. 162'380.68	0.55%	0.08%	40.00%
IBM	1	Fr. 307'800.00	1.09%	0.16%	20.00%
USI	6	Fr. 749'876.60	1.64%	0.38%	17.86%
PSI	4	Fr. 791'924.93	1.09%	0.41%	10.71%
ZHAW	4	Fr. 847'431.00	1.09%	0.43%	62.50%
UniFR	9	Fr. 2'990'687.00	2.46%	1.53%	42.57%
FMI	11	Fr. 3'729'893.25	3.01%	1.91%	31.91%
UniBE	12	Fr. 9'190'800.32	3.28%	4.70%	37.74%
SIB	3	Fr. 5'963'041.65	0.82%	3.05%	32.35%
UniL&CHUV	31	Fr. 11'507'207.25	8.47%	5.89%	22.53%
UniGE	32	Fr. 16'308'142.20	8.74%	8.35%	32.10%
UniBas	41	Fr. 25'842'792.24	11.20%	13.23%	37.36%
EPFL	57	Fr. 27'834'336.72	15.30%	14.25%	34.28%
UZH	71	Fr. 32'200'140.23	19.13%	16.48%	37.88%
ETHZ	81	Fr. 56'891'885.88	22.13%	29.12%	42.57%
Total	**366**	**Fr. 195'381'339.95**	**100.00%**	**100.00%**	**35.20%**

**Amounts exclusive SyBIT investments*

Structural Impact

Table A2: Newly created departments, centers and facilities for systems biology research as reported by the partner institutions (Source: Partner Questionnaire 2016)

Partner	Name	Type	Since	Responsible Person
UniNE	Competence Center in Chemical Ecology	Competence Center	2013	Prof. T. Turlings
UniBE	Section Bioinformatics and Computational Biology	Interfaculty Unit	2011	Dr. Rémy Bruggmann
PSI	InterAx Biotech	Spin out	2016	Martin Ostermaier
PSI	Crystallisation Facility	Facility	2012	May Marsh
ETH	Department of Biosystems Science and Engineering	Department	2006 (2008 expanded)	Mustafa Hani Khammash
UniBS	FACS Facility	Core Facility	2011	Janine Zankl
UniBS	Proteomics Core Facility	Core Facility	2009	Paul Jenö, Alexander Schmidt
UniBS	Imaging Core Facility	Core Facility	2011	Olivier Biehlmaier
UniBS	sciCORE Center for Scientific Computing	Core Facility	2014	Torsten Schwede
EPFL	Bioinformatics and Biostatistics Core Facility BBCF	Core Facility	2007	Vacant (previously: Jacques Rougemont)
EPFL	Lipidomics Initiative			Marc Moniatte
UniFR	Department of Biology	Professorship Proteomics Platform	2016	Prof. Jörn Dengjel
UZH	University Research Priority Program (URPP) Systems Biology/ Functional Genomics	Research Priority Program	2005-2016	Prof. Jiricny
UZH	Functional Genomics Center Zurich (FGCZ)	Core Facility	2001	Prof. Schlapbach
UZH	Service and Support for Science IT (S3IT)	Org. Unit Information Technology	2014	Dr. Riedi
FMI	Next Generation Sequencing Unit (initially joined with Uni BS and ETH BSSE, now independent)	Scientific Core Facility	2009	Prof. Dirk Schübeler
FMI	Data Analysis Unit (shift in focus)	Scientific Core Facility	2006	Dr. Michael Stadler
FMI	Proteomics Unit	Scientific Core Facility	2014	Prof. Marc Bühler
USI	Scientific computing group (focus on simulations of physical and biological systems)	Research group	2011	Igor Pivkin
USI	Institute of Biomedical Research, research group on computational structural biology	Research Institute	2013	Antonio Lanzavecchia/Andrea Cavalli (group leader)

Partner	Name	Type	Since	Responsible Person
UniL	Département de biologie computationnelle (reorientation of the former Dpt. de génétique médicale under the effect of the lemanic initiative CADMOS and the SystemsX.ch initiative toward the broader field of complex systems modelling)	Department	2016	Nicolas Salamin
IBM	System Biology	Group	2014	Dr. Maria Rodriguez Martinez

Table A3: Staff hired since 2008 to foster systems biology research as reported by the partner institutions (Source: Partner Questionnaire 2016)

Partner	Type	Name	Research Field	Replace-ment	Tenure Track	Since
UniBE	SNF Professor	Dr. Richard Smith	Computational biology	no	no	2008
UniBE	Group Leader	Dr. Rémy Bruggmann	Bioinformatics and Computational Biology	no	yes	2011
UniBE	Full Professor	Thomas Nevian	Systems Neuroscience (Dept. of Physiology)	yes	yes	2012
UniBE	Full Professor	Martin Fiedler, Institut für klinische Chemie	Clinical metabolomics	no	yes	2011
UniBE	SNF Assistant Professor	Antoine Adamantidis, Neurozentrum Inselspital	Sleep Circuitries and optogenetics	no	yes	2013
UniBE	Group Leader	Dr. Shankar Babu Sachidhanandam	Systems Neuroscience (Dept. Of Physiology)	no	no	2015
UniBE	Group Leader	Dr. Sonja Kleinlogel	Systems Neuroscience (Dept. Of Physiology)	no	no	2011
PSI	Group Leader	Dmitry Veprintsev	GPCR signaling	no	yes	2016
ETH	Full Professor	Fussenegger Martin	Biotechnologie und Bioingenieurwissenschaften			2008*
ETH	Full Professor	Hierlemann Andreas	Biosystems Eingineering			2008*
ETH	Full Professor	Stelling Jörg	Computational Systems Biology			2008
ETH	Full Professor	Müller Daniel J.	Biophysik			2010
ETH	Full Professor	Khammash Mustafa Hani	Regelungstheorie und Systembiologie			2011
ETH	Full Professor	Schroeder Timm	Zellsystem-Dynamik			2013
ETH	Associate Professor	Panke Sven	Bioverfahrenstechnik			2009*

Partner	Type	Name	Research Field	Replace-ment	Tenure Track	Since
ETH	Associate Professor	Beerenwinkel Niko	Rechnergestützte Biologie			2013
ETH	Associate Professor	Borgwardt Karsten M.	Data Mining			2014
ETH	Associate Professor	Dittrich Petra S.	Bioanalytik			2014
ETH	Associate Professor	Iber Dagmar	Rechnergestützte Biologie			2008
ETH	Associate Professor	Benenson Yaakov	Synthetische Biologie			2015
ETH	Assistant Professor	Tay Savas	Bioengineering	left	yes	2011
ETH	Assistant Professor	Pantazis Periklis	Biosystemanalyse		yes	2011
ETH	Assistant Professor	Claassen Manfred	Rechnergestützte Biologie		no	2013
ETH	Assistant Professor	Christen Beat	Experimentelle Systembiologie		no	2013
ETH	Assistant Professor	Gunawan Rudiyanto	Chemisches und Biologisches System Engineering		yes	2015
ETH	Assistant Professor (NCCR)	Platt Randall	Biologisches Engineering		yes	2016
ETH	Assistant Professor (3rd party funding)	Reddy Sai	Biomolekulares Engineering		yes	2012
ETH	Assistant Professor (SNF)	Snijder Berend	Molekulare Systembiologie		no	2016
ETH	Assistant Professor (ERC)	Stadler Tanja	Computergestützte Evolution		yes	2014
ETH	Assistant Professor (NCCR, University of Basel)	Tiefenbacher Konrad	Synthese von Funktionellen Modulen		yes	2016
ETH	Assistant Professor (NCCR, University of Basel)	Nash Michael	Engineering von Synthetischen Systemen		yes	2016
UniBS	Full Professor	Henning Stahlberg	Core Program Structural Biology and Biophysics	yes		2009
UniBS	Full Professor	Mihaela Zavolan	Computational and Systems Biology	no		2008
UniBS	Full Professor	Eric van Nimwegen	Computational and Systems Biology	no		2008
UniBS	Full Professor	Dirk Bumann	Microbial Pathogens	no		2008
UniBS	Full Professor	Attila Becskei	Regulatory circuits	yes		2011
UniBS	Full Professor	Verdon Taylor	Neural Stem Cells	no		2011

Partner	Type	Name	Research Field	Replace-ment	Tenure Track	Since
UniBS	SNF Professor	Clemens Cabernard	Cell Biology (SNF Professor)	no	no	2011-2015
UniBS	SNF Professor	Oliver Pertz	Cell migration and Neuritogenesis	no	no	2008
UniBS	SNF Professor	Roxane Tussiwand	Immunology	no	no	2014
EPFL	SNF Professor	Jacques Fellay	Human genomics of viral diseases	no	no	2011
EPFL	Professor funded by institution	Deplancke	Transcriptional networks	no	yes (now assoc prof)	2007
EPFL	Professor funded by institution	Suter	Single-cell circadian gene regulatory networks	no	Yes	2013
EPFL	Professor funded by institution	Gräff	Epigenetics and behavioral neuroscience	no	yes	2013
EPFL	Professor funded by institution	Andrew Oates	Oscillatory mechanisms in development	no	yes	2016
UniFR	Full Professor	Prof. Jörn Dengjel	Disease Proteomics	yes;	no	2016
UniFR	Professor funded by institution	Associate Professor in Bioinformatics and computational Biology	Mostly Genomics with some research in Systems Biology.	yes	yes	2013
UZH	Full Professor	Christian von Mering	Computational Biology	no	yes	2012
UZH	Full Professor	Anne Müller	Experimental Medicine, Helicobacter pylori and gastric cancer	no	Yes	2006 (AP URPP)2012 (MeF DP mit MNF)
UZH	Full Professor	Lucas Pelkmans	Quantitative cell biology, cell-to-cell variability and systems biology	yes	yes	2010
UZH	Full Professor	Damian Brunner	Cell Biology	yes	yes	2010
UZH	SNF Professor	Bernd Bodenmiller	Quantitative Biology	no	no	2013
UZH	SNF Professor	Mark Robinson	Statistical Genomics	no	no	2011
UZH	Associate Professor	Michael Baudis	Bioinformatics	no	no	2007
UZH		Reinhard Furrer	Applied Statistics	no	yes	2009
UZH		Kenatro Shimizu	Evolutionary Biology and Environmental Studies, Evolutionary Functional Genomics	no	yes	2006
UZH	Group Leader, Titularprofessor	Christof Aegerter	Disordered and Biological soft Matter	n/a	n/a	2009
FMI	SNF Professor	Prisca Liberali	Cellular heterogeneity during collective cell behavior	yes	yes	2015

Partner	Type	Name	Research Field	Replace-ment	Tenure Track	Since
FMI	Group Leader	Luca Giorgetti	Chromosome structure and transcriptional regulation	yes	yes	2015
FMI	Group Leader	Charisios Tsiairis	Self-organizing cellular systems	yes	yes	2016
USI	Associate Professor	Igor Pivkin	Scientific computing / Simulation of biological system	no	yes	2011, 2015
USI	Group Leader	Andrea Cavalli	Computational structural biology	no	yes	2012
UniL	Assistant Professor (private foundation)	Giovanni Ciriello	Functional interrelations in cancer	no	yes	2015
UniL	Assistant Professor (institution)	Anna Malaspinas (institution)	Human populations migrations modelling	no	yes	2017
UniL	Assistant Professor (institution)	Matthieu Robinson (institution)	Genotype / phenotype links modelling	no	yes	2017
UniL	Associate Professor (CADMOS)	Nicolas Salamin	Evolutionary relationships between species	no		2012
IBM	Technical leader	Maria Rodriguez Martinez	Network inference from high-throughput data	no	no	2013
IBM	Research Staff Member	Maria Gabrani	Image analysis	no	no	2014
IBM	Research Staff Member	Matthias Reumann	Big Data for health care	no	no	2013
IBM	Research Staff Member	Chiara Marciori	Cognitive health care	no	no	2015

** Transfer from ETH Zurich to D-BSSE in Basel*

Table A4: Investments of partner institutions in equipment and infrastructure necessary to conduct systems biology research (Source: Partner Questionnaire 2016)

Institution	Investments	Number of Investments	Offered to other groups inhouse	Offered to others	Total Investment (CHF)
UniNE	yes	5	5	5	2'400'000
UniBE	yes	2	2	2	2'600'000
SIB	no	0	0	0	0
PSI	yes	2	2	2	700'000
ETH incl. D-BSSE	yes	90	38	8	26'805'838
UniBS	yes	10	10	10	17'527'191
EPFL	yes	3	3	2	3'320'000
UniFR	yes	2	2	1	900'000
UZH	yes	23*	50*	50*	6'727'504
FMI	yes	4	4	4	2'533'823
USI	yes	8	8	2	5'240'000
UniL	yes	5	5	2	5'266'500
IBM	yes	1	1	1	1'000'000
ZHAW	yes	1	1	0	400'000
UniGE	yes	1	0	0	0
Total	**14**	**157**	**131**	**89**	**75'420'856**

** Including Functional Genomics Center, a joint venture between UZH and ETHZ*

Impact on Collaboration

Table A5: SystemsX.ch measures to promote and support public-private partnerships

Measure	Year	Comment
FMI became a SystemsX.ch partner	2007	
SEB sets up “Industry collaboration concept”	2008	
Visit selected companies	2008	
International Entrepreneurial Fund	2008	not implemented
Industry Day	2008, 2009	no interest
MipTec	2008-2012	
Swiss Biotech Association (annual meetings)	2009	
Support Spin-offs	2009ff	
SME workshop	2009-2010	
SystemsX.ch Industry Club	2009-2010	not implemented
Bridge to Industry Projects (BIP)	2009-2012	16 projects
Industrials having a Sabbatical at Academia (ISA)	2009-2012	no applications
Venture Kick Jury	2009-2017	
SEB meeting “public-private partnership”	2011 (Mar 21)	with 4 privates
Entrepreneur in Residence / innovation scout service	2012-2013	
Invitation to private groups to join applying consortia	2012-2016	
Transfer Projects (TF)	2012-2016	8 projects
National Topic Network Swiss Biotech (member)	2013-2016	
IBM became a SystemsX.ch partner	2015	

Table A6: List of industry partners contributing to SystemsX.ch projects

Call	Year	Project Type	Surname	First name	Role	Institution
3	2009	BIP	Spooren	Will	Industry Partner	Roche
3	2010	BIP	Bleuler	Stefan	Industry Partner	Nebion AG
3	2010	BIP	Bonner	Ron	Industry Partner	AB Sciex
3	2010	BIP	de Heras Ciechomski	Pablo	Industry Partner	Science Visuals
3	2010	BIP	Driggers	Ed	Industry Partner	Agios Pharma
3	2010	BIP	Emery	Yves	Industry Partner	Lyncée tec S.A.
3	2010	BIP	Fjeldsted	John	Industry Partner	Agilent
3	2010	BIP	Gabi	Michael	Industry Partner	Cytosurge LLC
3	2010	BIP	Meisner	Nicole	Industry Partner	Novartis
3	2010	BIP	Spooren	Will	Industry Partner	Roche
4	2011	IPP	Heeren	Ron	Co-applicant	Other
4	2011	BIP	Melkko	Samuel	Co-applicant	Novartis
4	2011	BIP	Hohmann	Hans-Peter	Co-applicant	DMS
6	2012	RTD	Beyeler	Felix	Industry Partner	FemtoTools AG
6	2012	RTD	Sebastian	Abu	Industry Partner	IBM
6	2012	TF	Jacobi	Carsten	Industry Partner	Novartis
6	2012	TF	Kaigala	Govind	Industry Partner	IBM
6	2012	TF	Mosbacher	Johannes	Industry Partner	Roche
6	2012	TF	Page	Malcolm	Industry Partner	Basliea
8	2013	TF	Bitsch	Francis	Industry Partner	Novartis
8	2013	TF	Cosulich	Sabine	Industry Partner	Novartis
8	2013	TF	Langen	Hanno	Industry Partner	Roche
9	2014	IPhD	Majer	Peter	co-Applicant	Bitplane AG
9	2014	IPhD	Rodriguez Martinez	Maria	co-Applicant	IBM Research Laboratory Zurich
9	2014	TF	Ebeling	Martin	Co-applicant	Roche
9	2014	TF	Grawunder	Ulf	Co-applicant	NBE Therapeutics
9	2014	TF	Beerli	Roger	Co-applicant	NBE Therapeutics
10	2014	MRD	Bogojeska	Jasmina	Co-applicant	IBM
10	2014	MRD	Rodriguez Martinez	Maria	Co-applicant	IBM

Table A7: RTDs and German research groups currently benefitting from the Consortial Agreement between BMBF and SystemsX.ch

RTD project	PI	German research group
PhosphoNet_PPM	Ruedi Aebersold, ETH Zurich	Andreas Beyer, University of Cologne
PlantGrowth2	Chris Kuhlemeier, University of Bern	Richard Smith, MPI Cologne
HostPathX	Thierry Soldati, University of Geneva	Heinz Koeppl, TU Darmstadt
MorphoGenetiX	Damian Brunner, University of Zurich	Richard Smith, MPI Cologne

Table A8: Key figures of the 1st and 2nd ERASysAPP call

	1st ERASysAPP Call 2013	2nd ERASysAPP Call 2014
Proposals		
Countries participating in call	Cyprus, Germany Latvia, Luxembourg, The Netherlands, Norway, Romania, Sweden, Switzerland	Cyprus, Estonia, Germany, Iceland, Latvia, The Netherlands, Norway, Romania, Sweden, Switzerland
Number of eligible project proposals	32	10
Number of partners on proposals total	196 partners from 15 European countries	48 partners from 7 European Countries
Number of Swiss partners on proposals	18 Swiss partners in 14 proposals	4 Swiss partners in 4 proposals
Funded Projects		
Number of funded projects	7	5
Number of funded research groups	46 research groups from 10 countries	25 research groups from 7 countries
Funded projects involving Swiss research groups	4	2
Rate of applying/funded Swiss researchers	22%	50%
Total Funding	**~EUR 10 mio**	**~EUR 5.75 mio**
Swiss Funding	**EUR 1.46 mio**	**EUR 463'582**

Table A9: List of projects funded under the 1st and 2nd joint ERASysAPP call

Acronym	Title	Coordinator	# Research Groups / Country	Requested Total Budget (EUR)	Swiss Partner	Swiss Funding (EUR)
1st Joint ERASysAPP Call 2013						
SysMilk	Designer microbial communities for fermented milk products: A Systems Biology Approach	**Kiran Patil**, EMBL, Germany	GER (2), CH (1), NED (1), SWE (2), DNK (1)	1'755'139	**Uwe Sauer,** ETHZ	400'000
SysVirDrug	Translating systems virology data into broad-spectrum antiviral drugs	**Lars Kaderali,** TU Dresden, Germany	GER (4), SWE (1), NED (2), CYP (1), CH (1)	1'352'156	**Niko Beeren-winkel** ETHZ	258'506
IMOMESIC	Integrating Modelling of Metabolism and Signalling towards an Application in Liver Cancer	**Ursula Klingmüller,** DKFZ, Germany	GER (3), NED (3), SWE (1)	1'248'540	-	-
MetApp	Systems biology of bacterial methylotrophy for biotechnological products from methanol	**Trygve Brautaset,** SINTEF Materials & Chemistry, Norway	GER (1), NOR (2), CH (1), FRA (1)	1'479'748	**Julia Vorholt,** ETHZ	399'950
SysMetEx	Systems Biology of acidophile biofilms for efficient metal extraction	**Mark Dopson,** Linnaeus University, Sweden	GER (2), SWE (3), CH (1), LUX (1)	1'799'651	**Igor Pivkin,** USI	398'200
Cropclock	Increasing crops biomass by uncovering the circadian clock network using dynamical models	**Jorge Goncalves,** University of Luxembourg, Luxembourg	GER (2), LUX (3), CYP (1), SWE (1)	755'305	-	-
WineSys	GMO free systems optimization of wine yeast for wine production by massive scale directed evolution	**Eivind Almaas,** NTNU, Norway	NOR (1), SWE (1), GER (1), ESP (1)	1'742'778	-	-
2nd Joint ERASysAPP Call in 2014						
RobustYeast	Optimizing metabolic regulation in yeast production strains for dynamic conditions	**Steffen Waldherr,** Otto-von-Guericke University Magdeburg, GER	GER(2) NED (1) CH (1)	914'349	**Vassily Hatzi-manikatis** EPFL	248'082
RootBook	Systems analysis of peptide-mediated cell-cell communication in the plant root by in situ sequencing	**Manfred Claassen,** ETH Zurich	CH (1) GER (2) NOR (1)	1'065'500	**Manfred Claassen** ETHZ	215'500
XyloCut	Shortcut to the carbon efficient microbial production of chemical building blocks from D-xylose	**Stephan Noak** Forschungs-zentrum Jülich GmbH, Germany	GER (2) NED (1) SWE (1)	1'245'500	-	-
SYSTERACT	Systematic Rebuilding of Actinomycetes for Natural Product Formation (SYSTERACT)	**Alexander Wentzel** SINTEF Materials and Chemistry, Norway	GER (2) NED (1) NOR (2) SWE (1)	1'983'340	-	-
LEANPROT	Systems biology platform for the creation of lean-proteome Escherichia coli strains	**Raivo Vilu** Competence Center of Food and Fermentation Technologies, Estonia	GER (2) EST(1) LVA (2) NOR (1)	1'187'744	-	-

Impact on Education

Table A10: List of reported Master programs offered at SystemsX.ch partner institutions (Source: SystemsX.ch Partner Questionnaire 2016)

Institution	Title Master Program	Participants	Offered since	Contact
Universities of Bern and Fribourg	Master's in Bioinformatics and Computational Biology	approx. 15	2013	Prof. Daniel Wegmann, Univ. of Fribourg
Universities of Bern and Fribourg	Master in Biomedical Sciences	15	2008	Tabea Ruegge, UniBern
ETH Zurich	Master "Systems biology"	30	2007	D-BIOL
ETH Zurich	Master "Computational Biology and Bioinformatics"	20	2008	D-BSSE
ETH Zurich	Master " Biotechnology" with specialization systems biology	15	2008	D-BSSE
EPFL	Life Sciences &Technology	appr. 40	2006 (with considerable adaptations since)	J. McKinney
EPFL	Bioengineering	appr. 60	2006 (with considerable adaptations since)	J. McKinney
University of Zurich	Master in Quantitative Biology und Systems Biology			Prof. Aegerter
University of Lausanne	Master Molecular Life Sciences, mention "bioinformatics"	appr. 25	2011	J. van der Meer, M. Robinson-Rechavi
ZHAW	Computational Life Science Master	15	2017	ottt@zhaw.ch

Table A 11: List of reorted PhD prorams offered at SystemsX.ch partner institutions (Source: SystemsX.ch Partner Questionnaire 2016)

Institution	Title of PhD Program	Offered Since	Contact Person
University of Bern	Grad School for Cellular & Biomedical Sciences	2005	Marlene Wolf
ETH Zurich and University Zurich	Interdisciplinary PhD Program Systems Biology	2010	Uwe Sauer, D-BIOL, Jörg Stelling D-BSSE
Universities of Bern, Fribourg, Geneva, EPFL Lausanne, Neuchâtel,	Doctoral Program StarOmics	2010	Corinne Dentan, University of Lausanne.
ETH Zurich and University Zurich	PhD Program Molecular and Translational Biomedicine		Prof. Wolfrum, ETH
University of Lausanne	Doctoral Program in Integrative Experimental and Computational Biology	2011	Keith Harshmann
EPFL	Doctoral Program in Molecular Life Sciences		D. Constam,
EPFL	Doctoral Program in Biotechnology and Bioengineering		M. Dal Peraro
EPFL	PhD Program in Neuroscience		M. Herzog
Università della Svizzera italiana	PhD program in Imnmunology, Cell Biology and Biochemistry	2003	Silvia Monticelli

Table A12: Overview of events organized, co-organized or supported by SystemsX.ch (2007-2016)

Date	Event	Place
Events organized by SystemsX.ch		
17.09.2007	All-SystemsX.ch Day 2007	Lausanne
2008	Various SystemsX.ch student seminars	Zurich/ Lausanne
16.10.2008	All-SystemsX.ch Day 2008	Basel
11.-12.09.2009	SystemsX.ch PhD Student Retreat	Weggis
18.11.2009	All-SystemsX.ch Day 2009	Bern
17.-24.08.2010	SystemsX.ch Computational Biology Summer School	Split (CRO)
30.09-01.10.2010	SystemsX.ch PhD Student Retreat	Murten
01.11-02.11.2010	All-SystemsX.ch Day 2010	Geneva
19.08-21.08.2011	3rd SystemsX.ch PhD Student Retreat	Kandersteg
24.-26.10.2011	1st International SystemsX.ch Conference on Systems Biology	Basel
04.-07.10.2012	4th SystemsX.ch PhD Student Retreat	Engelberg
13.05.2013	All SystemsX.ch Day 2013	Bern
02.-05.10.2013	SystemsX.ch Retreat 2013	Engelberg
20.-23.10.2014	2nd International SystemsX.ch Conference on Systems Biology	Lausanne
09.-10.02.2015	SystemsX.ch Postdoc Workshop 2015	Gerzensee
09.-12.03.2015	SystemsX.ch Retreat 2015	Rigi Kaltbad
15.09.2015	All SystemsX.ch Day 2015	Bern
16.-18.02.2016	SystemsX.ch Postdoc Workshop 2016	Gerzensee
24.-27.05.2016	SystemsX.ch Retreat 2016	Münchenwiler
01.09.2016	All SystemsX.ch Day 2016	Bern
16.-18.11.2016	SystemsX.ch Postdoc Workshop 2016	Muri bei Bern
Events co-organized by SystemsX.ch		
15.08-19.08.2011	Summer School / SIB	Kandersteg
09.-14.06.2013	CRG Summer School on “Modeling in Systems Biology”	Barcelona (E)
2.-7.03.2014	„SysBio 2014”: 5th Advanced Lecture Courses on Systems Biology	Innsbruck (A)
22.-27.06.2014	SystemsX.ch – SIB Summer School on “Systems Medicine and its Applications”	Kandersteg
08.-12.11.2015	SystemsX.ch – SIB Summer School on “Systems Modelling”	Schwarzenberg
20.02.-05.03.2016	"SysBio2016": 6th Advanced Lecture Course on Systems Biology 2016	Innsbruck (A)
21.-25.11.2016	SIB/SystemsX.ch/NGS Discussion Group UZH Machine Learning Course	Zurich

Date	Event	Place
Events supported by SystemsX.ch		
07.-13.03.2009	FEBS Sysbio 2009 / FEBS	Alpbach (A)
18.-19.06.2009	7th Basel Computational Biology Conference [BC]2 / SIB	Basel
24.- 25.06. 2010	8th Basel Computational Biology Conference [BC] 2 / SIB	Basel
16.-20.08.2010	Workshop: Systems Biology of Development / EMBO	Ascona
26.02.-03.03.2011	FEBS-SysBio 2011 / FEBS	Innsbruck (A)
16.-20.03.2011	6th International Ceramide Conference 2011 / UniGE	Villars-sur-Ollon
06-08.06.2011	International Workshop on Computational Systems Biology / ETHZ	Zurich
23.-24.06.2011	9th Basel Computational Biology Conference [BC] 2 / SIB	Basel
11.-13.09. 2011	TOR PI3K and Akt / UniBas	Basel
18.-21.03.2012	Workshop “Current Topics in Biophysics and Molecular Biology” U Oxford	Oxford (UK)
02.-04.05.2012	Systems Biology of Human Diseases (SBHD) 2012 / DKFZ, BioQuant, Harvard Medical School	Heidelberg (D)
27.-31.05.2012	International Conference on Brain Dynamics and Decision Making / Neurochoice	Ascona
15.-17.08.2012	2nd Basel Postdoc Network Retreat / UniBas	Leysin
09.-12.09.2012	11th European Conference on Computational Biology (ECCB) 2012 / SIB	Basel
12.09.2012	BC2 European Conference on Computational Biology 2012, Basel (ECCB12)	Basel
13.-14.12.2012	Bioconductor European Developers’ Workshop	Zurich
31.01.-01.02.2013	Life Science Switzerland Annual meeting 2013 ®Evolutions in Biology, Zürich	Zurich
28.04-30.04.2013	Systems Toxicology in Ascona	Ascona
03.-05.06.2013	Science Gateway	Zurich
12.-14.06.2013	Systems Biology of Human Diseases (SBHD) 2013 / DKFZ, BioQuant, Harvard Medical School	Heidelberg
23.-27.06.2013	Conference Systems Biology of Infection	Ascona
04.-05.07.2013	[BC]2 European Conference on Computational Biology 2013, Basel (ECCB13)	Basel
15.-19.07.2013	SRM Course 2013	Zürich
15.-19.07.2013	Practical course about “Targeted proteomics”	Zürich
22.-24.07.2013	Basel Postdoc Network Retreat 2013	Arosa
02.-03.09.2013	Plant Science Modeling Seminar	Bern
29.09.-04.10.2013	EMBO Systems Dynamics in Endocytosis	Villars
26.-28.11.2013	Physics of Biology 2013	Geneva
10.-14.02.2014	SRM Course 2014	Zürich

Date	Event	Place
18.-22.05.2014	Conference on Systems Genetics and Evolution of Non-Human Organisms	Ascona
17.-19.06.2014	International conference on Systems Biology of Human Disease 2014 (SBHD)	Boston (USA)
29.06.-04.07.2014	CRG Summer School on “Modeling for Systems Biology”	Barcelona (E)
06.-07.09.2014	Workshop on Logical Modeling and Analysis of Cellular Networks at the ECCB 2014	Strasbourg (F)
10.-12.09.2014	Basel Postdoc Network Retreat, Switzerland	Engelberg
26.-28.09.2014	Targeting the Kinome III Conference	Basel
29.9.-01.10.2014	7th Conference of the International PhD program in Basic and Applied Molecular Life Sciences	Les Diablerets
29.-30.01.2015	LS2, UZH Irchel	Zürich
07.-10.06 2015	[BC]2 Basel	Basel
11.-13.06.2015	7th PhD retreat of the Biozentrum Basel	Saas Fee
14.-19.06.2015	CRG Summer Course	Barcelona (E)
21.-26.06.2015	FASEB Molecular Mechanisms and Physiological Consequences of Protein Aggregatio	Big Sky, MT (USA)
22.-26.06.2015	Targeted Proteomics Course	Zürich
06.-08.07.2015	Systems Biology of Human Diseases 2015 (SBHD)	Heidelberg (D)
09.-10.07.2015	9th LMB-FMI Graduate Student Symposium	Cambridge (UK)
18.-22.08.2015	Arolla Workshop (FMI)	Arolla
02.-04.09.2015	Life Science Symposium 2015 (LSS 2015)	Lausanne
06.-10.09.2015	2nd edition Systems Biology of Infection Symposium	Ascona
07.-09.09.2015	Systems Biology PhD Program Retreat 2015 of the Life Science Zurich Graduate School	Reichenau (D)
12.09.2015	Swiss Meeting for Infectious Disease Dynamics (SMIDDY)	Bern
23.-25.09.2015	Basel PostDoc Network Retreat	Kandersteg
27.-29.01.2016	Systems Toxicology Meeting	Les Diablerets
18.-20.01.2016	PhD retreat 2016 Basic and Applied Molecular Life Sciences UniGE	Leysin
24.-26.01.2016	Interdisciplinary Rigi Workshop	Rigi Kulm
08.-12.02.2016	Targeted Proteomics Course	Zurich
10.02.2016	YSN Zurich Life Science Day 2016	Zurich
15.-16.02.2016	Annual LS2 Meeting	Lausanne
Apr-Dec 2016	ICSB-RSG Career Chats	Zurich
14.-16.06.2016	Systems Biology of Human Diseases 2016 (SBHD)	Boston (USA)
22.-24.06.2016	Basel Postdoc Network Retreat	Saas Fee

Date	Event	Place
21.05.2016	Life Science Career Day	Lausanne
October 2016	Cancer Biology PhD program Retreat	
29.-30.09.2016	Symposium 30th Anniversary EPD	Lausanne
16.-20.09.2016	International Conference on Systems Biology (ISCB)	Barcelona (E)
28.-30.09.2016	Annual Retreat Systems Biology PhD Program of the Life Science Zürich Graduate School	Leissingen
09.11.2016	4th Annual ETH Life Sciences Postdoc Day 2016	Zurich
23.-25.11.2016	Physics of Biology 2	Geneva

Table A13: Next steps in the career of researchers after they left their RTD project

RTD Project	Group	PhD-student	Postdoc	New Function	Location
AgingX	Auwerx		Seiko Ishida	not known	not known
AneuX (2014/261)	Bijlenga	Samuel Sommaruga		PhD student	Yale University
	Bijlenga		Roduit Nicolas	analyste en informatique	Geneva University Hospital
	Kuster	Wissmann Phillippe		developer	IT'IS
AntibodyX (2012/193)	Oxenius		Kirsten Richter	Researcher	Roche
	Oxenius	Joshua Mark Crouse		Medical specialist	Takeda
	Reddy		Tarik Khan	Postdoc	Roche
	Oxenius		Zimmerman, Kathrin	Diagnostic coordinator	University Hospital Zurich
	Regoes		Bertels Frederic	Senior Postdoc	MPI Ploen
	Trkola	Schanz Merle Mareike		PostDoc	IMV
BattleX (2009/004)	Arrieumerlou	Therese Tschon		Technical associate	University of Basel
	Bairoch		Camille Mary	Junior lecturer (Maitre-Assistante)	University of Geneva
	Bairoch	Lisa Salleron		PostDoc	CEA -Université de Nice Antipolis (France)
	Bumann		A. Chirkova	Clinical rsearch trainee	University of Basel
	Bumann		Julien Limenitakis	PostDoc	University of Bern
	Bumann		Nicole Freed	Lecturer	Massey University, Auckland New Zealand
	Hatzimanikatis		Ho Ki Fung	Assistant Professor	Singapore Institute of Technology
	Hatzimanikatis		Ljubisa Miskovic	Scientist - Lecturer	EPF-Lausanne
	Hatzimanikatis	Soh, Keng Cher		Postdoc	ISIC
	Schlapbach		Fuat Akal	University Lecturer	Hacettepe University, Ankara
	Schlapbach		Jonas Grossmann	Sr. Data Analyst	FGCZ
	Schlapbach		Paolo Nanni	Group Leader	FGCZ
	Schlapbach		Ugur Gürel	Software Engineer	FGCZ
	Vorholt		Orane Guillaume-Gentil	PostDoc	ETH-Z
	Vorholt	Martano, Giuseppe		Postdoc	ETHZ, Vorholt group
	Bumann		David Kentner	Documentation Expert	Novartis
	Bumann		Olga Burton (Timoshenko)	Clinical Trial Administration Specialist	Actelion
	Bumann		Olivier Casse	Group Leader Analytical Chemistry	Hutchinson

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Bumann		Rachel Benzies	Team Leader, External search	Syngenta
	Bumann	Benjamin Steeb		Manager Distance Learning	Springer Verlag
	Hatzimanikatis		Anirikh Chakrabarti	PostDoc	Nestlé Institute of Health Sciences
	Schlapbach		Asa Wahlander	Staff Scientist	Astra Zeneca, Sweden
	Vorholt		Delmotte, Nathanaël	Scientist	Swiss BioAnalytics
Cell Plasticity (2009/007)	Christofori		Aleksander Kuzmanov	Postdoctoral Fellow	Triemlispital, Zürich
	Christofori	Dorothea Maass		Postdoctoral Fellow	Institute for Molecular Cancer Research, University Zürich
	Christofori	Neha Tiwari		Postdoctoral Fellow	Johannes Gutenberg University Mainz
	Gasser		Benjamin Towbin	Postdoctoral Fellow	Weizmann Institute, Israel
	Peters		Helène Royo	Postdoc	FMI
	Peters	Méreau Hélène		Technician	University Children's Hospital
	Peters/ Schwaller		Vaya Stavropoulou	Postdoc	University of Basel, Switzerland
	Schübeler		Rabih Murr	SNSF Professor	Medical University Geneva, CH
	Schübeler	Angelika Feldmann		Postdoc	University of Oxford
	Schübeler	Anne Schöler		Postdoc	Helmholtz Center Munich, Germany
	Stadler		Lukas Burger	Bioinformatician	FMI
	van Nimwegen		Peter Pemberton-Ross	Research Scientist	Tropen Institute Basel
	van Nimwegen		Saeed Omidi	Postdoc	EPFL
	van Nimwegen	Piotr Balwierz		Postdoc	University College London
	van Nimwegen	Silvia Salatino		Postdoc	CRG Barcelona
	Zavolan		Biter Bilen	Postdoc	Stanford University
	Zavolan		Florian Geier	Scientific Programmer	DBM UniBas
	Zavolan		Jean Hausser	Postdoc	Weizmann Institute of Science
	Christofori		Anna Fantozzi	Scientist	Novartis Pharma AG
	Christofori	Lorenz Waldmeier		Scientist	Biotech: Antibody4You
	Matthias		Nina Reichert	Scientist	AbbVie
	Peters/ Schwaller		Brault Laurent	Senior Scientist	Exquiron
	Peters/ Schwaller		Stefano Morettini	Clinical Research Manager	MED-EL Medical Electronics, Austria
	Peters/ Schwaller	Susanne Kaspar		Consultant	APP Unternehmensberatung AG, Switzerland
	van Nimwegen		Nicholas Kelley	Research Scientist	Novartis

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	van Nimwegen	Phil Arnold		Research Scientist	Novartis
CINA (2009/006)	Hierlemann		Carlos Escobedo	Professor	Queen's University, Kingston, Ontario, Canada
	Stahlberg		Preeti Kumari	Postdoc	Stanford University
	Stahlberg/ Engel		Daniel Castaño-Diez	Postdoc	MPI Frankfurt
	Stahlberg/ Engel		Misha Kudryashev	Postdoc	Biozentrum, Uni Basel
	Stahlberg/ Engel		Stefania Mari	Postdoc	ETH D-BSSE
	Stahlberg/ Engel	Bryant Gipson		Postdoc	Rice University
	Stahlberg/ Engel	Christopher Bleck		Postdoc	Biozentrum
	Stahlberg/ Engel	Jörg Ziegler		Postdoc	Uni Zürich
	Stahlberg/ Engel	Venkata Dandey		Postdoc	New York Structural Biology Center
	Vogel	Luigino Grasso		Postdoc	EPFL/Uni Basel
	Gasser		Mariano Oppikofer	Postdoc	Genentech SF (USA)
	Gasser		Stephanie Kueng	Scientist	Roche
	Hierlemann		Nils Goedecke	Entrepeneur	Microduits
	Hierlemann		Ralf Streichan	Entrepeneur	Microduits
	Stahlberg/ Engel	Simon Kemmerling		Employe	Straumann
	Vogel	Olivia Baud		Employee	Biorad/Cressier
	Stahlberg/ Engel	Benjamin Bircher		Employe	Eidgenössisches Institut für Metrologie
	Vogel	Sophie Roizard		Employee	World Business Council for Sustainable Development / Geneva
CycliX (2009/008)	Deplancke		Komeel Hens	Assistant Prof.	Oxford University, UK
	Deplancke		Sunil Raghave	Assistant Prof.	ILS India
	Deplancke	Alina Isakova		Postdoc	EPFL
	Deplancke	Irina Krier		Postdoc	UniGE
	Desvergne		Aurélien Naldi	Postdoc	Université de Montpellier
	Desvergne		Federica Gilardi	Senior researcher	UniL
	Hernandez		Gergana Bounova	Postdoc	Netherlands Cancer Institute
	Herr		Kyle Gustafson	Postdoc at EPFL with Felix Naef	EPFL
	Herr	Tanja Bhuiyan		Postdoc	UniL
	Naef		Nacho Molina	Chancellor's Fellow	University of Edinburgh
	Rougemont		Marion Leleu	Permanent staff	EPFL
	Schibler		Gwendal Le Martelot	Postdoc	UniGE-demed

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Schibler		Maud Demarque	Postdoc	UniGE-bimol
	Hernandez		Annemieke Michels	Unemployed	
	Deplancke	Carine Delattre		Market Access Consultant	InnoPeritus
	Hernandez		Donatella Canella	Personal life coach in Zürich	
	Hernandez	Marianne Renaud			McKinsey
	Naef	Julia Cajan		Associate Consultant	Strategic Access Solutions Ltd - Stratas Partners
	Naef	Laura Symul		Data analysis & visualisation, scientific illustration	Quantum Business Intelligence Services AG (QBIS) and freelance
GutX (2014/263)	Macpherson	Geuking Markus		Assistant professor	University of Calgary
	Macpherson	McCoy Kathleen		Full professor	University of Calgary
HIVX (2014/262)	Günthard		Vongrad Valentina	temporary interruption of her scientific career (son born March 2016)	
HostPathX (2013/157)	Hilbi		Ina Haneburger	Ph.D. program coordinator	Technical University Munich
	Soldati		Sébastien Kicka	Maître Assistant	UniGE
	Soldati	Valentin Trofimov		Postdoc	UniGE
	Hilbi	Christopher Harrison		Company employee	
InfectX (2009/005)	Arrieumerlou		Christoph Kasper	Project Manager	Type 3 Technologies
	Beerenwinkel		Edgar Delgado-Eckert	Research Group Leader	University Children's Hospital - University of Basel
	Cossart	Andreas Kühbacher		Postdoc	Fraunhofer-Institut für Grenzflächen un Bioverfahrenstechnik IGB
	Cossart	Juan José Quereda Torres		Postdoc	Same lab
	Dehio		Houchaima Ben-Tekaya	Postdoc	University of Basel
	Dehio		Matthias Truttmann	Postdoc	Whitehead Institute for Biomedical research
	Dehio		Maxime Quebatte	Postdoc	University of Basel
	Dehio		Raquel Condé-Alvarez	Investigator	Institute of Tropical Health
	Dehio	Quebatte, Maxime		Postdoc	Biozentrum, Basel
	Dehio	Shyan Low		Postdoc	University of Basel
	Greber		Mark Lötzerich	Associate Staff Scientist	Hussman Institute for Autism

RTD Project	Group	PhD-student	Postdoc	New Function	Location
				Neuroimmunology	
	Greber		Nina Wolfrum	Research Associate	Tierspital Zürich
	Greber	Artur Yakimovich		Research Associate	University of Zurich
	Greber	Martin Engelke		Postdoc	University of Michigan
	Greber	Pascal Roulin		Research Associate	Same group
	Hardt		Benjamin Misselwitz	Oberarzt	Klinik für Gastroenterologie und Hepatologie USZ
	Hardt	Pascale Vonäsch		Postdoc	Institut Pasteur, Paris
	Hardt	Saskia Kreibich		Postdoc	ETH Zurich
	Helenius	Samuel Kilcher		Postdoc	LMCB-University College London
	Iber	Georgio Fengos		Postdoc	EPFL - Prof. Hatzimanikatis group
	Pelkmans		Berend Snijder	Postdoc	CeMM, Center for Molecular Medicine, Giulio Superti-Furga group
	Pelkmans		Katharina Schönrath	Datamanager, Clinical Trials	UniversitätsSpital Zürich
	Wollscheid	Andreas Frei		Postdoc	Stanford University
	Arrieumerlou		Simon Ittig	Project Leader	Type 3 Technologies
	Arrieumerlou		Veronika Reiterer	Postdoc	Biotechnology Institute Thurgau
	Beerenwinkel	Juliane Siebourg		Biostatistician	Roche
	Dehio		Pauli Rämö	Senior Solutions Consultant	Mirai Solutions GMBH
	Dehio	Truttmann, Matthias		Pensionskassenberater	Swisscanto Vorsorge AG
	Greber	Andreas Jurgeit		Lecturer	IFJ start-up essentials
	Hardt		Claudia Hoffmann	Scientific journalist	Scitec Media
	Hardt	Dilling, Sabrina		Scientist	TECAN
	Iber	Federico Felizzi		Health Economics Statistician	Roche
	von Mering	Manuel Stark		IT Quality Consultant	Roche
LipidX (2012/206)	Gruenberg		Dos Santos Aline	Postdoc	Friedrich Miescher Institute for Biomedical Research, Basel
	Hatzimanikatis	Racle Julien		Postdoc, Gfeller lab	Ludwig Center for Cancer Research of the UNIL
	Pelkmans		Liberali Prisca	Group leader	Friedrich Miescher Institute for Biomedical

RTD Project	Group	PhD-student	Postdoc	New Function	Location
					Research, Basel
	Gonzales-Gaitan	CAMPOS Claudia		Technician	Instituto Gulbenkian Ciencia (Portugal), Feijo lab
	Hatzimanikatis	Burri Olivier		Engineer	EPFL BioImaging and Optics Core Facility
	Helenius	Schmidt, Florian		Postdoc	same group
	Pelkmans	Snjder, Berend		Postdoc	same group, UniZH, Ce-M-M-, Vienna
	Soldati	Limenitakis, Julien		Postdoc	Biozentrum, Uni Basel, Bumann lab
	Hatzimanikatis	Radivojevic, Andrijana		Visiting Scientist	Novartis Pharma AG
	Pelkmans	Polzhofer, Herbert		Product manager	Medartis AG
	Sbalzarini	Helmut, Jo Arne		Quantitative financial analyst	LGT Finance (Pfäffikon SZ)
	Sbalzarini	Schrader, Birte		Scientific software engineer	Cyfex AG (Zürich)
	Riezman		Charlotte Gehin	Postdoc, Gavin Lab	European Molecular Biology Laboratory, Heidelberg
	van der Goot	Sanja Blaskovic		Postdoc	Faculty of Medicine, University of Geneva
	Riezman		Ursula Loizides-Mangold	senior researcher	Editorial Coordinator for the Journal of Hepatology (EASL)
LiverX (2008/002)	Krek	Buch, Hakon		new Phd projek	Automatic Control Lab/BISON Group, ETHZ
	Roth	Vogt, Julia		Maternity	UNI BASEL
	Stoffel	V. Meyenn, Ferdinand		Postdoc	IMHS ETH
	Bühlmann	Stekhoven, Daniel		own company	-
	Krek	Walter, Katharina		Scientific co-worker	Swissmedic Bern
MalarX (2013/155)	Hatzimanikatis		Kyparissides D.	Lecturer	University College London (UCL)
	Soldate-Favre		Graindorge Arnault	Maitre de Conference	University of Montpellier
	Soldate-Favre	Oppenheim Rebecca		Graduated PhD	UniGe
	Hopfgartner		Jahn Sandra	Lab Head	BASF, Germany
MecanX (2012/202)	Grossniklaus		Vogler Hannes	PostDoc	no change
	Grossniklaus	Lituiev Dmytro		PostDoc	University of California, San Francisco
	Herrmann	Munglani		PostDoc	no change

RTD Project	Group	PhD-student	Postdoc	New Function	Location
		Gautam			
	Nelson		Chengzhi Hu	PostDoc	no change
	Nelson		Selman Sakar Mahmut	Group Leader	Ecole Polytechnique Federale Lausanne
	Nelson	Jang Bumjin		PhD student	no change
	Nelson	Shamsudhin Naveen		PhD student	no change
	Nelson	Simone Schürle		Postdoc	MIT, ,USA
	Ringli	Ndinyanka Fabrice Tohnyui		PhD student	no change
	Nelson	Dimitris Felekis		Development Engineer	Helbling Technik AG
MERIC (2013/150)	Hall		Shimobayashi Mitsugu	Ambizione Fellow	Biozentrum, University of Basel
	Beerenwinkel		Behr Jonas	Scientist	Sophia Genetics
	Christofori		Gossen Ryan	Computational Scientist	Private Sector
MetaNetX (2009/009)	Gruissem		Katja Baerenfaller	Senior Scientist	ETH Zurich
	Gruissem		Oender Kartal	Postdoc	Univ. Zurich
	Gruissem		Sean Walsh	Staff Scientist	Univ. Freiburg
	Gruissem	Pascal Schläpfer		Postdoc	Standord University, USA
	Sauer		Hannes Link	Group Leader	MPI Marburg
	Sauer		Tobias Fuhrer	Senior Scientist	ETH Zurich
	Sauer	Luca Gerosa		Postdoc	Harvard Med School
	Gruissem	Marlen Müller		Project Manager	PolyGene AG
	Sauer		Bart Haverkorn	Senior Scientist	Private Sector
	Sauer	Dominik Heer		Scientist	Private sector (Pharma)
	Stelling		Hans-Michael Kaltenbach	Senior Scientist	Private sector (Statistics)
	Stelling	Mathias Ganter		Strategy Consultant	Private Sector
	Vital-IT		Bernard, Thomas	Independent software engineer	France
MetastasiX (2014/268)	Weber	Savas Soysal		Staff surgeon	University Hospital Basel
	Christofori	Ernesta Fagiani		Staff Scientist	NBE Therapeutics
MicroScapesX (2013/158)	Or		Ilie Olga	left ETH August 2015	
	van der Meer	Moreno Silvia		finished 2015	
	van der Meer	Sauvain Loic		abandoned	
Morphogenetix (2013/151)	Aegerter	Giulia Ghielmetti		Engineer	Geographisches Institut
	Affolter		Emmanuel Caussinus	Scientific assistent	IMLS, UniZürich
	Affolter		Oguz Kanca	Postdoc	Baylor College Houston
Neurochoice (2008/007)	Bossaerts	Anjali D. Nursimulu		Scientific Collaborator	UniL

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Bossaerts	Elise Payzan Le Nestour		Assistant Professor	Australian School of Business, Sydney
	Fehr		Christoph Eisenegger	Research Assistant	University of Cambridge
	Fehr		Kerstin Preuschoff	Research Assistant	EPFL
	Fehr		Thomas Baumgartner	Research Assistant	University of Basel
	Helmchen		David Margolis	Assistant Professor	Rutgers University, NJ, USA
	Helmchen	Benjamin Grewe		Postdoc	Stanford, CA, USA
	Lüscher	Camilla Bellone		Research Assistant	UniGE
	Lüscher	Gwenael Labouebe		PostDoc	University of British Columbia, Vancouver
	Petersen	Celine Mateo		Postdoc	UC San Diego, CA, USA
	Senn	Johannes Friedrich		PostDoc	UniBE
	Helmchen	Christoph Engelbrecht		Patent Attorney	E. Blum & Co AG, Switzerland
	Helmchen	Werner Göbel		Industry	Storz Endoscopes, Tuttlingen Germany
	Stephan	Kay Brodersen		Industry	Google, Paris
NeuroStemX (2012/194)	van Nimwegen		Berninger Philipp	Scientist	Evolva AG, Reinach, Schweiz
	Iber	Dzianis Menshykau		Scientist	Bayer
PhosphoNet PPM (2012/191)	Aebersold		Ebhardt Alex	Group leader	University College Dublin
	Wild		Fritz Christine	Molecular Diagnostic Assistant	Univ. Hospital Zurich
	Wild		Rechsteiner Markus	Lab Head	Univ. Hospital Zurich
	Wild		Zhong Qing	Computer Scientist	Univ. Hospital Zurich
	von Mering		Kahraman Abdullah	Professor	Istanbul
	Bodenmiller		Giesen Charlotte	Researcher	Roche
	von Mering		Wanka Stefanie	Scientist	Novartis
PhosphoNetX (2008/001)	Aebersold	Weisser Hendrik		Postdoc	Sanger center, Hinxton
	Pelkmans	Wippich Frank		Postdoc	EMBL
	Plückthun	Schaefer Jonas		Coordinator HT Lab.	UZH
	Vogel/Nelson		Ihalainen Teemu	Postdoc	University of Tampere
	Vogel/Nelson	Ergeneman Olgac		Postdoc	ETHZ
	Vogel/Nelson	Yalak Garif		Postdoc	Harvard, Boston
	von Mering		Schilling Sabine	second Postdoc	ETHZ / IMSB
	Plückthun	Batyuk Alexander		WM	Biochemistry

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Plückthun	Parizek Petra		Scientist	Industry
	Plückthun	Schilling Johannes		Scientist	Industry
Plant Growth (2008/004)	C. Ringli	Benjamin Kuhn		Postdoc	Energy Biosciences Institute, Berkeley
	Nelson	Simon Muntwyler		Postdoc	Institute of Robotics and Intelligent Systems, ETHZ
	Reinhardt	Flavia Ercolin		Postdoc	Biosciences Institute, Berkeley, CA
PlantGrowth 2 (2012/203)	Hardtke	Emanuele Scacchi		Postdoc	MPI Dev. Biol. Tübingen Germany
	Hardtke	Luca Santuari		Postdoc	Ben Scheres Lab, Wageningen Netherlands
	Mazza	Florence Yerly		Postdoc	Uni FR
	Fankhauser/Xenarios	Markus Kohnen		Postdoc	UniL
	Kuhlemeier		Burian Agata	group leader	Univ of Katowice
	Smith/Fankhauser	Mosca Gabriella		postdoc	MPI Köln
	Zeeman	Katharina Kölling		Postdoc	ETH Zurich
	Fankhauser		Saxena Prashant	Faculty position	India
	Kuhlemeier	Deb Yamini		severe car accident	
	Hardtke	Schmitt Marta		technician	DMF
	Hardtke		David Pacheco-Villalobos	Staff scientist	KWS Germany
	Hardtke		Sankar Martial	Staff member	Vital-IT
	Reinhardt/C. Mazza	Chrystel Feller		Postdoc	Novartis
	Smith/Fankhauser	Alain Weber		research engineer	Meyer&Burger
	Zeeman	Kölling Katharina		Postdoc	OMYA, Schweiz
	Zeeman/Gruissem	Herwig Stefan		Postdoc	Glycart Biotechnology
PrionX (2014/260)	Aguzzi		Yakushev Sergey	Head of DNA/RNA Isolation	Microsynth
SignalX (2013/156)	Aebersold		Christina Ludwig	Head of proteomics facility	Technical University Munich
	Aebersold		Vaga Stefania	postdoctoral fellow	MRC, United Kingdom
	Lygeros		Alberto Busetto	Assistant Professor	University of California, Santa Barbara
	Sauer		Zampieri Mattia	Senior postdoc	ETH Zurich
	Sauer	Laura Falter		Manager	Klinikum Basel
	Stelling		Mikael Anders Sunnaker	Postdoctroal fellow	Swiss paraplegic research
	Stelling	Ottoz Diana		postdoctoral fellow	Yale University

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Buhmann		McWilliams Brian	Research Fellow	Disney Research Zurich
	Loewith		Montana Sayas Enric M.	Assistant Editor	MDPI Barcelona
	Lygeros	Jakob Ruess		Research Fellow	IST Austria
	Lygeros	Ruess Jakob		Research Fellow	IST Austria
	Stelling		Sotiris Dimopoulos	Data Scientist	IT-Logix
StoNet (2012/195	Zavolan		Rzepiela, Andrzej	Postdoc	Biozentrum UniBas
	Becskei		Chieh Hsu	Eastern ARC Research Fellow	School of Bioscience, Uni Kent, UK
	Becskei		Marie Mi Bo Hansen	wissenschaftliche Mitarbeiterin	Clinical Trial Unit, Unispital Basel
	Becskei	Jaquet Vincent		PhD student	same lab different project
	Felix Naef		Wang Jingkui	PostDoc	IBI@EPFL
	Gatfield	Du Ngoc-Hien		PostDoc	University of Zurich (S. Brown lab)
	Matthias Lutolf		Cosson Steffen	PostDoc	University of Queensland (UQ)
	Matthias Lutolf	Sylke Höhnel		PostDoc	INNOGRANT at EPFL
	Matthias Lutolf	Tabata Yoji		PhD student	IBI@EPFL
	van Nimwegen	Lazzari Gianrocco		trainee	EPFL
	Zavolan	Gruber Andreas J.		PhD student	same lab, different project
	Matthias Lutolf	Andrea Negro		CTO - Chief Technology Officer	start-up company Morphodyne SA
	Matthias Lutolf	Okawa Yuya		Project Manager	Biotech company in Japan
	van Nimwegen	Kaiser Matthias		Product Management	marketing department of Fresenius-Kabi, Switzerland
	van Nimwegen	Luise Wolf		Industry	F. Hoffmann-La Roche Ltd
	Zavolan	Grandy William Aaron		Industry	Novartis
	Matthias Lutolf		Ranga Adrian	Research Fellow in Pathology	Brigham and Women's Hospital Pathology, Boston
SyBit (2012/210)	Csucs		Smith Kevin	Researcher / Postdoc	University of Basel
SynaptiX (2012/205)	Scheffold		Bruegger Georges	Safety engineer/scientist	SBB
	Senn	Brea Johanni		graduated as PhD at Physio UniBern	now Postdoc at EPFL
	Senn	Wiechert Martin		Postdoc	Physio UniBern
	Senn	Zhao Chang		PhD student (own Chinese grant)	Physio UniBern
SysGenetiX (2012/201)	Dermitzakis		Kilpinen Leena Helena	Lecturer	UCL, UK

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Dermitzakis	Bryois Julien		post-doc	Karolinska Inst, Sweden
TargetInfectX (2013/152)	Beerenwinkel		Szczurek Ewa	Assistant Professor	Warsaw University
	Beerenwinkel	Pejman Mohammadi		Postdoc	New York Genome Center and Columbia University
	Dehio	Low Shyan		Research Fellow	Lee Kong Chian School of Medicine - Singapore
	Zavolan		Mittal Nitish	(same lab, different project)	Universität Basel
	Zavolan	Breda Jeremy		(same lab, different project)	Universität Basel
	Zavolan	Gypas Foivos		(same lab, different project)	Universität Basel
	Zavolan	Schmidt Ralf		(same lab, different project)	Universität Basel
	Bühlmann	Drewek Anna		Consultant in Data Analytics and Modelling	PricewaterhouseCoopers
	Dehio		Schmutz Christoph	CTI Researcher and Project Manager	Therapeptix
	Dehio	Casanova Alain		Market Access Intern	Novartis
	Hardt	Andritschke Daniel		Market Access Specialist	MSD
TbX (2013/154)	Aebersold		Collins Ben	Oberassistent	ETH
	Aebersold		Olga Schubert	Postdoc	UCLA
	Aebersold		Schubert Olga	Postdoc	UCLA
	Gagneux		Coscolla Mireia	Research Scientist	Swiss TPH
	Sauer		Michael Zimmermann	Postdoc	Yale
	Aebersold	Jeppe Mouritsen		Staff Scientist	Novo Nordisk
TubeX (2012/192)	Barral		Marcin Leda	Postdoc	Edinburgh
	Barral	Bayer Mathias		Postdoc	ETH
	Barral	Wang Xuan		Postdoc	ETH
WingX (2008/003)	Affolter		Fisun Hamaratoglu	independent group leader	UniL
	Affolter	Yannick Blum		Travelling, before researcher at Imaging Core Fascility (IMCF), UniBas	UniBas
	Basler		Aegerter-Wilmsen Tinri	Postdoc	UZH, another institute
	Bergmann	Aitana Morton De Lachapelle		Postdoc	EPFL, Pierre Gönczy
	Brunner-Wollscheid	Thomas Bock		Postdoc	EMBL Heidelberg, Borg/Beck group
	Hafen	Mojca Adlesic		Researcher	UZH

RTD Project	Group	PhD-student	Postdoc	New Function	Location
	Sbalzarini	Rajesh Ramaswamy		Postdoc	MPI-PKS Dresden, Germany
	Basler	Herr Patrick		Postdoc	SciLifeLab, Stockholm, Sweden
	Affolter	Alex Weiss		postdoc	
	Basler		Hödl Martina	Postdoc	Denmark
	Hafen	Mirjam Balbi		Surfing Teacher	Bali
	Koumoutsakos	Basil Bayati		Works for Bill & Melinda Gates Foundation	Bill & Melinda Gates Foundation
	Sbalzarini	Ferit Büyükkeçeci		Officer	Turkish Army
YeastX (2008/006)	Buhmann	Busetto Alberto Giovanni		Postdoc	ETHZ
	Buhmann	Fuchs Thomas		Postdoc	Caltech
	Hall		Robitaille Aaron	Postdoc	Univ. of Washington, Seattle
	Hall		Soulard Alexandre	Postdoc	Villeurbanne
	Lygeros		Debasish Chatterjee	Professor	IIT Bombay
	Lygeros	Andreas Millias Argeitis		Postdoc	ETHZ
	Lygeros	Sean Summers		Postdoc	ETHZ
	Sauer	Ewald Jennifer		Postdoc	Stanford
	Sauer	Fendt Sarah Maria		PI	KU Leuween
	von Mering	Matias Rodrigues Joâo		Postdoc	Uni Zurich
	Wagner		Hyden Eric	Prof	IIT Madras
	Wagner		López Adrián	Postdoc	Institute for Systems Biology
	Wagner		Raman Karthik	Prof	Uni Boise
	Heinemann	Volkmer Benjamin		Teacher	Not known
	Sauer	Schnidder Julian		Consultant	Basel
	Heinemann	Christen Stefan		Postdoc	Jobsearch
	Aebersold		Jünger Martin	Scientist	Company
	Aebersold		Schiess Ralph	Scientist	Own Company ProteoMedix
	Buhmann	Patrick Pletscher		Machine learning scientist	Amazon
	Hall	Cremonesi Alessio		Postdoc	ThermoFisher
	Sauer		Jozefcuk Syzmon	Scientist	Lonza
	Sauer	Begemann Boris Niklaus		IT Specialist	Private Company
	Wagner / Stelling		Elias Zamora Sillero	Head of Research	GET Capital AG
	Lygeros		Eugenio Cinqueman	Researcher	INRIA

Scientific Impact

List A1: Top 25 SystemsX.ch acknowledged publications

1. Wu Y, Williams EG, Dubuis S, Mottis A, Jovaisaite V, Houten SM, Argmann CA, Faridi P, Wolski W, Kutalik Z, Zamboni N, Auwerx J, Aebersold R. (2014), *Multilayered genetic and omics dissection of mitochondrial activity in a mouse reference population.* **Cell 158 (6),** 1415-1430, 10.1016/j.cell.2014.07.039, *AgingX*
2. Marbach D, Lamparter D, Quon G, Kellis M, Kutalik Z, Bergmann S. (2016), *Tissue-specific regulatory circuits reveal variable modular perturbations across complex diseases.* **Nature Methods 13 (4),** 366-370, 10.1038/nmeth.3799, *AgingX*
3. Claudi B, Spröte P, Chirkova A, Personnic N, Zankl J, Schürmann N, Schmidt A, Bumann D. (2014), *Phenotypic variation of Salmonella in host tissues delays eradication by antimicrobial chemotherapy.* **Cell 158 (4),** 722-733, 10.1016/j.cell.2014.06.045, *BattleX*
4. Kentner D, Martano G, Callon M, Chiquet P, Brodmann M, Burton O, Wahlander A, Nanni P, Delmotte N, Grossmann J, Limenitakis J, Schlapbach R, Kiefer P, Vorholt JA, Hiller S, Bumann D. (2014), Shigella reroutes host cell central metabolism to obtain high-flux nutrient supply for vigorous intracellular growth. **Proceedings of the National Academy of Science of the United States of America 111 (27),** 9929-9934, 10.1073/pnas.1406694111, *BattleX*
5. Mercer J, Snijder B, Sacher R, Burkard C, Bleck CK, Stahlberg H, Pelkmans L, Helenius A. (2012), *RNAi Screening Reveals Proteasome- and Cullin3-Dependent Stages in Vaccinia Virus Infection,* **Cell Reports 2(4),** 1036-1047, https://doi.org/10.1016/j.celrep.2012.09.003, *CINA*
6. Rajkumar AS, Dénervaud N, Maerkl SJ. (2013), *Mapping the fine structure of a eukaryotic promoter input-output function.,* **nature genetics 45 (10)**, 1207-15, 10.1038/ng.2729, *DynamiX*
7. Gomez de Agüero, Mercedes, Ganal-Vonarburg, Stephanie C., Fuhrer, Tobias, Rupp, Sandra, Uchimura, Yasuhiro, Li, Hai, Steinert, Anna, Heikenwälder, Mathias F., Hapfelmeier, Siegfried, Sau (2016), *The maternal microbiota drives early postnatal innate immune development.* **Science 351 (6279),** 1296-1302, 10.1126/science.aad2571, *GutX*
8. Kreibich S, Emmenlauer M, Fredlund J, Rämö P, Münz C, Dehio C, Enninga J, Hardt WD.(2015), *Autophagy Proteins Promote Repair of Endosomal Membranes Damaged by the Salmonella Type Three Secretion System 1.* **Cell Host Microbe 18 (5),** 527-537, 10.1016/j.chom.2015.10.015*, InfectX, TarfectInfectX*
9. Scott CC, Vossio S, Vacca F, Snijder B, Larios J, Schaad O, Guex N, Kuznetsov D, Martin O, Chambon M, Turcatti G, Pelkmans L, Gruenberg J.(2015), *Wnt directs the endosomal flux of LDL-derived cholesterol and lipid droplet homeostasis. EMBO reports.* **EMBO reports 16 (6),** 741-752, 10.15252/embr.201540081, *LipidX*
10. Sévin DC, Sauer U, (2014), *Ubiquinone accumulation improves osmotic-stress tolerance in Escherichia coli.* **Nature chemical biology 10 (4),** 266-272, 10.1038/nchembio.1437, *MetaNetX, TbX, LiverX, GutX*
11. Stadler MB1, Murr R, Burger L, Ivanek R, Lienert F, Schöler A, van Nimwegen E, Wirbelauer C, Oakeley EJ, Gaidatzis D, Tiwari VK, Schübeler D. (2011), *DNA-binding factors shape the mouse methylome at distal regulatory regions.* **Nature 480 (7378)**, 490-495, 10.1038/nature10716, *MetastasiX, Cell Plasticity*
12. Battich N, Stoeger T, Pelkmans L. (2015), *Control of Transcript Variability in Single Mammalian Cells.* **Cell. 163 (7)**, 1569-610, 10.1016/j.cell.2015.11.018, *PhosphoNetX, PhosphoNetPPM, InfectX, LipidX (2x), PrionX, MorphogenetiX*
13. Berend Snijder, Raphael Sacher, Pauli Rämö, Eva-Maria Damm, Prisca Liberali & Lucas Pelkmans (2009), *Population context determines cell-to-cell variability in endocytosis and virus infection*, **Nature 461**, 520-523, 10.1038/nature08282, *PhosphoNetX, PhosphoNetPPM, InfectX, LipidX (2x), PrionX, MorphogenetiX*
14. Bieler J, Cannavo R, Gustafson K, Gobet C, Gatfield D, Naef F. (2014), *Robust synchronization of coupled circadian and cell cycle oscillators in single mammalian cells*, **Molecular System Biology 10 (7)**, 739 10.15252/msb.20145218, *StoNets*

15. Hausser J, Syed AP, Selevsek N, van Nimwegen E, Jaskiewicz L, Aebersold R, Zavolan M. (2013) *Timescales and bottlenecks in miRNA-dependent gene regulation.* **Molecular Systems Biology 9 (711)**, 10.1038/msb.2013.68, *StoNets*
16. Kierzkowski D, Nakayama N, Routier-Kierzkowska AL, Weber A, Bayer E, Schorderet M, Reinhardt D, Kuhlemeier C, Smith RS. (2012) *Elastic domains regulate growth and organogenesis in the plant shoot apical meristem.* **Science 335 (6072)**, 1096-1099, http://dx.doi.org/10.1126/science.1213100, *Plant Growth 1 & 2*
17. Mathieu Frechin, Thomas Stoeger, Stephan Daetwyler, Charlotte Gehin, Nico Battich, Lilli Stergiou, Eva-Maria Damm, Howard Riezman & Lucas Pelkmans (2015) *Cell-intrinsic adaptation of lipid composition to local crowding drives social behavior*, **Nature 523**, 88-91, 10.1038/nature14429, *PhosphoNetX, PhosphoNetPPM, InfectX, LipidX (2x), PrionX, MorphogenetiX*
18. Ngoc-Hien Du, Alaaddin Bulak Arpat, Mara De Matos, David Gatfield (2014), *MicroRNAs shape circadian hepatic gene expression on a transcriptome-wide scale*, **eLife, 3:e02510**, 10.7554/eLife.02510, *StoNets*
19. Oliveira AP, Dimopoulos S, Busetto AG, Christen S, Dechant R, Falter L, Haghir Chehreghani M, Jozefczuk S, Ludwig C, Rudroff F, Schulz JC, González A, Soulard A, Stracka D, Aebersold R, Buhmann JM, Hall MN, Peter M, Sauer U, Stelling J (2015), *Inferring causal metabolic signals that regulate the dynamic TORC1-dependent transcriptome.* **Molecular systems biology 11 (4)** , 10.15252/msb.20145475., *YeastX, SignalX*
20. Pasakarnis L, Frei E, Caussinus E, Affolter M, Brunner D. (2016), *Amnioserosa cell constriction but not epidermal actin cable tension autonomously drives dorsal closure.* **Nature Cell Biology 18 (11)**, 1161-1172 ,10.1038/ncb3420, *MorphogenetiX*
21. Picotti P, Clément-Ziza M, Lam H, Campbell DS, Schmidt A, Deutsch EW, Röst H, Sun Z, Rinner O, Reiter L, Shen Q, Michaelson JJ, Frei A, Alberti S, Kusebauch U, Wollscheid B, Moritz RL, Beyer A, Aebersold R. (2013), *A complete mass-spectrometric map of the yeast proteome applied to quantitative tranalysis.* **Nature, 494(7436)**, 266-270, *PhosphonetPPM*
22. Pierre Barbier de Reuille Anne-Lise Routier-Kierzkowska Daniel Kierzkowski George W Bassel Thierry Schüpbach Gerardo Tauriello Namrata Bajpai Sören Strauss Alain Weber Annamaria Kiss Agata Burian Hugo Hofhuis Aleksandra Sapala Marcin Lipowczan Maria B Heimlicher Sarah Robinson Emmanuelle M Bayer Konrad Basler Petros Koumoutsakos Adrienne HK Roeder Tinri Aegerter-Wilmsen Naomi Nakayama Miltos Tsiantis Angela Hay Dorota Kwiatkowska Ioannis Xenarios Cris Kuhlemeier Richard S Smith (2015) *MorphoGraphX: A platform for quantifying morphogenesis in 4D*, **eLife 2015;4:e05864**, http://dx.doi.org/10.7554/eLife.05864, *Plant Growth 1&2*
23. Robitaille AM, Christen S, Shimobayashi M, Cornu M, Fava LL, Moes S, Prescianotto-Baschong C, Sauer U, Jenoe P, Hall MN. (2013). *Quantitative phosphoproteomics reveal mTORC1 activates de novo pyrimidine synthesis.* **Science 339 (6125)**, 1320-2310, 1126/science.1228771, *YeastX, SignalX*
24. Simicevic J, Schmid AW, Gilardoni PA, Zoller B, Raghav SK, Krier I, Gubelmann C, Lisacek F, Naef F, Moniatte M, Deplancke B. (2013), *Absolute quantification of transcription factors during cellular differentiation using multiplexed targeted proteomics*. **Nature Methods 10 (6)**, 570-576, doi: 10.1038/nmeth.2441, *CycliX*
25. Stefan Harmansa, Fisun Hamaratoglu, Markus Affolter, Emmanuel Caussinus (2015), *Dpp spreading is required for medial but not for lateral wing disc growth,* **Nature 527**, 317-322, 10.1038/nature15712, Morphogenetix, *WingX*

Table A14: ERC grants awarded to SystemsX.ch researchers 2007-2016

Year	Grant type	Scientists
2007	**ERC Starting Grant**	Christian Wolfrum, Melody Swartz, Dirk Schübeler, Petra Dittrich, Robbie Loewith
2008	**ERC Advanced Grant**	Pierre Gönczy, Konrad Basler, Viola Vogel, Jeffrey Hubbell, Rudolf Aebersold, Marcos Gonzalez Gaitan, Johan Auwerx, Denis Duboule, Ari Helenius
2009	**ERC Advanced Grant**	Yves Barral, Stylianos Antonarakis, Antonio Lanzavecchia, Ulrich Grossniklaus, Adriano Aguzzi, Laurent Keller, Ulrich Schibler
	ERC Starting Grant	Mohamed Bentires-Alj, Christian Von Mering
2010	**ERC Advanced Grant**	Bradley James Nelson, Michael Unser, Bernard Thorens, Didier Trono, Wulfram Gerstner, Andreas Hierlemann, Andreas Plückthun, Sebastian Bonhoeffer, Matthias Peter
	ERC Starting Grant	Botond Roska, Felix Naef, Roland Sigel, Emmanouil Dermitzakis, Aleksandra Radenovic
2011	**ERC Advanced Grant**	Ernst Fehr, Carl Christian Holger Petersen
	ERC Starting Grant	Kathleen Mccoy
2012	**ERC Advanced Grant**	Douglas Hanahan, Melody Swartz, Martinus Adela Maria Gijs, Christian Lüscher, Dani Or
	ERC Starting Grant	Govindkrishna Govind Kaigala, Sebastien Gagneux, Aurelien Roux, Simon Sprecher, Rainer Andreas Krause, Matthias Lutolf, Mihaela Zavolan
2013	**ERC Advanced Grant**	Pascale Cossart, Pierre Gönczy, Jeffrey Alan Hubbell, Christoph Dehio, Petros Koumoutsakos, Marcos Gonzalez Gaitan, Gisou Van Der Goot
	ERC Starting Grant	Tanja Stadler, Dietmar Zehn, Paola Picotti, Bernd Bodenmiller, Savas Tay
	ERC Synergy Grant	"Mechanisms of Evasive Resistance in Cancer" (MERiC). Michael Hall, Gerhard Christofori, Markus Heim, and Niko Beerenwinkel. This grant application was based on the running RTD MERIC, and enabled the consortium to scale up their plans (increased number of patient samples, recruitment of patients from other Swiss cancer centers)
	ERC Consolidator Grant	Christoph Handschin, Robbie Loewith
2014		Switzerland was not eligible to apply for ERC Grants
2015	**ERC Advanced Grants**	Andreas Hierlemann, Peter Scheiffele, Rolf Zeller, Dominique Soldati-Favre, Mohamed Bentires-Alj, Antoine Peters, Bernard Thorens, Didier Trono
	ERC Starting Grant	Martin Müller
	ERC Consolidator Grant	Petra Dittrich

SystemsX.ch Consortium Report

SystemsX.ch
The Swiss Initiative in Systems Biology

APPENDIX B

Bibliometric evaluation of the SystemsX.ch initiative: performance, benchmark and collaboration analysis

March 2017

CWTS B.V.
Centre for Science and Technology Studies,
Leiden University

CWTS Meaningful metrics

CWTS BIBLIOMETRIC REPORT

Bibliometric evaluation of the SystemsX.ch initiative: performance, benchmark and collaboration analysis

March 2017

Universiteit Leiden

date
CWTS B.V.
Centre for Science and
Technology Studies,
Leiden University

Bibliometric evaluation of the SystemsX.ch initiative: performance, benchmark and collaboration analysis

Report for SystemsX.ch, the Swiss Initiative in Systems Biology

Project team

Ed Noyons, *Project leader*

CWTS B.V.
P.O. Box 905
2300 AX Leiden, The Netherlands
Tel. +31 71 527 3909
Fax +31 71 527 3911
E-mail info@cwts.nl

date
CWTS B.V.
Centre for Science and
Technology Studies,
Leiden University

Table of contents

date
CWTS B.V.
Centre for Science and
Technology Studies,
Leiden University

Executive summary

An extensive bibliometrics study was executed to monitor the potential effect of SystemsX.ch funding. SystemsX.ch is a funding initiative in the area of systems biology. The report focuses on the entire initiative as well as on 5 specific projects within. In the report we provide statistics on production (publication output), impact as measured by citations, interdisciplinarity and collaboration as measured by co-authorships. In such analysis we use the world as benchmark. In this case we also defined ad hoc benchmarks to position in more detail the impact.

In total we analyzed more than 1200 publications acknowledging StystemsX.ch from 2008 onwards. These publications have a high citation impact normalized by field and year, not only as compared to the world but also much higher than the defined benchmarks (UK and Germany). Moreover, SystemsX.ch researchers managed to get their work published in high impact journals. This means that at least that SystemsX.ch was able to select high impact researchers. We cannot claim that this impact is *due* to the funding. Regarding collaboration, however, we do see a positive effect of the funding. The funded researchers not only publish more as from 2008 onwards, but also their mutual collaboration increased, as measured by co-authorships. Moreover, we found that the increased collaboration does not only involve the funded publications. They increased their collaboration measured in all their output. This indicates an impact of SystemsX.ch beyond the directly funded research. Finally, we did not find any evidence of an increased interdisciplinary character of research funded by SystemsX. It seems that this remains at a similar level throughout 2000-2015.

1. Introduction

SystemsX.ch is a public research initiative in Switzerland focusing on a broad topical area of basic research[1]. The initiative advances systems biology in Switzerland with the aim of positioning Switzerland among the world leaders in this area of research.

The work of the initiative as a whole, as well as that of the individual research projects, is monitored by the Swiss National Science Foundation (SNSF). This report entails a robust bibliometric analysis to measure its impact.

The two key statements which need to be answered in the impact analysis are:

1. SystemsX.ch has funded interdisciplinary research projects that had a high impact output
    - Interdisciplinarity of research consortia should be shown
    - Impact of research/publications to be shown rather than pure absolute numbers of publications
2. SystemsX.ch systematically initiated and funded interdisciplinary, inter-institutional research collaborations between the partner institutions
    - New collaborations between partner institutions/research groups
    - Interdisciplinarity of research consortia

This report provides the results of a sophisticated bibliometric analysis that supports the two key statements.

This study uses standard bibliometric performance analyses to measure output and impact of research funded by the SystemsX.ch initiative. As the positioning of this research as compared to similar initiatives is difficult, if not impossible, we developed a way to benchmark the performance.

[1] Information on the initiative is available at systemsx.ch.

2. Data and Method

Data

The evaluation study regards the output of SystemsX.ch as a whole and of 5 projects within: InfectX/ TargetInfectX, LipidX 1&2, NeuroChoice, PhosphoNetX/ PhosphoNetPPM and PlantGrowth 1&2.

In the bibliometric evaluation we analyze publications within the context of Web of Science (WoS, the core collection). CWTS has developed an enhanced version of WoS for bibliometric purposes.

Publications for SystemsX.ch and the 5 projects were collected in 2 steps:

1. A list of publications was compiled by SystemsX.ch for the 5 projects and sent to CWTS. These publications were already linked to Web of Science data through a publication identifier.
2. CWTS collected publications by using the acknowledgement information in WoS. If possible publications were assigned to one of the five projects. If only a reference to SystemsX.ch was mentioned, the publication was added to the overall set.

The process yielded the following numbers of publications, as listed in the table below (Table 1).

Table 1 Numbers of publications collected for SystemsX.ch and 5 projects

Actor	# WoS pubs
SystemsX.ch	*1254*
InfectX/TargetiInfectX	54
LipidX 1&2	175
NeuroChoice	82
PhosphoNetX/PhosphoNetPPM	58
PlantGrowth 1&2	100

The distribution of number for the entire SystemsX.ch is in Table 2. The overview shows that in 2008, which was the starting year of the initiative, the number is rather low. This is caused by the early stage of the initiative but also by the fact that

in WoS only since 2009 acknowledgements were processed. For that year we were not able to collect data besides the ones provided by SystemsX.ch. Therefor it should be noted that the analysis may not be covering the entire output of SystemsX.ch. The number in 2016 is not complete as we had to limit the results to the ones processed until the third quarter WoS update. For the performance analysis as well as for the benchmark analysis we do not consider the 2016 publications at all. For citation analysis we require a full year of citations in order to be included. For the benchmark analysis we used the publication classification (See Annex D) which covers 2000-2015.

For the performance (citation) analysis we consider articles, letters and reviews only, c.f., citable publications. For SystemsX.ch we analyzed 1143 publications (2008-2015).

Table 2 Distribution of publications of years identified for SystemsX.ch

Pub Year	# WoS pubs
2008	30
2009	82
2010	125
2011	176
2012	210
2013	184
2014	159
2015	190
2016	98

Methods

In this section we discuss the methods used for each type of analysis: performance measurement, benchmarking and collaboration networks

Performance

The first analysis involves a standard performance analysis of (citable) publications. In this analysis we measure output and impact using the CWTS standard indicators (See Annex A). We thus characterize output in terms of volume as well as collaboration type (proportion involving (inter)national collaboration and collaboration involving Industry). Moreover we characterize the output by means of

the impact of the journal (MNJS). Furthermore, we measure impact of output by means of absolute numbers of citations as well as by citations normalized by field. More details about the method in Annex A. In addition we performed for all actors a trend analysis of their impact (MNCS) accompanied by stability intervals. The stability intervals are calculated using a bootstrap method ([ref]) and provide some idea of the stability we found for the measures in the publication sets at stake. In general, if the number of publications is low the stability tends be low and the other way around. The results of this trend stability analysis is Annex C.

Research profile

In order to characterize the performance in more detail, we create a research profile of SystemsX.ch. Publications are distributed over the 250 WoS subject categories, through the journals in which they are published. For each subject category we calculated the average normalized impact (MNCS, PP[top10]) and added that information to the overview of largest subject categories. If a journal is assigned to more than one category, a SystemsX.ch paper (and impact) is fractionalized over the categories accordingly.

Interdisciplinarity

Measuring interdisciplinarity is a challenge because there are probably as many definitions as there are disciplines in science. Not only is it difficult to properly define and measure interdisciplinarity, there are no world standards to define above average interdiscplinarity or the like. Therefore, we confine ourselves to measure the development of the interdisciplinarity of SystemsX.ch funded research output.

The definition of interdisciplinarity is based on the assumption that references at the end of a publication represents the content and knowledge base. We define interdisciplinarity as the measure in which research output refers to (cites) other fields of science. Moreover, we will take the cognitive distance between the publication and the cited fields into account. Citing a field that is cognitively distant shows more interdisciplinarity than citing a field nearby. We operationalized fields and their cognitive distance at two levels of the CWTS classification system (c.f., Annex D; top level of 27 clusters and intermediate level of around 800 clusters) and measured the interdisciplinarity of the individual years from 2008 to 2015.

Benchmarks

The data collection for the benchmark analysis is more complicated and arbitrary choice had to be made. However during the testing of thresholds to apply, we monitored the results on sensitivity.

The method to benchmark the SystemsX.ch results comprised the following steps. The output of SystemsX.ch was distributed over the more than 4000 publication clusters of the CWTS publication classification. The output of SystemsX.ch appeared in 274 clusters. The best populated clusters were used to define the field to which (the output of) SystemsX.ch belongs. In the field defined as such, we collected the output of the UK, Germany and Switzerland. The output with at least one affiliation from the UK and from Germany was used as benchmarks.

The selection of clusters to be used to define the 'SystemsX.ch field is challenging. The distribution of SystemsX.ch publications over clusters is such that using all 274 clusters would be far too broad, whereas using only the top cluster (including 118 SystemsX.ch publications) would be far too narrow and representing only 10% of the SystemsX.ch output. In order to study the effect of adding clusters to the field definition we applied the following indicators:

- Proportion of SystemsX.ch output represented
- Ratio SystemsX.ch output and output in Switzerland (in field definition)
- Ratio SystemsX.ch output and Germany output (in field)
- Ratio SystemsX.ch output and UK output (in field)

An overview of the indicators is depicted in the diagram below (Figure 1).

The chart shows the development of ratios if the threshold of SystemsX.ch publications populating a cluster from the classification is increased or decreased. For example, if the threshold is set to 10, over 50% of the total SystemsX.ch output is represented (Purple line), and the output of SystemsX.ch is 13% of the total Swiss output (Blue line) and 4% of the UK (Green)) or German (Red) output. If the threshold is set to 5, the representation of SystemsX.ch increases to almost 70%, at the expense of representation of 8% Swiss output, and only 3% of the German or UK output.

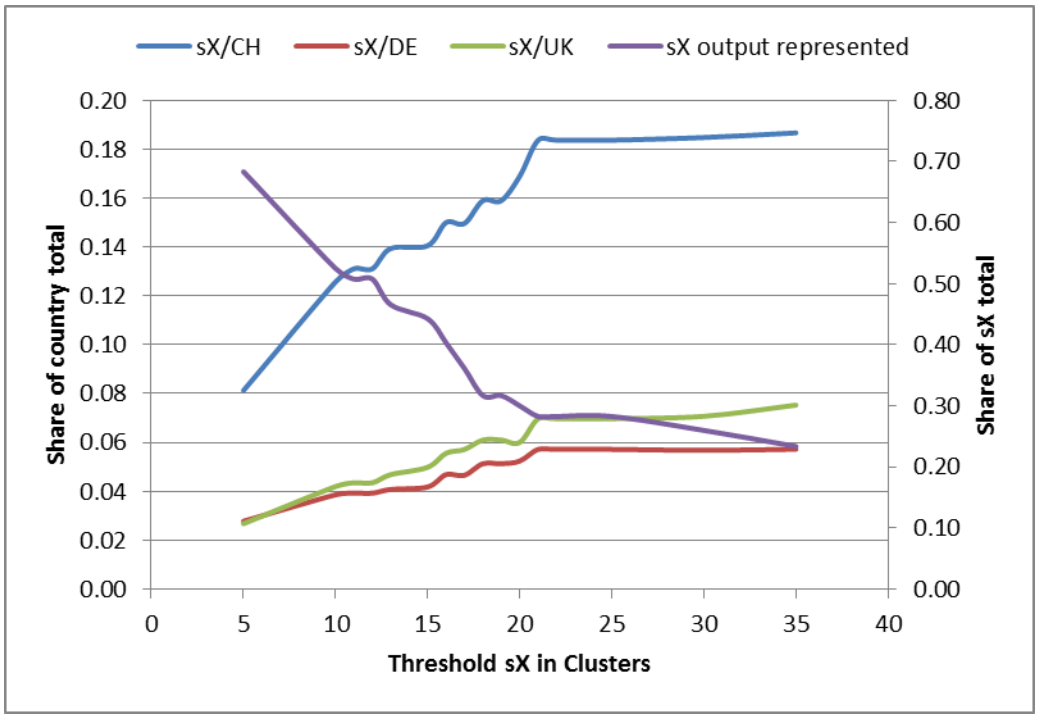


Figure 1 Effects of thresholds to define 'SystemsX.ch field'

The three indicators were used in the following way to decide upon a threshold. First of all a substantial part of SystemsX.ch output should be represented. We chose a threshold that would represent at least 50%. Subsequently we look at the ratio SystemsX.ch output and the output of Switzerland, Germany and the UK. If we increase the threshold, the 'home advantage' of SystemsX.ch will be bigger. In order to make a fair comparison the field should not be too biased. Compared to the overall output of Switzerland, the share is over 70% if the threshold is higher than 20. We noticed that if we the threshold is higher than 20, the ration SystemsX.ch as compared to UK, Germany and Switzerland countries increases substantially. We consider this a sign of data becoming more biased towards SystemsX.ch. All these findings considering, we chose a threshold of 12. This means that 24 clusters will define the SystemsX.ch field covering almost 135,000 publications in entire Switzerland in 2008-2015. More details about the selected clusters can be found in Annex D.

Within the definition of the field, we collected publications from Germany and the UK to serve as benchmarks.

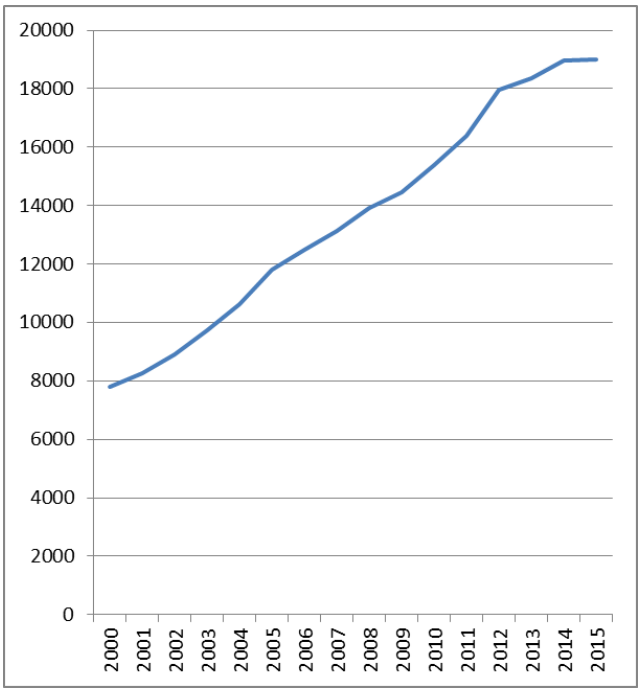
Collaboration networks

Co-author Network analyses provide insight into the collaboration patterns of actors at stake. The challenge with such analysis is the interpretation of results. There are no actual benchmarks or references to assess the network. However, we do have a list of actors (organizations, institutions) involved in SystemsX.ch and hence are able to compare the results since the initiative started with the period before. The problem is that the actors involved are in our data only available at main organization level, in other words: the universities and research organization at the top level, not at the faculty or institutional level. For that reason, a 'SystemsX.ch field' delineation is necessary to monitor co-authoring before 2008, taking only relevant publications into account. The definition of this field is the same as for identifying benchmarks. The number of publications considered in 2000-2015 is around 217,000.

In addition to the analysis on the level of organizations we conducted an analysis on a much lower level. For a selection of principle investigators (PI's) with SystemsX.ch funding (in the mentioned 5 projects) we investigated collaboration in terms of co-authorships. For these PI's we collected their full oeuvre 2000-2015 and analyzed their network over time.

Table 3 Output per year for the 'SystemsX.ch field', 2000-2015

Pub year	# pubs
2000	7,801
2001	8,279
2002	8,898
2003	9,737
2004	10,633
2005	11,813
2006	12,472
2007	13,127
2008	13,919
2009	14,452
2010	15,404
2011	16,405
2012	17,977
2013	18,364
2014	18,964
2015	18,995



We detected a steady growth throughout the entire period. In absolute numbers the collaboration is expected to increase at a similar pace. We will use the total numbers in 2000-2007 and in 2008-2015 to normalize the statistics on collaboration. The networks were visualized with VOSviewer (www.vosviewer.com).

Results

In this section we will describe the results for each of the three analyses and relate them to each other if possible or appropriate.

Performance

The research performance of SystemsX.ch and its five projects are in the table below.

Table 4 Performance statistics of SystemsX.ch and 5 projects

Unit	P	MNJS	TCS	MCS	MNCS	PP (top10)	PP UIC	PP collab	PP Intl collab
SystemsX.ch	1,143	2.14	24,432	21.37	2.35	0.32	0.04	0.75	0.55
InfectX	54	2.39	2,342	43.37	4.53	0.37	0.09	0.76	0.46
LipidX	165	2.28	3,865	23.42	2.38	0.34	0.01	0.65	0.53
NeuroChoice	81	2.24	2,420	29.88	2.74	0.43	0.00	0.80	0.78
PhosphoNetX	52	4.29	2,959	56.63	5.07	0.63	0.08	0.87	0.66
PlantGrowth	93	1.70	1,736	18.67	1.89	0.28	0.02	0.82	0.61

The output analysis shows that in all projects and in SystemsX.ch in general researchers get their results published in high impact journals. The MNJS ranges from high (70% above world average) to very high (more than four times world average). Particularly the MNJS of SystemsX.ch overall is worth mentioning because even with more than 1100 publications the MNJS is more than two times world average. The impact of journals in which authors with SystemsX.ch funding managed to get their research published (MNJS) shows al slight decrease until 2011 (stabilizing at 2, Figure 2) which is often observed when the amount of output increases.

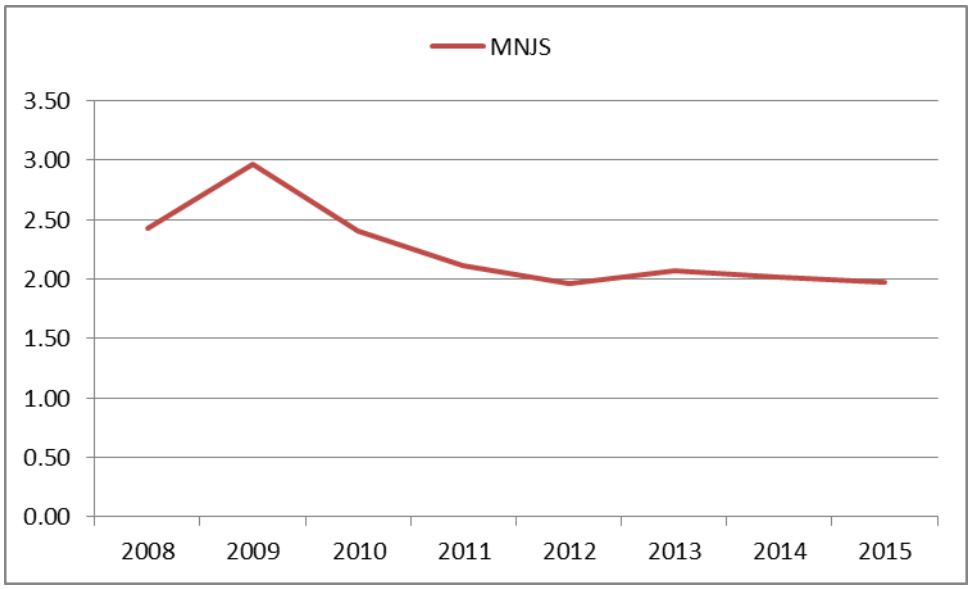


Figure 2 Development of impact of journals published in (MNJS, 2008-2015)

Furthermore, 65%-87% of the publications involve collaboration, while 45% to even 78% involves international collaboration.

The impact of the studied units is high. In all 6 case the impact as measured by MNCS is at least 90% above world average. And in two cases even four and five times world average. In the case of the entire SystemsX.ch it is more than two times world average. The proportion of top 10% most highly cited publications indicator (PPtop10), which is not sensitive for outliers, is an alternative measure for impact and shows basically the same picture. SystemsX.ch has 32% of its publications in the top 10% which is even more than three time the expected 10%.

Finally we listed the ten academic organizations citing most often SystemsX.ch funded publications over the entire period. The result is in the table below.

Table 5 Top ten organizations citing SystemsX.ch funded publications

Organization	# Cits
Harvard University	879
Max Planck Society	834
Centre National de la Recherche Scientifique	603
National Institutes of Health	582
Chinese Academy of Sciences	582
University of Toronto	431
University College London	411
University of Cambridge	409
Massachusetts Institute of Technology	397
ETH Zurich	377

Research profile

To characterize the output and impact in more detail, we calculated them by WoS subject category. The results are in the table below.

Table 6 Research profile SystemsX.ch (output & impact 2008-2015)

Category	P	MNCS	PP[top10]
MULTIDISCIPL SC	162	2.98	0.40
BIOCHEM&MOL BIOL	156	3.25	0.39
CELL BIOLOGY	134	2.67	0.43
BIOCHEM RES METH	108	2.48	0.31
NEUROSCIENCES	58	2.89	0.45
PLANT SCIENCES	49	1.75	0.18
GENETICS&HEREDIT	46	2.17	0.30
BIOTECH&APPL MIC	41	1.79	0.25
MATH&COMPUT BIOL	38	1.10	0.12
MICROBIOLOGY	37	3.02	0.39
DEVELOPMENT BIOL	32	1.62	0.29

The top 11 largest categories show the most relevant areas for SystemsX.ch funded research with their impact (all 11 have more than 30 publications in 2008-2015). **The largest category is multidisciplinary sciences, which means that most papers are published in journals such as PLOS, PNAS and Nature.** These are obviously also the journals in which high impact is achieved. Actually in all 4 largest categories the MNCS is very high (2-3 times world average). In addition, we observe Neurosciences and microbiology as high impact categories but in these categories the output is much lower than in the top 4.

Interdisciplinarity

The measure of interdisciplinarity of SystemsX.ch funded output is measured from year to year. We applied two structures of science as a kind of sensitivity analysis. We observe a rather stable measure over the years in both ways of measurement. We may see a slight increase from 2009 onwards, particularly if we use the high level structure (Blue line). However, the differences between years are very small.

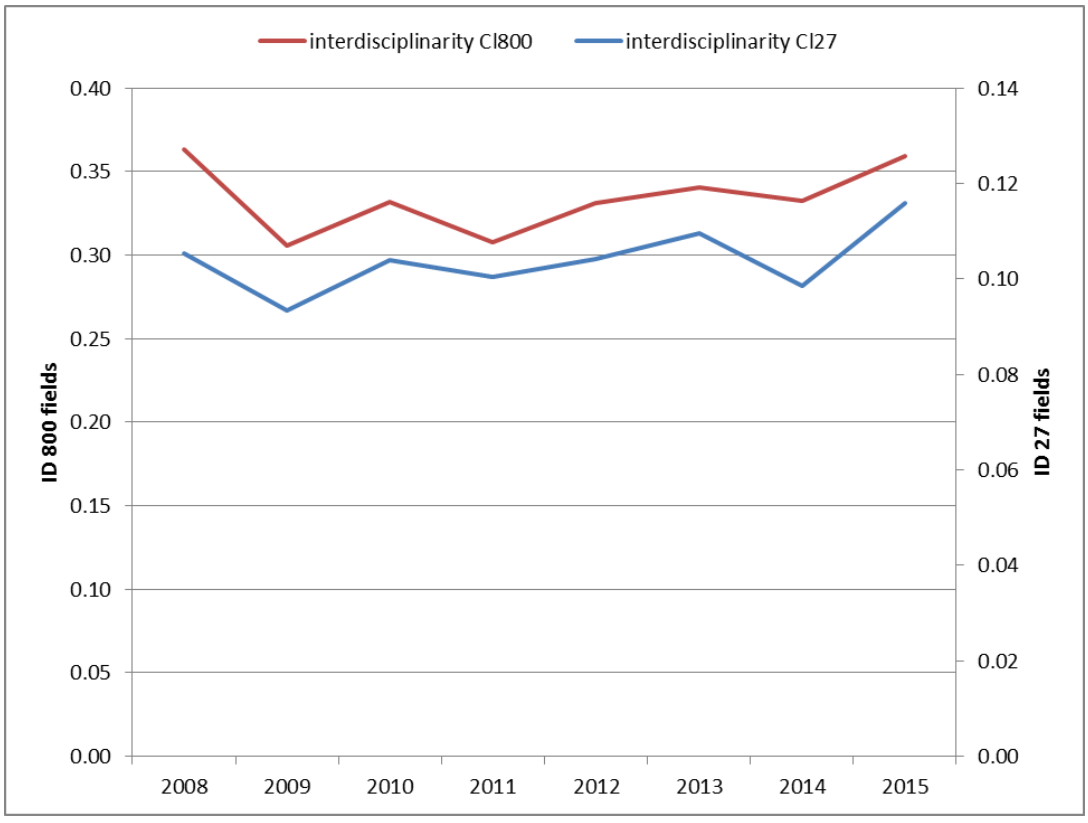


Figure 3 Development interdisciplinarity of SystemsX.ch funded output (2008-2015)

Benchmarks

Within the research field defined as 'SystemsX.ch field', we collected data from UK, Germany as well as for Switzerland and SystemsX.ch. This means that in this analysis we do not consider the entire SystemsX.ch output but only a representative subset. The results of this analysis is in the table below.

Table 7 Performance (output & impact) for SystemsX.ch and benchmarks

Unit	P	MNJS	TCS	MCS	MNCS	PP (top10)	PP collab	PP Intl collab
SystemsX.ch (BM selection)	580	2.13	14,293	24.63	2.48	0.31	0.77	0.59
Germany	14,781	1.15	183,562	12.42	1.20	0.13	0.74	0.54
United Kingdom	13,338	1.27	193,706	14.52	1.38	0.15	0.72	0.61
Switzerland	4,424	1.52	76,519	17.29	1.76	0.20	0.80	0.68

First of all, we see that the subset of SystemsX.ch output, covering around 50%, is representative for the entire set. The MNJS, MNCS as well as PPtop10 are almost equal as measured by the entire SystemsX.ch set. This is also the case for the proportion of publications involving national and international collaboration.

Then, if we compare these results to the selected benchmarks Germany and the UK, we see large differences of output of course. This should be noted interpreting the results. Higher impact scores are 'more easily' reached with smaller number of publications. Still it is clear that the impact of SystemsX.ch (MNCS and PPtop10) is much higher, even twice the measure. Meanwhile the proportion of publications involving collaboration and international collaboration are a similar level. **Furthermore, the impact of journals (MNJS) in which SystemsX.ch publishes is substantially higher.**

To estimate the impact scores considering the large differences in output, we took Switzerland as a whole into consideration. The output is then still not as large as the UK and Germany but eight times the output of SystemsX.ch. Still the impact is considerably higher. We assume that the impact of SystemsX.ch is for a great deal responsible.

Collaboration networks

Main organizations

As indicated in the method section, the numbers of publications increased at a steady pace from around 8,000 in 2000 to almost 19,000 in 2015. For the network analysis we selected a set of author affiliations (institutes/ organizations) to be included. These institutes should at least have 8 publications in the entire period within the fields as defined by SystemsX.ch research.

The proportion of publications involving collaboration by these institutes is stable over the 15 years. The set we analyzed for collaboration patterns covers around 25% of the number of publications in each year. The number of institutes involved in the network analysis is stable at around 50 over the years. In that sense we cannot say that the network has become bigger over the years. **However, if we look at the number of co-authorships and the number of connections, we can conclude that the network has become more dense.**

We compared the period 2000-2007 with 2008-2015. In the first period the set consists of just over 20,000 publications. In the second period, the set consists of almost 35,000 publications. The amount of actors is 50 in period 1 and 52 in period 2. The main statistics are in the table below.

Table 8 Network statistics field SystemsX.ch for selected affiliations (2000-2007 and 2008-2015)

	2000-2007	2008-2015
# connections	703	1,008
# nodes (affiliations)	50	52
# possible connections	1,225	1,326
Density	0.57	0.76
# pubs	20,256	34,150
sum weighted connections	3,792	13,558
weighted per connection	5.39	13.45
divided by #pubs	0.266	0.394

The number of connections increases from around 700 to 1000. This means that there are more institutes collaborating since SystemsX.ch started. If we divide this number by the number of possible connections (between 50 in the first and 52 in the

second period) we see that in the first period 57% of the possible connections has actually happened, while 76% in the most recent period (Density).

Still, as the number of publications increased as well, we assumed we should look at the weight of the connections (i.e., the number of co-authorships between the pairs). The sum of these weights increased from less than 4,000 to over 13,000. If we normalize this sums by the number of connections in each period, we see an increase from 5.39 to 13.45. And even if we divide that score by the number of publications, we see an increase from 2000-2007 to 2008-2015. In other words: there is a more dense collaboration between SystemsX.ch funded partners since the start of the initiative.

Finally, we visualized the networks. The co-authorships between the affiliations involved in the two periods were depicted using VOSviewer. In the figures below we present screenshots of these networks.

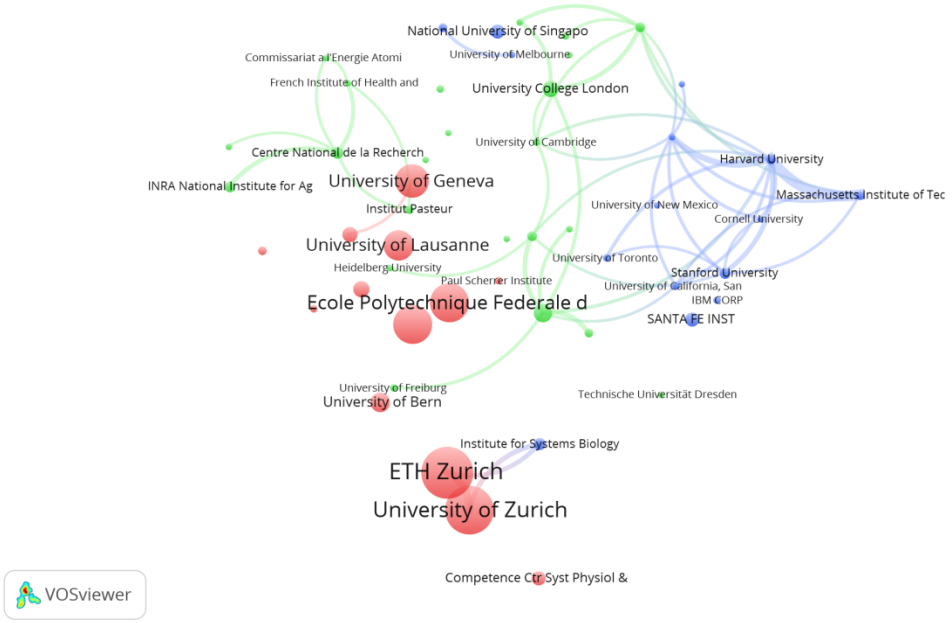


Figure 4 Collaboration network in SystemsX.ch field (2000-2007)

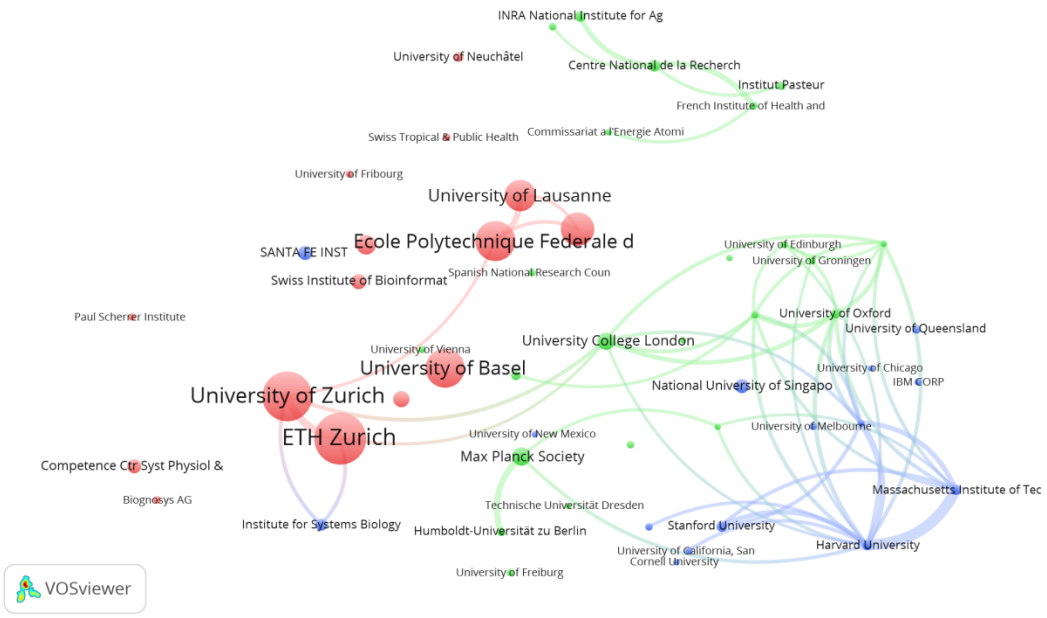


Figure 5 Collaboration network in SystemsX.ch field (2008-2015)

In these networks we depict all 50 and 52 affiliations as well as the 50 most prominent linkages. The size of a circle indicates the number of publications by an affiliation. The color represents the geographical location (Red: Switzerland, Green: Europe and Blue: rest of the world).

We detect in these graphs the usual tendency to collaborate with partners nearby. The Swiss institutions prefer to collaborate with other Swiss institutions, then with Europeans and ultimately outside Europe. This we observe in both periods. Furthermore, we visually don't detect any clear difference between the two networks at all. It is the numbers in Table 8 that indicate a more dense network of collaboration that may be stimulated by the SystemsX.ch initiative.

Collaboration network at the level of individual PI's

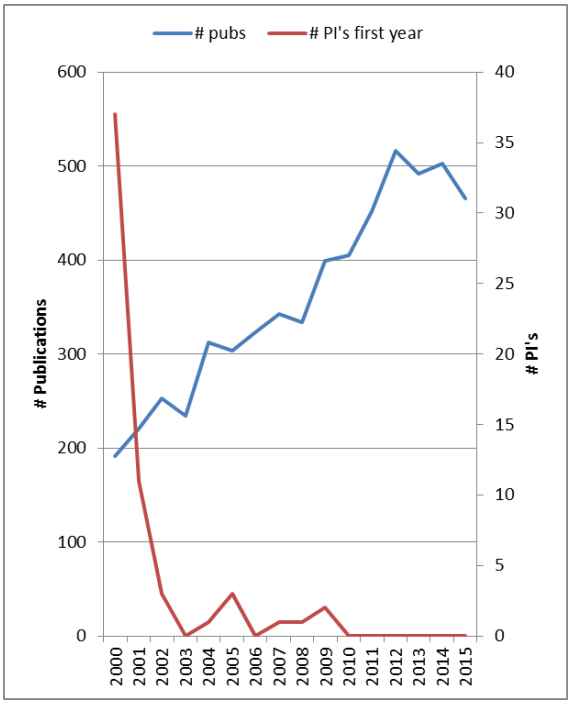
In more detail we investigated the **collaboration patterns between selected principle investigators** in the 5 programs. In order to get more robust data and results, we aggregated the data for the 5 programs but kept the information of the program the PI's belong to. In some cases PI's were connected to more than one

program. In total there were 70 combinations of 64 PI's with 5 programs. For 59 of them we were able to collect publications in the period studied.

In the results below, we integrated the oeuvres of all 59 PI's and created a network of collaboration in the period 2000-2007 and 2008-2015. Four of the programs started in 2008, while of started in 2010. Taking into account the overall objective and the complexity of splitting oeuvres of individuals, we chose for this split of periods. By comparing results in the two periods we will get a useful insight into the effect of the funding. Overall we collected almost 6000 publications of 59 PI's in the 16 years of our analysis. The amount of publications increases over the years with 7% on average. In the third column we included the number of PI's that had their first publication (included in the analysis). This should shed light on the influence of new PI's to the total amount of publications per year. As 51 out of the 59 are represented in the data, we consider this effect almost zero. In other words, a great majority of PI's are represented over the entire period of our analyses. This means that we can 'safely' make a comparison of the periods 2000-2007 and 2008-2015.

Table 9 Number of publications of the 64 PI's (2000-2015)

pub_year	# pubs	# PI's first year
2000	191	37
2001	221	11
2002	253	3
2003	234	0
2004	312	1
2005	304	3
2006	323	0
2007	343	1
2008	334	1
2009	399	2
2010	405	0
2011	452	0
2012	516	0
2013	492	0
2014	503	0
2015	466	0



In the analysis of the 59 PI's we created a collaboration network of the entire period and of the two period separately. Each PI is characterized with a color to indicate the

program they belong to. Those active in more than one program, we colored dark Grey.

The network of the entire period was used to position each PI in a two dimensional space. Subsequently we drew lines between the PI's indicating their mutual collaboration, in terms of co-authorships.

There are a few important observations to be made, comparing the two networks. First of all the overall structure matches the assignments of PI's to programs. This means that the collaboration between PI's is (as expected) according to the grouping by programs. **Secondly, we see a clear acceleration of connections since 2008. In the period until 2007 there are 17 connections while in the period since 2008 the amount of connections is 144.**

Finally we observed the following. The map of 2008-2015 (Figure 7) includes all collaborations between these PI's, regardless if these collaborations were funded by SystemsX.ch. If we would confine the map to only SystemsX.ch publications, the map looks mainly the same. Out of the 144 connections, 116 would remain (Figure 8).

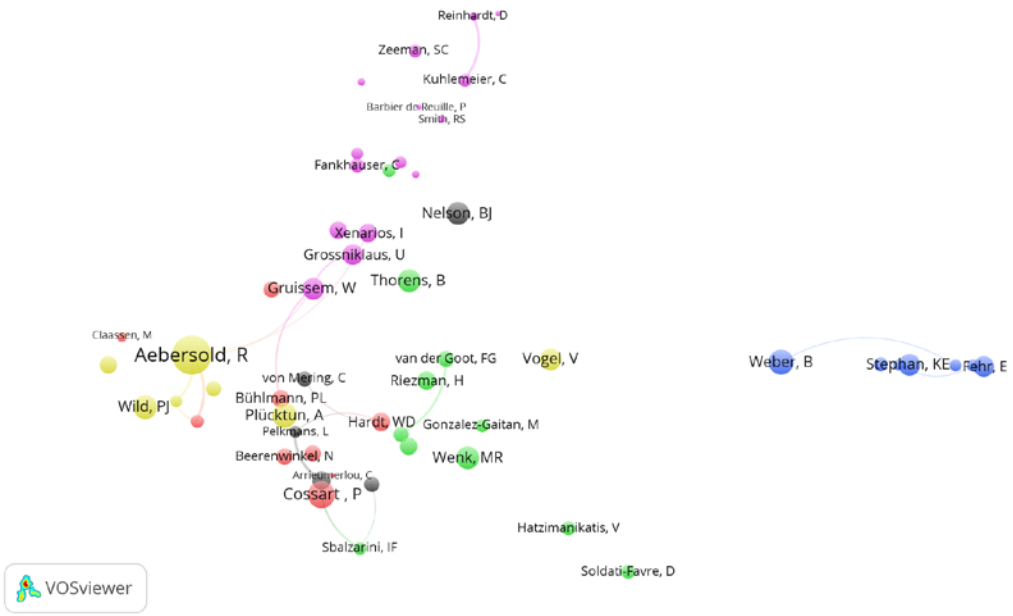


Figure 6 Collaboration map of PI's from 5 SystemsX.ch programs (2000-2007)

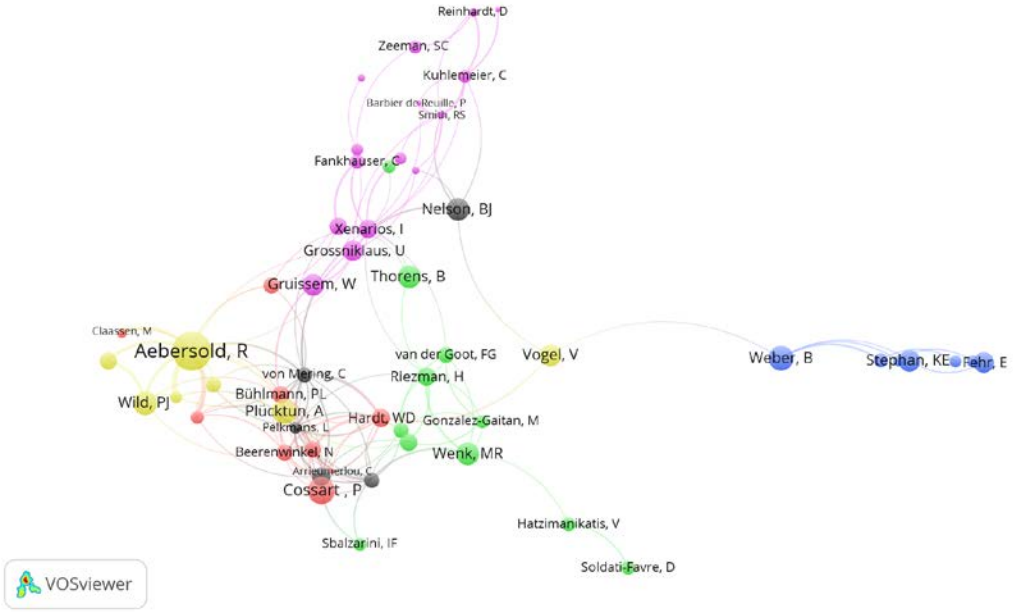


Figure 7 Collaboration map of PI's from 5 SystemsX.ch programs (2008-2015)

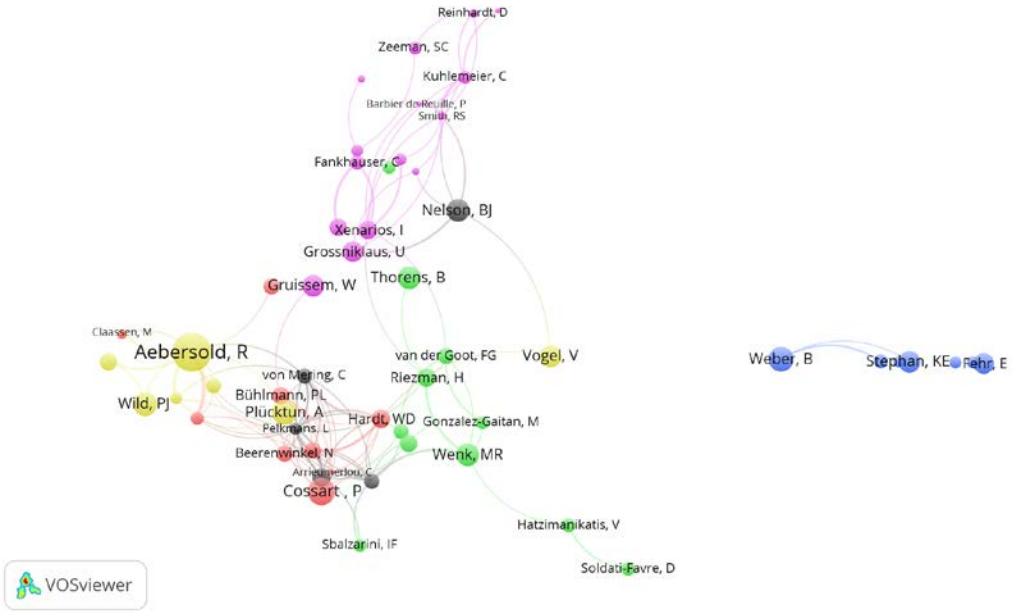


Figure 8 Collaboration map including SystemsX.ch funded publications only (2008-2015)

In each of the above networks PI's are in the same position. Only the number of connections (lines) between them differs from one network to the other.

Finally, we visualized two largest networks of SystemsX funded projects (PlantGrowth and InfectX) by zooming in and only including the PI's involved.

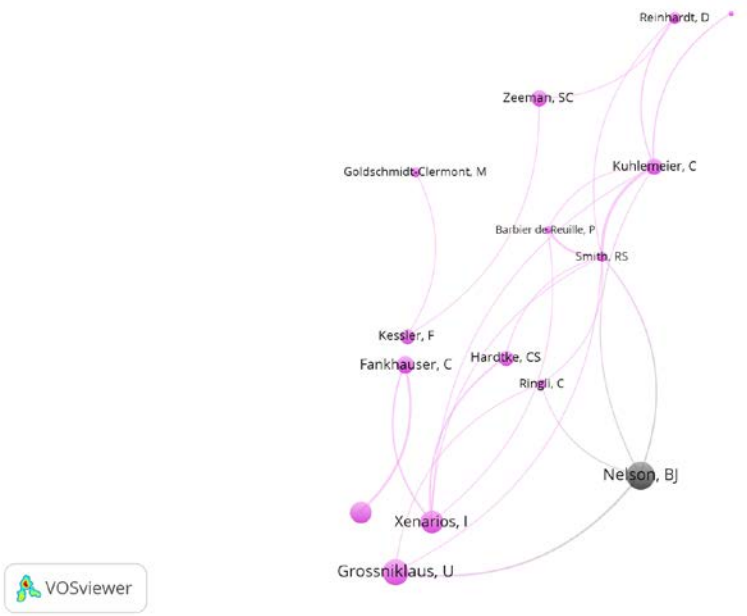


Figure 9 Collaboration network of SystemsX.ch PlantGrowth project (2008-2015)

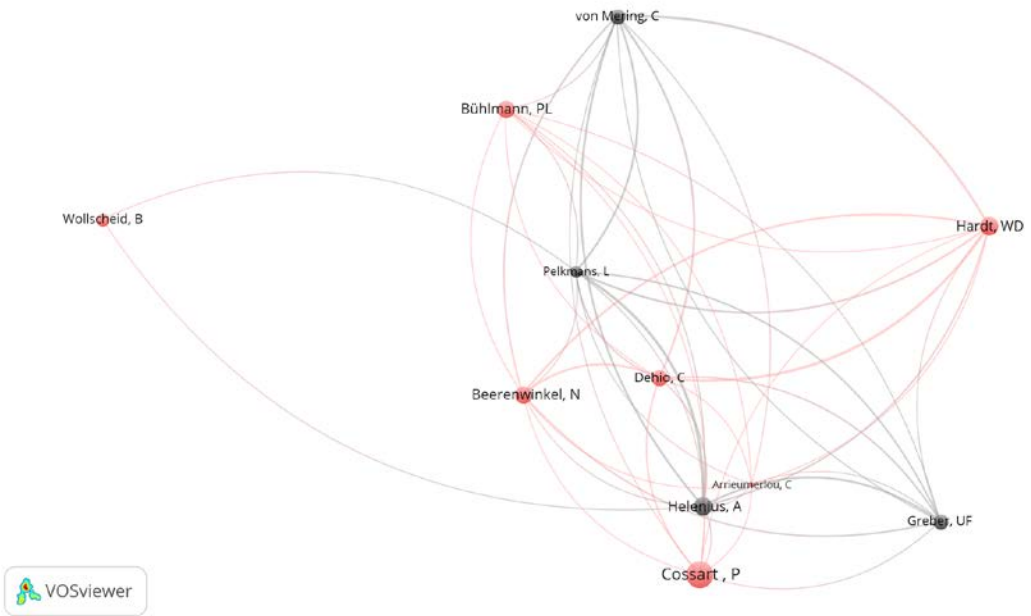


Figure 10 Collaboration network of SystemsX.ch InfectX project (2008-2015)

We used the same color-coding for PI's as in the overall Systems.ch network. Hence we can see that particularly in the InfectX project many PI's (Grey: 4 out of 11) are also involved in other projects. In PlantGrowth there is only one PI involved in another project as well.

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date
CWTS B.V.
Centre for Science and
Technology Studies,
Leiden University

Annex A

Indicators and parameters used for all performance analyses

Parameters:

Database:	All publications in Web of Science
Classification system:	Publication-level classification system (about 4000 fields)
Publication window:	2008-2015
Citation window:	Fixed length of 4 year(s)
Letters:	Included (weight 0.25)
Counting method:	Full counting
Self citations:	Excluded
Top indicators:	top 10%

Annex B

CWTS Standard performance indicators

- Number of publications (**P**) in international journals of the unit of analysis in the period.
- Total and average number of citations received in four years after publication (**TCS** and **MCS**). For these and all other citation impact measures, self-citations
- The mean field normalized citation score (**MNCS**); the actual number of citations (without self-citations) is divided by the expected number of citations on a paper basis. Here, the expected number of citations is based on the world-wide average citation score without self-citations of all similar papers belonging to the same field (cluster of the publication-based classification) and in the same year. In this way, a field normalized score is calculated for each paper. Next, the MNCS indicator is computed for each unit of analysis, by taking the average of these field normalized citation scores for individual papers. A value above 1 indicates that the mean impact for the unit is above world average whereas a value below 1 indicates the opposite.
- The mean normalized journal score (**MNJS**) indicates the average citation impact of the journals in which the papers appeared that were published by the unit of analysis. The indicator is calculated based on the same principles as the MNCS, i.e., normalized by field and publication year. It shows to what extent the analyzed unit was able to get its papers published in the higher impact journals.
- Proportion of highly cited publications (**PP[top10]**) in international journals of the unit of analysis in the period. Normalized by field and year of publication.
- Number and proportion of publications involving international collaboration (**PP IntCollab**).
- Number and proportion of publications co-authored by a university and industry (**PPui**).
-

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CWTS B.V.
Centre for Science and
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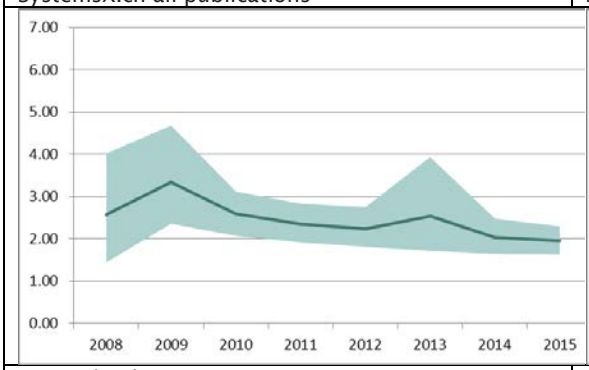
Leiden University

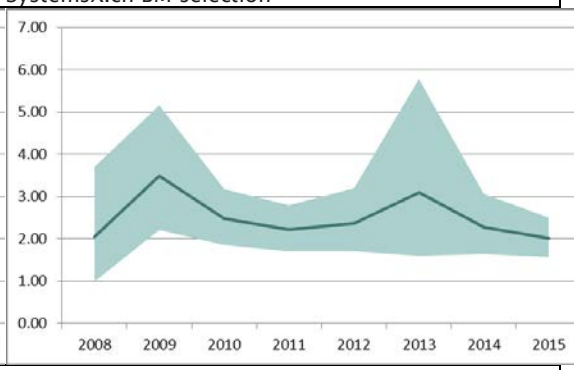
Annex C

Trend and stability analysis of SystemsX.ch, Switzerland and benchmark sets

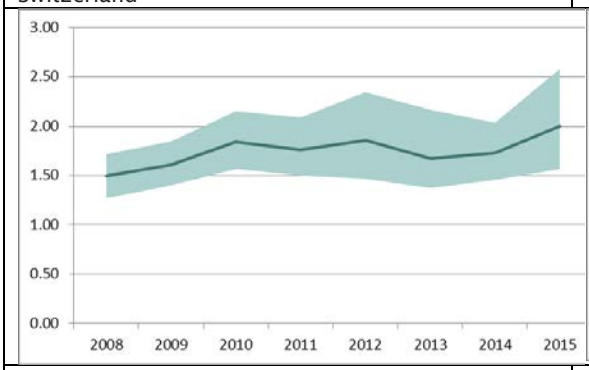
SystemsX.ch all publications



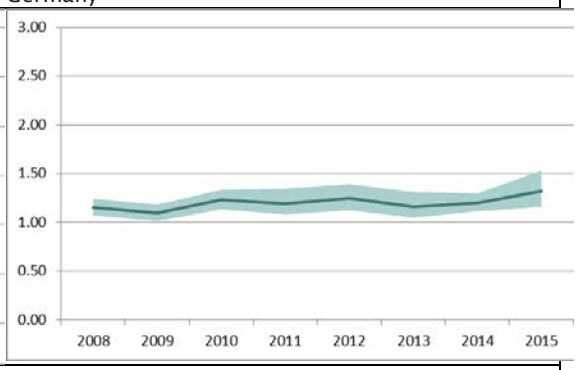
SystemsX.ch BM selection



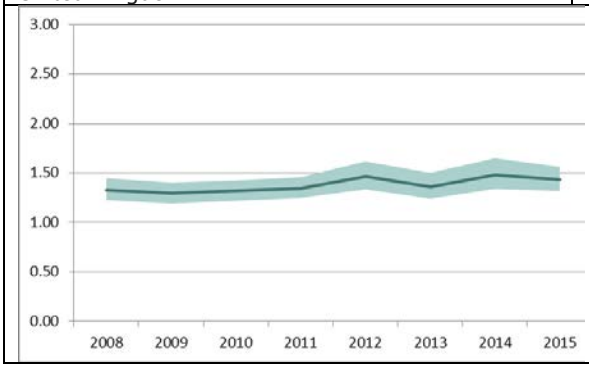
Switzerland



Germany



United Kingdom



Annex D

The CWTS publication classification system

The CWTS citation database is a bibliometric version of Web of Science (WoS). One of the special features of this database is the publication based classification. This classification is an alternative to the WoS journal classification, the WoS subject categories. The reason to have this publication based classification is the problems we encounter using the journal classification for particular purposes. We discern the following as most prominent ones.

1. *Journal scope (including multi-disciplinary journals)*

A journal classification introduces sets of journals to represents a class, in this case a subject category. This implies that journals have a similar scope. The don't need to be comparable with regard to volume (number of articles per year) but they should represent a similar specialization. This is not the case, of course. Journals represent a very broad spectrum. There a very specialized journals (e.g., *Scientometrics*) and very general ones (e.g., *Nature* or *Science* but also *British Medical Journal*). The classification scheme can therefore not be very specialized. In WoS a subject category Multi-disciplinary hosts the very general ones so that a bibliometric analysis of, for instance, the *Social Sciences* or *Nanotechnology*, using this classification, will not take papers in Nature into consideration.

2. *Granularity of the WoS subject categories*

The WoS journal classification scheme contains 250 elements. As such it is a stable system. In many cases however, it appears that these 250 subject categories are insufficient to be used for proper field analyses. The problem, however, is that the granularity of the system looks somewhat arbitrary. 'Biochemistry & Molecular biology' on the one hand and 'Ornithology' on the other, for instance, represent rather different aggregates of research. This is illustrated by the number of journals in each of them. Where the category 'Biochemistry & Molecular biology' contains almost 500 journals, 'Ornithology' has only 27. We acknowledge that there is no perfect granularity but we argue that in the WoS subject categories the differences are really too big. A classification based on more objective grounds does not solve this problem but at least is transparent.

3. *Multiple assignment of journals to categories*

In journal classifications from multi-disciplinary databases, journals are assigned to more than one category. Journals often have broader scopes than the categories 'allow'. Also here there are large differences between categories. In the example we used before, 'Biochemistry & Molecular biology,' journals are on average assigned to almost 2 categories. This means that (on average) each journal in this category is also assigned to one other category. For the more specialized category of 'Ornithology' the average is 1. This means that in this category all journals are assigned to this one only. If publications in journals with a multiple assignment would always cover the categories at stake, this should not necessarily be a problem. However, mostly it means that such journals contains structurally publications form the different categories. Therefore, publications may be assigned to two categories although they belong to just one of them.

The CWTS publication based classification scheme

An advanced alternative for the Web of Science journal classification has been developed at CWTS. It counters three major issues:

1. Journal scope (including multi-disciplinary journals)
2. Granularity of the WoS subject categories
3. Multiple assignment of journals to categories

The CWTS publication based classification is developed as described in Waltman & Van Eck (2012) . Since the first version there have been yearly updates of the system. The main characteristics of the classification are as follows.

Publication to publication citation clustering

Clusters of publications are created on the basis of citations from one publication to another. Almost 18 Million of publications are processed. The clusters contain publications from multiple years (2000-2015). Each publication is assigned to one cluster only at each level. A cluster is considered and in many cases validated as representative for disciplines, research areas, fields or sub-fields. For each cluster, we can calculate growth indices pointing at changing research foci over time.

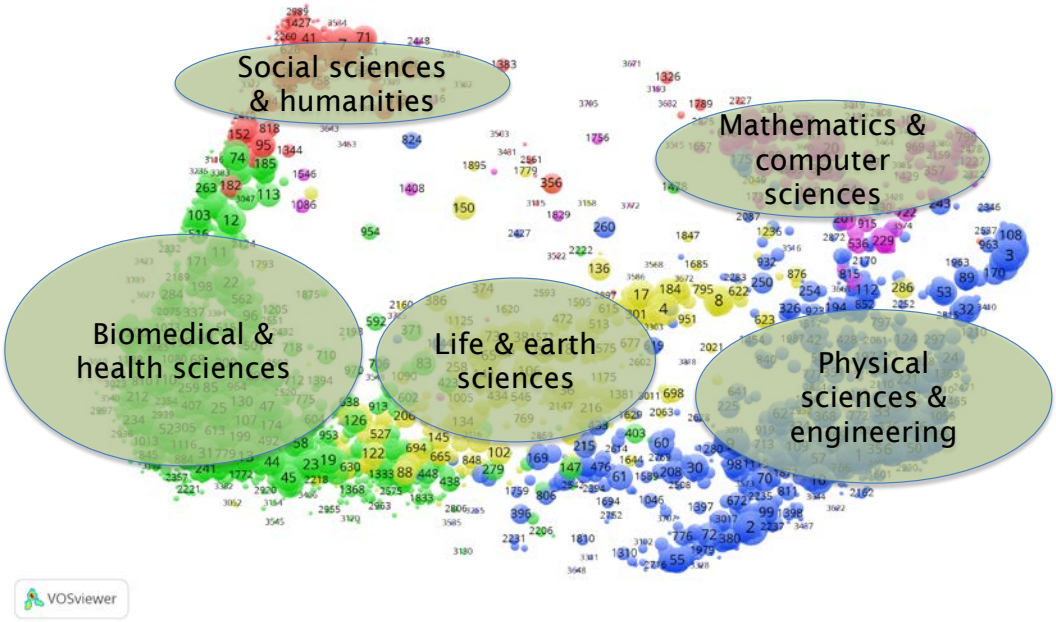
Multi-level clustering

The classification scheme has at present three different levels. The clusters are hierarchically organized. Currently we discern the following levels.

1. A top level of 27 clusters (areas)
2. A second level of 817 clusters (fields)
3. A third level of 4,113 clusters (sub-fields)

Labels

In a 'self-organized' classification scheme like ours, the labeling of clusters is the biggest challenge. As such, our clusters have no name. Still there is sufficient information available for each cluster to characterize them by suggested labels. These suggestions are based on journal categories, journal names, keywords, publication titles and key authors. An impression of our classification scheme is depicted in the VOSviewer map below. In this map the citation relations between the clusters on the second level are used to position the hundreds of clusters in a two dimensional space. The VOS mapping technique places clusters that have a strong citation traffic in each other vicinity while clusters with a weak relation are distant from each other.



Map of all sciences based on WoS publication classification (817 clusters at intermediate level)

Selection of Clusters to define the research field of SystemsX.ch and its benchmarks

The field defining the context of SystemsX.ch funded research is delimited by 24 of the 4113 clusters in which SystemsX.ch publications occurred the most. These 24 clusters are depicted in the map of all sciences (Red colored in te figure below).

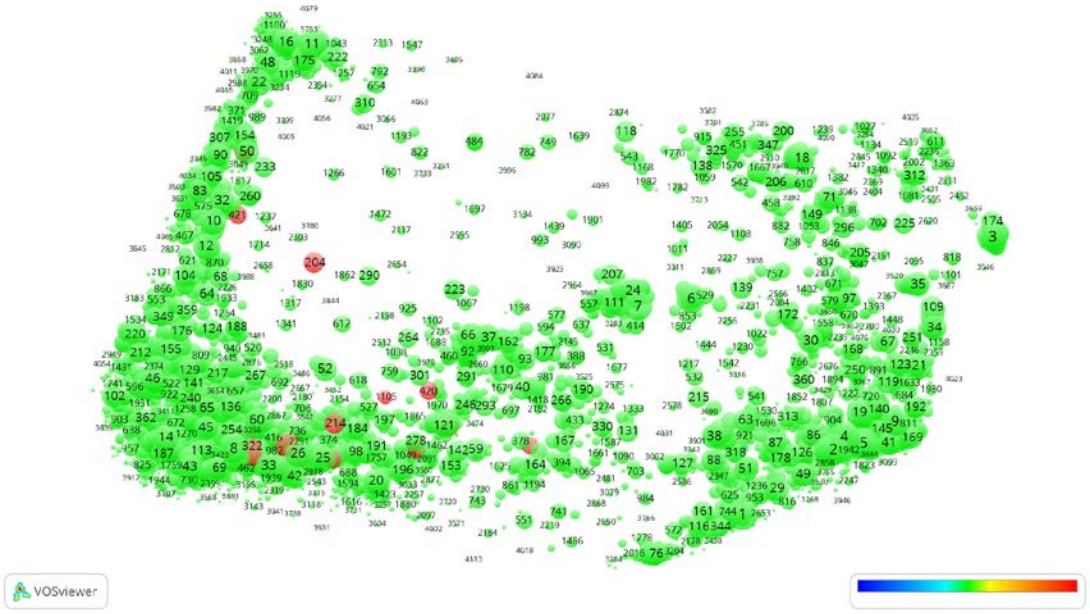


Figure 11 Positioning of SystemsX.ch research in the map of all sciences

The clusters are self-organized and as such don't have names or labels. We characterize the clusters by the most discriminative keywords derived from titles and abstracts. In the table below we describe the 24 clusters using keywords together with added the amount of publications worldwide and funded by SystemsX.ch. The map and list indicate that the fields covers a broad variety of research in the biomedical & health, life & earth as well as physical sciences.

Table 10 Clusters defining the context of SystemsX.ch funded research

id	P world 2000-2015	p systemsx.ch	Keywords to describe the cluster
53	16244	81	proteomic analysis; dimensional gel electrophoresis; quantitative proteomic; proteome; phosphopeptide
128	13795	17	ezh2; lysine; saccharomyces cerevisiae; histone; nucleosome
173	12752	53	gravitropism; microtubule; cytokinesis; endoreduplication; pollen tube
204	12229	45	layer; spike timing dependent plasticity; neuron; spiking neuron; pyramidal neuron
214	12060	13	protein interaction network; biological network; network; gene ontology; protein complex
320	10686	15	iowa gambling task; performance monitoring; error processing; negativity; decision
322	10663	30	hermansky pudlak syndrome; golgi; trans golgi network; escrt; endosome
367	10242	12	typhoid fever; salmonella pathogenicity island; serovar typhi; enteric fever; salmonella infection
393	10034	26	fission yeast; schizosaccharomyces; saccharomyces cerevisiae; kluyveromyces lactis; cytokinesis
408	9874	12	dendritic cell; expression; purification; macrophage; biosynthesis
420	9790	50	noise; gene regulatory network; delay; boolean network; bistability
421	9787	20	functional mri; fmri data; arterial spin labeling; functional magnetic resonance imaging; fmri
437	9670	39	corynebacterium glutamicum; production; metabolic engineering; glycerol; propanediol
470	9439	15	atomic force microscopy; substrate stiffness; mechanic; nanotopography; fabrication
550	8765	17	fluorescence correlation spectroscopy; green fluorescent protein; fret; gfp; diffusion
555	8722	19	sphingosine; phosphate; lysophosphatidic acid; ceramide; fty720
564	8653	12	reductase; photoinhibition; ferredoxin nadp; f complex; cyclic electron flow
681	7945	12	toxoplasma gondii; neospora caninum; congenital toxoplasmosis; seroprevalence; pregnant woman
894	6681	16	mads box gene; circadian clock; phytochrome; flc; constan
1105	5831	16	epistasis; positive selection; experimental evolution; adaptation; approximate bayesian computation
1338	5057	13	transcription factor binding site; site; chip seq; enhancer; motif discovery
1591	4315	16	morphogen gradient; hox gene; hox; gastrulation; branchio oto renal syndrome
2635	2023	17	cat scratch disease; bartonella henselae; mycoplasma; bacillary angiomatosis; neuroretinitis
2646	2004	15	laser scanning cytometry; flow cytometry; cd4; lymphocyte subset; high content screening

SystemsX.ch Consortium Report

SystemsX.ch
The Swiss Initiative in Systems Biology

APPENDIX C

SyBIT Report for the SystemsX.ch Impact Analysis

December 2016

Bernd Rinn, ETH Zurich

SystemsX.ch
The Swiss Initiative in Systems Biology

SyBIT
SystemsX.ch
Biology IT

Dr. Bernd Rinn
Manager SyBIT

Weinbergstr. 11
WEC D 19
CH-8092 Zürich

Phone: +41 44 632 0608
Email: brinn@ethz.ch

SyBIT Report for Impact Analysis SystemsX.ch

2016.12.09

Key Statement 2: SystemsX.ch initiated and enabled Swiss-wide sustainability of research assets by supporting science IT and data management services.

Executive Summary

SyBIT was created by the SystemsX.ch Scientific Executive Board to address the increased scientific IT needs of the SystemsX.ch Research and Technology Projects. The project runs from 2009 to 2018 with a total budget of CHF 17.6 Mio. It is important to stress that SyBIT has not been a research project, but a project for supporting and enabling research. SyBIT involves 6 partners that collaborate both directly and via the Swiss Institute of Bioinformatics. As the investment into SyBIT is substantial, it is essential that the effort is sustainable beyond its duration.

Thanks to the sustainability efforts of SyBIT, the partners of the project today are established support units of their respective organizations that do not depend on SystemsX.ch anymore for their long-term sustainability. Many computational experts active already in SyBIT are today working in these units, ensuring that the know-how built in SystemsX.ch is preserved beyond SyBIT's duration.

SyBIT has both driven and embraced important technical developments and built a tool box for supporting the Swiss life-science research community which will last beyond its duration. openBIS (www.openbis.net), applicake (github.com/lcb/applicake), CIFEX (cifex.ethz.ch), EPPIC (www.eppic-web.org/ewui) and GDV (github.com/bbcf/bbcfutils), to just name a few, are actively used in the research community. Further development is funded in research projects using the tools while maintenance is done as part by the local groups who create them as part of their institutional support mandate.

Last but not least, SyBIT has been driving a cultural change both for closer interaction between IT support groups and research groups, and for closer collaborations of science IT groups across research institutions. Such collaborations used to be rather an exception, but are now common when tackling new challenges. The coordination of future activities is established within the SIB as well as through projects like the national eScience Support Coordination Team (*"eSCT"*, new: *"EnhanceR"*) funded through the CRUS program on scientific information. Finally, in the Swiss Personalized Health Network (SPHN) which is planned to start in 2017, the inter-institutional collaboration on data sharing will be key to achieve scientific goals. The road for this collaboration has been paved by the SyBIT effort in systems biology.

Institutional Adoption

The sustainability of many of SyBIT's functions can only be ensured by the involved academic institutions taking them over when SyBIT runs out. In the Arc Lémanique, an organization already existed before SyBIT that provides support and infrastructure for life science research: The Vital-IT bionformatics competency center of the Swiss Institute of Bioinformatics SIB in Lausanne. It is co-financed by 5 universities (UniGE, UniL, EPFL, UniBE, UniFR) and receives additional federal funding directly through the SIB. Vital-IT is able to secure substantial amounts of 2nd and 3rd party funding through collaborative and R&D projects. Researchers who want to take advantage of the expertise of Vital-IT have to set aside the funding for a collaborative support agreement that includes people's expertise and infrastructure, e.g. by including them in the research proposal.
In the Basel / Zurich area, SyBIT catalyzed a similar development, however adapted to the local circumstances and needs. In the years 2013 and 2014, ETH Zurich, University of Zurich and University of Basel founded local science IT units, each of them incorporating the local SyBIT groups. Scientific IT Services at ETH Zurich and S3IT at University of Zurich are part of the central IT service departments of these institutions, sciCORE at University of Basel is a separate center that collaborates closely with the IT services department for computational infrastructure. Also these units use a combination of institutional base funding, and 2nd and 3rd party funds to ensure their continued operation. In 2017, the University of Berne who was not a partner in SyBIT will create a science IT unit, following the example of ETH Zurich and the Universities of Zurich and Basel and thus indirectly stimulated by SyBIT.
While providing support of science IT units for individual research projects is largely a solved problem today, it can still be challenging to find continued funding for maintaining built and actively used research infrastructures like data analysis pipelines which cannot be unambiguously attributed to a single research project. This is because third party funding organizations like the SNF or the European Commission have set rules for internal cost allocation which require services billed on research grants to be unambiguously assigned to one research project.
The institutional adoption of the science IT units helps sustaining a set of support activities outlined in the SyBIT business plan:

- **Publication support**: Published papers often have an associated set of data that need to be made available as well. SyBIT has provided and still provides assistance to the SystemsX.ch projects to assure that the data are published properly. The published data need to be kept available for at least 10 years, i.e. beyond the duration of SyBIT. Thus the responsibility for the published data has to be taken over by the institutions. SyBIT partners are also cooperating with the university libraries both locally and on a national level to assure that long-term solutions are found. This collaboration is organized in the project *Data Lifecycle Management* (DLCM) of the CRUS program on scientific information, where all SyBIT partners (except FMI) are partners.
- **Software support**: Software and services that have been developed with funding from SystemsX.ch need to be further maintained and supported by the hosting institutions over the applications' life cycle. For successful software systems developed in SystemsX.ch that need to be sustained, institutional funding is available and can be combined with new project funding beyond SystemsX.ch to ensure sustained availability. An example is the openBIS platform, which is

maintained by both institutional funding of ETH Zurich and project funding (see also below).

- **Operational support**: Databases, web sites, portals, etc. that have been set up by projects and are being used in the daily work of the researchers need to be maintained and operated by someone also after the project has run out of funding. The essential services built up by SyBIT will continue to be supported as necessary by the local units. If the corresponding service still has an active user community, its maintenance can be funded locally.
- **Long-term data storage and archiving, sharing and accessibility**: Data generated by scientific projects need to be stored for a certain amount of time to enable data reuse and ensure data provenance tracking and to allow verification of past experiments (*reproducible science*), even when the data are not published explicitly. This can only be ensured by the academic institutions, i.e. the researchers and the science IT support units collaboratively.

Technical Assets developed by SyBIT

By their nature, software written for the use in research projects is often specific to and only relevant in the project it was written for. SyBIT has engaged in this type of activity as needed by the SystemsX.ch projects. From the point of view of sustainability this type of activity is not critical and thus is not considered here. However, software that is used in multiple research projects may become technical assets which are part of research infrastructure and need to be supported longer-term. Some of them like e.g. applicake, Datamover or CIFEX while highly useful, are simple tools that need only little effort for maintenance and further development once they are developed.

SyBIT has also engaged in developing the openBIS research data management platform as a strategic development, based on the understanding that data management and sharing is particularly important and non-trivial for research projects that extend beyond multiple institutions and run for a longer period of time. The work was performed at ETH Zurich. Early versions of openBIS have been used already in late 2009 and early 2010 to support RTD projects of the first round like YeastX, PhosphoNetX and LipidX. From there, it has spread to facilities like the Genomics Facility Basel of ETH and University of Basel, The Light Microscopy Center (today part of the ScopeM facility) of ETH, and the Single Cell Unit of ETH D-BSSE. Today, openBIS is a mature software platform that has many applications in systems biology and life-science data management, sharing and analysis. It is used by an international user community in labs, research projects and scientific facilities in Switzerland and Europe, as well as by some pharmaceutical companies, for managing laboratory information management, documenting experiments, large-scale management of digital research assets and back-bone of data analysis pipelines. As the software is provided to the academic research community as Open Source software free of charge, it is not possible for us to know about all currently running installations. We know of more than forty installations and estimate that it is used by more than thousand regular users and an unknown number of casual users. Large installations manage more than 350 TB of research (both primary and secondary) data on multiple storage systems including multi-tier storage and many different types of data, e.g. genomics, metabolomics proteomics, imaging, FACS, High Content Screening or chemical data. As a software platform, openBIS focuses on interoperability with other software, in particular for data measurement and analysis and has been integrated with data analysis software systems

like KNIME (www.knime.org), Icy (icy.bioimageanalysis.org) or Jupyter (jupyter.org). While the platform was developed for systems biology and life-sciences, it has found also some use-cases beyond this domain, e.g. to management and share the result of a large study in social sciences.

SyBIT has supported large-scale data analysis efforts in SystemsX.ch projects which developed technical assets which are useful beyond any particular project. Examples are the iPortal system for mass spectrometry Proteomics data analysis, emzed for LCMS metabolomics data analysis, EASE for RNA-seq data analysis and ScreeningBee for High Content Screening image analysis. Many of the analysis systems developed in SyBIT are integrated with High Performance Computing clusters to enable scaling up of data analysis and each of them are in regular use by a research community. Many of the systems are continuously developed further, either as part of regular institutional maintenance, or with new features to support new research projects, so they are clearly useful beyond their original use in SystemsX.ch. It has to be noted that none of these systems ‘re-invented the wheel’, but all to the contrary was built on already existing and well-supported open source components and tools, which helps sustaining the tools as maintenance and further development work from other groups outside SyBIT is re-used.

Beyond tools, SyBIT has supported (and still is supporting) the RTD projects in data publication and has e.g. built data publication portals such as www.infectome.org, lipidx.vital-it.ch/base/exps or cyclix.vital-it.ch. For other projects, SyBIT supported the projects in uploading data to already existing community data portals such as GEO. As data publication is usually a late activity in projects, these efforts is expected to be ongoing until the very end of SystemsX.ch, for example SyBIT is currently building an exploratory data visualization portal for NeuroStemX. Accessible high-quality data sets will be a valuable heritage of SystemsX.ch and SyBIT has made a relevant contribution to it.

Cultural Changes and Continued Collaboration

SyBIT was a highly collaborative project right from the start and brought together biologists, bioinformaticians and software developers into a collaborative setup, often with embedded computational experts in the life-science groups bridging the gap. This will have a lasting impact on the Swiss life-science research. The newly created science IT groups are today very aware of the needs of the life-science research community, while traditionally science IT groups focused on classical computational areas as physics, chemistry of electrical and mechanical engineering. On the other hands, researchers in the life-sciences became aware of the possibilities and challenges of scientific computing and improved their knowledge on it, e.g. on using compute clusters and automation tools. At ETH Zurich for example, SIS is now regularly organizing specific programing courses for biology master and PhD students and prospective bioinformaticians which are always fully booked out.
SyBIT has also brought together groups from different institutions, also from Arc Lémanique and the Zurich / Basel area which did not work together regularly before. SyBIT has organized 15 ‘tech days’, retreats and technical workshops among its partners until now, not counting bilateral training sessions. This effort increased knowledge about one another and created a collaborative setup that will be (and already has been) useful beyond SyBIT. All SyBIT partner groups but one had already been member of the Swiss Institute of Bioinformatics (SIB) or become SIB members during the runtime of SyBIT. Thus, the regular SIB meetings have become a loose, but valuable point to meet, exchange information and ideas, and coordinate. The strongest collaborations took place

within the two clusters Zurich / Basel (ETH Zurich, Universities of Zurich and Basel and FMI) and Arc Lémanique (SIB Vital-IT and EPFL BBCF), and only in few cases there was support provided to SystemsX.ch projects jointly by partners from both clusters. The data management solution for LipidX was a notable exception. However, the SyBIT experience helped even between these two clusters to raise awareness of each other's' approaches and strengths which became apparent when forming the e-Science Support Coordination Team (eSCT) of the CRUS 'scientific information' program and the Track 2 on active research data management of the Data Lifecycle Management (DLCM) project of the same program: both projects have been joined by all SyBIT partner institutions and actually the same groups, except for EPFL where there are different groups participating in all three projects. As the CRUS program 'scientific information' aims at developing (sustained) national services, these projects are expected to develop into a regular, sustained collaboration beyond institutional boundaries. Today, the projects have led both to regular technical meetings (eSCT) and co-organized national events (Swiss Research Data Management Day 2016 in DLCM).
Beyond the CRUS program, different SyBIT partners have collaborated in new projects or taken over joined coordination efforts:

- University of Zurich and ETH Zurich have joined the FAIRDOM project, also supported by SystemsX.ch with partners from University of Manchester and HITS Heidelberg. Based on the FAIR (**F**indable, **A**ccessible, **I**nteroperable and **R**eusable) principles, FAIRDOM supports research projects in data management and publication and Open Science approaches in the life-sciences. This project is now leading to the establishment of the FAIRDOM association which will have continued joined activities in systems and synthetics biology, as well as bio-medical data and model management.
- Ioannis Xenarios (Vital-IT) and Bernd Rinn (ETH Zurich) have jointly taken over the Swiss representation of the European project CHARME (*'Harmonising standardisation strategies to increase efficiency and competitiveness of European life-science research'*).
- Discussions have started between the SyBIT partner groups of University of Basel, ETH Zurich and University of Zurich on how to best coordinate the required computational infrastructure for the Swiss Personalized Health Network. This initiative which will be starting in 2017 and is a natural area of continued collaboration between the SyBIT partners.

While SyBIT is still ongoing, it is a fair prediction that the cultural changes initiated will outlast it.

Summary

To summarize, SyBIT has:

- Helped to initiate the creation of institutional science IT units in several partner institutions,
- Created longer-term valuable technical assets for data management, sharing and analysis of life-science research data,
- Catalyzed a cultural change towards more collaboration both between life-science researchers and scientific IT support groups, and between scientific IT support groups from different institutions.

While not all problems could be solved, i.e. funding of research infrastructures continues

to be a challenge and collaboration between Arc Lémanique and Zurich/Basel could still be stronger, the organizational, technical and social impacts of SyBIT will be of continued value to the research community and have paved the way for a close collaboration on national computational infrastructure and services in the Swiss Personalized Health Network. By setting up the SyBIT project, SystemsX.ch has made a lasting contribution to science IT support and research data management in Switzerland.

Anhang C

Bericht des externen Expertenpanels

Report on SystemsX.ch by the expert panel

SystemsX.ch: Statement about the „Report on SystemsX.ch by the expert panel"

Questions for the international expert panel

Terms of reference for external experts (TOR)

Expertenpanel, Juli 2017 / Statement SystemsX.ch, 16. Oktober 2017

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER

Swiss Science and Innovation Council SSIC

SSIC: Impact Evaluation of the National Funding Programme SystemsX.ch

Report on SystemsX.ch by the expert panel

Authors:

- **Prof. Dr. Luis Serrano, Centre for Genomic Regulation, Barcelona, Spain**
- **Prof. Dr. Martin Vingron, Max Planck Institute for Molecular Genetics, Berlin, Germany**

July, 2017

Swiss Science and Innovation Council
Einsteinstrasse 2, 3003 Bern
Phone +41 58 463 00 48, Fax +41 58 463 95 47
praesidium@swir.admin.ch
www.swir.ch

Report on SystemsX by Luis Serrano and Martin Vingron

From both the distributed material, the presentations, and simply based on the panel members' familiarity with the field, it is clear that SystemsX has produced the very best science and has put Switzerland firmly on the international map as a major hub of systems biology research. The publication output has been outstanding and a number of systems biology techniques and results are now firmly linked to the names of Swiss researchers and research institutions.

Part I: "Excellence in Science"

I/1. To what extent has the SystemsX.ch funding contributed to the rise of systems biology in Switzerland?
Before SystemsX there was little expertise on Systems Biology in Switzerland. The funding played a seminal role in the establishment of systems biology – as a discipline and as a new way of thinking about biology. As we have seen in the report we now have groups at different cities and universities and not only in Basel and Zurich. Several universities have introduced Systems Biology in their training curriculum and it is reported that Systems Biology approaches are now part of the standard research in many groups.

I/2. How do you valuate the scientific output regarding the overall objective of the initiative (to bring Switzerland to a leading position in this research area)? In your opinion, how far did Swiss research need to catch up with the international competition (before 2008)?
Switzerland is now one of the reference points in the world in systems biology.
Switzerland, in general, has already had excellent science also before 2008. With systems biology being a very new field then, the SystemsX initiative was not following but leading, together only with some select places like the Harvard systems biology department. The long term structural effect of SystemsX lies (1) in boosting systems biology and interdisciplinary, quantitative biology in Switzerland; and (2) raising the level also of smaller universities as compared to the already good places.

I/3. How well did the research activities comply with the explicitly wished interdisciplinary orientation of the programme?
In contrast to the Leiden report, which sees no evidence for an increase in interdisciplinarity, the panel feels that a large number of highly visible papers have been co-authored by scientists representing different fields. This holds true for the work coming out of different labs like those of, for example, Ruedi Aebersold (technology, biology, computer science), Uwe Sauer (biology, metabolomics, mathematical modeling), Willi Gruissem (plant biology, mathematical methods), etc. We have seen a significant increase in the number of physicists, mathematicians and computer scientists working in biology labs. Perhaps the only discipline not well represented is chemistry, but this seems more for a lack of enthusiasm of the chemistry departments than any other thing.

I/4. How do you valuate the bibliometric analysis, both in terms of main findings and methodological limitations (see self-evaluation, appendix B)?
The bibliometric analysis confirms the general feeling in the community (shared by the panel) that the publication output stemming from SystemsX has been superb. The analysis by the Leyden group is excellent. The main shortage is the analysis of interdisciplinarity, which is not an easy one. On this one issue the panel feels that the Leyden report disagrees with impression of the panel (as pointed out above). Also, it would have been nice to see the average and median number of papers per researcher (PI) in SystemsX to get a better idea of the average output and if there are biases towards certain groups.

I/5. Did pushing one scientific approach for systems biology impact (positively or negatively) on other research approaches?
Systems biology is inclusive rather than exclusive. As such, it is unlikely that supporting systems biology would do harm to other fields. Much rather, the panel feels that strong funding for systems biology has in fact led to a highly productive integration across different fields.

Part II: "Structural impact"

II/1. How do you valuate the structures and technological infrastructures developed with the support of SystemsX.ch in the partner institutions?
In principle, the institutions are to be commended on the establishment of technology plattforms. This is a legacy that will survive SystemsX and will be of benefit for the whole Swiss scientific community.

II/2. How do you valuate the sustainability of the funding programme beyond its own life cycle? What elements will remain in place after the end of the programme, what was just part of a passing phase?
SystemsX has certainly led to a change in the general thinking of Swiss life-science researchers. This will, also in the future, be reflected in the use and integration of different technologies and analysis methodology. A major shift has occurred in the integration of data analysis and/or modeling into biological and biomedical projects. The concentrated effort has led to a new spirit: Emphasis in recruitment as well as the landscape of collaboration have changed, the educational pathways have changed. This is very connected to the fact that SystemsX has been such a concentrated effort.
Also as mentioned above the newly created core facilities will remain and help other scientists.

II/3. How do you valuate the long-term data management systems (developed with the support of SystemsX.ch), how far did they help prepare Switzerland for the next step in the field of precise medicine / personalized health?
The report did not contain much information on this. In the presentation, it was described that standardization efforts are ongoing, especially in hospitals.
It is hard to see that such standardization efforts would be within the mandate of SystemsX. Rather, this needs to be done in a concerted effort of the internationally strongest groups in the respective fields (mass spec, functional genomics, etc). The establishment of numerous omics-technologies did indeed prepare Switzerland for the age of precision medicine, but standardization will not be solely a Swiss undertaking.
There is now a pool of well-trained scientists on systems biology that can tackle the new challenge of precision medicine. Without SystemsX is doubtful that a successful program in precision medicine could be launched.

Part III: "Networking and partnership"

III/1. How do you valuate the measures taken to promote interdisciplinary and/or interinstitutional research collaborations?
The inclusion of different disciplines as a prerequisite for funding, and the emphasis in the second phase of SystemsX on modeling was indeed a very effective instrument in forging interdisciplinarity. Likewise, courses, meetings, and interdisciplinary predoc and postdoc programs have helped.

III/2. Regarding private partners and their relatively small share of funding: how do you valuate the activities that SystemsX.ch undertook to promote application of scientific results. Are there lessons learned from international examples in this area?

Apparently, companies have different priorities and one would assume that they are also better than publicly funded research at tasks like drug development. Public funding should be focused on basic research and technology development. More importantly, although it was stated that SystemsX should provide further basis for the cooperation between publically funded research and the private sector, there was no clean structure set up to organize it, or a very clear mandate demanding that commercialization of the research was a must. As a result and due to the fact that the funded projects were excellent scientifically but far away from translation, big pharma was not interested. Furthermore, the lack of a clear structure to promote translation or valorization of their findings, with local technology transfer structures taking the role, resulted in poor translational activities. Despite this a significant number of start-up companies were founded, especially at the beginning. In fact all of them are alive and some seem to be successful.
We think an important lesson for the future is that technology transfer activities should be a must in these large projects. An infrastructure run by a leading professional should be put in place and it should be clear that this structure will take charge of translation activities in collaboration with the universities. Also reserving a small percentage of the budget for valorization will help. Finally, perhaps big pharma should be involved in proposing some of the RTD projects, to ensure their interest.

Part IV: "Promoting young talents"

IV/1. How do you valuate the funding schemes "IPhD" (interdisciplinary PhD) and "TPdF" (Transition Postdoc Fellowship) from your perspective?
The panel sees this as very successful. The PhD students and postdocs are the glue that will make interactions functional. In such an interdisciplinary set-up the students/postdocs can then naturally develop an understanding for another field and learn the skills needed from the new areas.
There was mention of the "two supervisor problem": The solution suggested by SystemsX of having one primary supervisor among the two seems viable and is recommended.

IV/2. What is your current appreciation about training and education in the field of systems biology in the Swiss Higher Education Institutions? How much did SystemsX.ch contribute in this respect?
Before SystemsX there was – to the panel's best knowledge – no education in systems biology, or modeling and bioinformatics, either. The curricula which exist now can to a large degree be attributed to the drive introduced by SystemsX. Generally, the scientific community perceives the quality of these educational programs as very high. It will remain a challenge to maintain this high level, in particular since the effort it takes to establish and maintain an interdisciplinary teaching program is generally underestimated.

Part V: Overall aspects

V/1. What might be general lessons learned from the funding programme?
An interesting and specific feature of SystemsX was the high degree of self-administration of SystemsX by its PIs. Researchers from the community had a say in the funding decisions. Admittedly, this does require control mechanisms, but it has also proven to be very effective and successful.
V/2. What could be the overall impact of the programme on Switzerland and its Higher Education and Research landscape?
SystemsX has largely been responsible for a new attitude in life science research in Switzerland, and for the establishment of new generation of more interdisciplinary and more computationally/mathematically skilled biologists. It has helped introduce omics technologies on a large scale into the research process. Taken together, this forms the basis also for the new developments of precision medicine and single cell biology.

SystemsX.ch
The Swiss Initiative in Systems Biology

Clausiusstr. 45, CLP D 6
CH-8092 Zürich

Daniel Vonder Mühll, PhD
Deputy Managing Director

tel: +41 44 632 78 88
fax: +41 44 632 15 64
daniel.vondermuehll@systemsx.ch
www.svstemsx.ch

Prof. Dr. Gerd Folkers
Präsident
Eidgenössisches Departement für
Wirtschaft, Bildung und Forschung WBF
Schweizerischer Wissenschafts- und Innovationsrat SWIR
Einsteinstrasse 2,
3003 **Bern**

Zurich, 16 October 2017

Statement about the "Report on SystemsX.ch by the expert panel"

Dear Sirs,

Thank you very much for sending us the draft report to comment it from the perspective of SystemsX.ch. All SystemsX.ch representatives attending the site visit read the draft report and concluded the statement below.

General comment

SystemsX.ch shares the findings of the panel and is satisfied with the various aspects treated in the report. The statements made are largely well justified, which also reflects that the panel elaborated a comprehensive view to the Swiss Initiative in Systems Biology.

Specific comments

a) Interdisciplinarity in the Leiden report (I/3 and I/4)

It is true that Figure 3 (on page 16 of the Leiden report) does not show significant changes in interdisciplinarity. This surprised us as well. However, Table 6 (on page 15) states that the most successful category of SystemsX.ch publications is "Multidisciplinary Sciences" with a MNCS of almost 3.0 and a share of 40% in the top ten percent publications.

b) Private sector (III/2)

As the panel mentioned, the first priority of SystemsX.ch was to foster scientific excellence and added value in systems biology. Commercialization of results had a lower priority. For the latter, a

whole set of measures was elaborated and implemented (SystemsX.ch Consortium Report on pages 31-32): (1) SystemsX.ch Industry Day, (2) SME Workshop, (3) biotech fairs, (4) link to the Swiss Biotech Association, (5) visits at numerous companies, (6) entrepreneur in residence and (7) promoting spin-offs.

Moreover, during the 2nd phase (i.e. from 2012) members of private partners were encouraged and invited to participate in consortia already during proposal writing. There are several of examples of companies that joined RTD and MRD consortia.

In fact, "post festum" the reasons are understood much better. They are rooted in the silo-like structure of big pharma companies where global silo heads have budget authority. However, they do not have extra budget for exploratory projects. It, therefore, needs even more time to include the private sector with a high commitment. Nevertheless, in the long run, big pharma will benefit a lot from such basic science initiatives.

If you have any further questions, do not hesitate to contact me

With best regards

Daniel Vonder Mühll

Questions for the international expert panel

Introduction

In September 2016, the Swiss Science and Innovation Council (SSIC) received a mandate from the Swiss State Secretariat for Education, Research and Innovation (SERI) to conduct an impact evaluation for the National Funding Programme SystemsX.ch.

The complete evaluation procedure consists of three phases:

a) Internal impact evaluation (*self-evaluation report, delivered to the SSIC end of March 2017*) carried out by the SystemsX.ch Consortium. The requirements and conditions are stated in the SERI mandate
b) Independent external assessment by a panel of international experts (*panel report, **to be delivered to the SSIC beginning of September 2017***)
c) Synthesis and overall assessment of the information gathered from national sources, from the self-evaluation report and from the panel report by the SSIC (*SSIC report, to be delivered to the SERI end of February 2018*)

Following, the SSIC formulates questions to the international experts, in order to benefit as much as possible from their view, which will underpin SSIC's overall assessment. The questions in bold are of particular importance for the SSIC.

Questions

Part I: "Excellence in Science"

I/1. To what extent has the SystemsX.ch funding contributed to the rise of systems biology in Switzerland?

I/2. How do you valuate the scientific output regarding the overall objective of the initiative (to bring Switzerland to a leading position in this research area)? In your opinion, how far did Swiss research need to catch up with the international competition (before 2008)?

I/3. How well did the research activities comply with the explicitly wished interdisciplinary orientation of the programme?

I/4. How do you valuate the bibliometric analysis, both in terms of main findings and methodological limitations (see self-evaluation, appendix B)?

I/5. Did pushing one scientific approach for systems biology impact (positively or negatively) on other research approaches?

Part II: "Structural impact"

II/1. How do you valuate the structures and technological infrastructures developed with the support of SystemsX.ch in the partner institutions?

II/2. How do you valuate the sustainability of the funding programme beyond its own life cycle? What elements will remain in place after the end of the programme, what was just part of a passing phase?

II/3. How do you valuate the long-term data management systems (developed with the support of SystemsX.ch), how far did they help prepare Switzerland for the next step in the field of precise medicine / personalized health?

Part III: "Networking and partnership"

III/1. How do you valuate the measures taken to promote interdisciplinary and/or interinstitutional research collaborations?

III/2. Regarding private partners and their relatively small share of funding: how do you valuate the activities that SystemsX.ch undertook to promote application of scientific results. Are there lessons learned from international examples in this area?

Part IV: "Promoting young talents"

IV/1. How do you valuate the funding schemes "IPhD" (interdisciplinary PhD) and "TPdF" (Transition Postdoc Fellowship) from your perspective?

IV/2. What is your current appreciation about training and education in the field of systems biology in the Swiss Higher Education Institutions? How much did SystemsX.ch contribute in this respect?

Part V: Overall aspects

V/1. What might be general lessons learned from the funding programme?

V/2. What could be the overall impact of the programme on Switzerland and its Higher Education and Research landscape?

Overall schedule

When	What
Now, present paper	The expert panel gets the SSIC's questions and additional documents
June 14-15, 2017	The site visit and other meetings take place in Zurich (see below)
Beginning of September, 2017 (at the latest)	The draft of the expert report is submitted to the SSIC
Beginning of November, 2017	The SSIC sends the comments of the SystemsX.ch Consortium and of the Swiss National Science Foundation on the draft report to the expert panel
November 15, 2017 (at the latest)	The expert panel decides about making an addition or a change to their report and, if appropriate, sends a final version of the report to the SSIC
February, 2018	The SSIC submits the complete impact evaluation to the SERI. The expert report is included in the SSIC evaluation report.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER

Swiss Science and Innovation Council SSIC

Impact evaluation "SystemsX.ch"

Terms of reference for external experts (TOR)

February, 2017

1 Purpose of TOR

The following TOR are to clarify the rights and obligations of the panel of experts on the one hand and the Swiss Science and Innovation Council (SSIC) and its staff on the other. These TOR also determine procedures and deadlines.

2 Purpose and context of the impact evaluation by the SSIC

In accordance with the official mandate of the State Secretariat for Education, Research and Innovation (SERI) delivered in September, 2016, the SSIC conducts an impact evaluation of the national funding program "SystemsX.ch".

The impact evaluation focusses on the following dimensions:

- Structural impact on the SystemsX.ch partner institutions (structural changes)
- Impact on interdisciplinary and inter-institutional collaborations (networking and partnerships)
- Educational impact (promoting young talents)
- Scientific impact (excellence in science)

General systemic aspects (i.e. indirect effects on the national and international research potential) will complete the perspective.

3 Procedure of the impact evaluation

The complete evaluation procedure consists in three phases:

a) Internal impact evaluation (*auto-evaluation report*) carried out under the responsibility of the SystemsX.ch Consortium. The requirements and conditions are stated in the SERI mandate
b) Independent external assessment by a panel of international experts, based on the auto-evaluation report by SystemsX.ch, additional documents provided by the SSIC and the information gathered during a site visit incl. interviews (*panel report*)
c) Synthesis and overall assessment of the information gathered from national sources, from the auto-evaluation report and from the panel report by the SSIC (*SSIC report*)

See Annex for a timetable of the complete procedure.

4 Objectives of the assessment by the panel of experts

The assessment by the panel of experts focusses on a list of questions of the SSIC (based on the "dimensions" mentioned above, especially on scientific impact: research directions and scientific quality).

Based on the documentation delivered by the SSIC as well as other sources (i.e. interviews at the site visit, see 7 below), the panel of experts shall critically assess the findings from an international perspective. The panel can draw comparisons with funding schemes or programs from other countries.

Swiss Science and Innovation Council
Einsteinstrasse 2, 3003 Bern
Phone +41 58 463 00 48, Fax +41 58 463 95 47
praesidium@swir.admin.ch
www.swir.ch

The SSIC will use the results of the expert panel assessment for its own analysis. Furthermore, the panel report will be addressed to the Swiss Federal Government as an annex to the SSIC report.

5 Procedure of the assessment by the panel of experts

a) **Beginning of May, 2017** – the SSIC provides the auto-evaluation of SystemsX.ch, additional documents and the SSIC's main questions to the expert panel
b) **June 14-15, 2017** – the site visit will take place in Zurich: coordinated by the SSIC, the expert panel will meet the SystemsX.ch Consortium and other actors
c) **Beginning of September, 2017** – (at the latest) a first draft of the expert report will be delivered to the SSIC
d) **Beginning of November, 2017** – the SSIC will send the positions of the SystemsX.ch Consortium and of the Swiss National Science Foundation on the draft report to the expert panel
e) **Mid-November, 2017** – the expert panel will decide about making a comment to the positions and, if appropriate, send the comment to the SSIC on November 15, 2017, at the latest

6 Constitution of the panel of experts

The assessment will be carried out by an international panel of independent experts. The SSIC is responsible for selecting the panel.

The panel organizes itself and will nominate a contact person for the SSIC. Every member of the panel can address the SSIC's office for any questions.

7 Documentation

The SSIC will provide the panel of experts with all the necessary documentation and information. This includes:

- General information on Swiss higher education system
- A summary of the SERI mandate
- The auto-evaluation of the SystemsX.ch Consortium
- Additional documents and questions by the SSIC
- Administrative information (i.e. on participants and agenda of the site visit)

8 Tasks and responsibilities of the experts

At their discretion, experts can gather additional information they regard as relevant. In its report, the panel must disclose all sources of additional information.

The SSIC will receive the draft report from the contact person of the experts' panel at the beginning of September, 2017, at the latest. This report will contain the panel's findings and recommendations, in accordance with the SSIC's questions, as well as a statement on the methods and documentation used by the panel.

The report will be in English. It will be no longer than 20 pages. The report must be delivered in electronic form, both as a PDF and as a Word file.

The report is meant to have group authorship. If the panel cannot reach a consensus, each member of the panel will sign his own text.

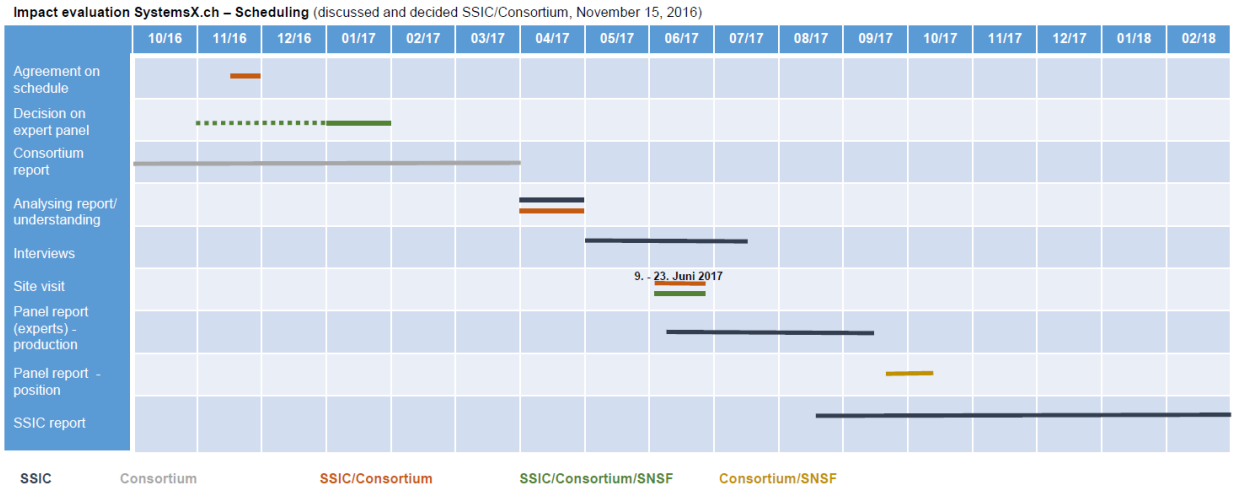
9 Independence, confidentiality and conflicts of interest

The members of the panel work independently and do not represent any organization. Panel members are required to declare any personal or other conflicts of interest.

Discussions between the panel of experts and the SSIC occurring during the site visit are not public and their content is confidential. No official minutes will be kept, but all participants are free to take notes for their own use.

Panel members may not make any use of, and may not divulge to third parties, any non-public information they learned or accessed during the procedure, including but not limited to information, knowledge, documents or other matters that are communicated to them or brought to their attention.

Annex



Anhang D

SystemsX.ch und die Dateninfrastruktur

Fritz Sager, David Kaufmann und Johanna Künzler (2017), *Wirkungsprüfung SystemsX.ch – Bericht zum Mandat „SystemsX.ch und die Dateninfrastruktur“*, Bern: Kompetenzzentrum für Public Management, kpm

kpm, 29. September 2017

UNIVERSITÄT
BERN

Kompetenzzentrum für
Public Management

Wirkungsprüfung SystemsX.ch – Bericht zum Mandat „SystemsX.ch und die Dateninfrastruktur“

Prof. Dr. Fritz Sager

Dr. David Kaufmann

Johanna Künzler, M.A.

Bericht im Auftrag des Schweizerischen Wissenschafts- und Innovationsrats SWIR

Bern, 29. September 2017

Impressum

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Projektteam des Kompetenzzentrums für Public Management

Prof. Dr. Fritz Sager
Dr. David Kaufmann
Johanna Künzler, M.A.

Der Bericht gibt die Auffassung des Projektteams wieder, die nicht notwendigerweise mit derjenigen des Auftraggebers übereinstimmen muss.

Universität Bern
Kompetenzzentrum für Public Management
Schanzeneckstrasse 1, Postfach
CH – 3001 Bern
+41 31 631 53 11
kpm@kpm.unibe.ch

Zusammenfassung

Dieser Bericht untersucht die Rolle der nationalen Forschungsinitiative „Swiss Systems Biology Initiative (SystemsX.ch)“ bei den Entwicklungen nachhaltiger Dateninfrastruktur im Bereich der schweizerischen Systembiologie-Forschung. Die wichtigsten Erkenntnisse zu den untersuchten Fragen werden im Folgenden dargestellt.

(1) Was war der Ist-Zustand vor Beginn der Initiative bezüglich Dateninfrastruktur, was war der Bedarf der Institutionen, resp. der Forschenden (und wurde dieser erfüllt)?

Der Bedarf und das diesbezügliche Bewusstsein waren 2007 über die Forschungsprojekte hinweg sehr heterogen. Die interviewten RTD-Projektleitenden äusserten sich positiv bezüglich der Bedarfserfüllung.

(2) Wie sieht die heutige Situation im Bereich der Dateninfrastruktur für die Systembiologie aus?

Die zu verarbeitenden Datenmengen sowie die entsprechenden Infrastrukturen sind seit 2007 stark angestiegen. In der Deutschschweiz sind diese Infrastrukturen auf lokaler (universitärer) Ebene verankert, in der Romandie findet sich mit Vital-IT hingegen ein zentraler Ansprechpartner für alle universitären Hochschulen.

(3) Wie (und warum) veränderten sich Strategien, Strukturen und Schnittstellen in ausgewählten Institutionen zwischen 2007 und 2017?

Es lassen sich drei elementare Wendepunkte erkennen:

(1) Die Etablierung von SyBIT als Einheit mit eigenem Projektmanagement (2008)
(2) Der Richtungsentscheid des SNF, stärker auf die Forschung als auf Infrastruktur zu fokussieren (2010)
(3) Die Initiierung von FAIRDOM mit internationalen Partnern (2014)

Diese Veränderungen sind Ausdruck des fortbestehenden Spannungsfelds zwischen lokaler Verankerung von Dateninfrastruktur und Datenmanagement beziehungsweise der Aggregation desselben auf übergeordnete Ebenen.

(4) Welche Rolle spielte dabei SystemsX.ch als nationale Initiative bei der Förderung der Dateninfrastruktur?

SystemsX.ch und SyBIT waren entscheidend, um wissenschaftliche IT-Unterstützungseinheiten an Schweizer Universitäten zu etablieren. Die Forschenden sind grundsätzlich zufrieden mit den Leistungen von SyBIT. Der Output von SyBIT sei aber schwer zu messen.

(5) Wie ist die Implementierung von Dateninfrastrukturen in den Institutionen und die Unterstützung durch SystemsX.ch dafür insgesamt zu beurteilen (insbesondere bezüglich Nachhaltigkeit und Transparenz)?

Es konnte sich weder eine zentrale SyBIT-Organisationsstruktur noch eine zentrale Plattform zur Datenaufbewahrung aus den SystemsX.ch-Forschungsprojekten etablieren. SyBIT war jedoch entscheidend in der Implementation von nachhaltigen Softwarelösungen und für die Etablierung von wissenschaftlichen IT-Unterstützungseinheiten an Schweizer Universitäten. SyBIT war auch wichtig, um die Aufbewahrung von erhobenen Daten zu sichern.

(6) Was sind die Gründe, dass sich nicht eine einzige nachhaltige Organisationsstruktur kristallisierte?

Der Aufbau einer zentralen Organisationsstruktur und einer zentralen Datenplattform war zu Beginn von SyBIT angedacht, wurde aber aus den folgenden vier Gründen nie umgesetzt:

(1) Es gab keine Nachfrage der Forschenden bezüglich einer zentralisierten Organisationsstruktur. Die Forschenden wünschten sich eine projektbasierte Unterstützung.
(2) Die unterschiedlichen Datenformate machten es schwierig, Daten zentral abzulegen und diese auszuwerten.
(3) Es gab keine Steuerungsentscheide, an der geplanten zentralen Organisationsstruktur festzuhalten.
(4) „Politische Gründe" erschwerten die Zusammenarbeit. Darunter fallen die schwierige Zusammenarbeit zwischen Deutschschweizer und Westschweizer Organisationen, Verantwortungsstreitigkeiten und persönliche Meinungsverschiedenheiten zwischen Schlüsselpersonen.

Obwohl sich keine zentrale nachhaltige Struktur von SyBIT ergab, war SyBIT nachhaltig in Bezug auf Softwarelösungen und auf die dezentralen wissenschaftlichen IT-Unterstützungseinheiten. SyBIT konnte auch helfen, erhobene Daten öffentlich zu machen.

(7) Welche Lehren ziehen beteiligte Akteure daraus für künftige Vorhaben dieser Art?

Die Interviewpartner sind sich bezüglich Lehren aus dem Fall SystemsX.ch respektive SyBIT nicht einig. Die Mehrheit rät bei künftigen Projekten zu einer dezentralisierten Organisationstruktur und Dateninfrastruktur, vor allem wenn die Akteure und Daten sehr divers sind, wie etwa im Fall des SPHN. Andere Interviewpartner sehen hingegen Synergiepotential in einer zentralisierten Organisationsstruktur und Datenplattform, weil Spitäler eine solche Infrastruktur ihrer Meinung nach nicht selber aufbauen und betreiben könnten.

Der Bericht schliesst mit Empfehlungen für die Lancierung einer nationalen Plattform für die Datenlagerung, -analyse und den Datenaustausch unter verschiedenen Akteuren:

(1) Für eine erfolgreiche Projektdurchführung sind fixe, vertraglich geregelte Vorgaben vonseiten der Auftraggebenden zentral.
(2) Die Leistungsbereitschaft von Akteuren, deren Beitrag für den Erfolg des Projekts entscheidend ist (im Falle von SystemsX.ch: die Forschenden) sollte im Voraus abgeklärt und während der Projektdurchführung aktiv gefördert werden.
(3) Die Finanzierungssicherheit muss gegeben sein: Ein grösseres Projekt nationaler Ausrichtung braucht entsprechende und langfristige Ressourcen, die nicht zugleich für die Erfüllung anderer Aufgaben verwendet werden sollen.
(4) Die Planungssicherheit mittels stabiler Vorgaben über die Projektzeit hinweg muss gewährt sein.

Inhaltsverzeichnis

Abkürzungsverzeichnis

BoD	Board of Directors von SystemsX.ch
C-ISD	Center for Information Sciences and Databases, ETH Zürich
ETH Zürich	Eidgenössische Technische Hochschule Zürich
FAIRDOM	"Findable, Accessible, Interoperable and Reusable, Data, Operating Procedures and Models". Internationale Plattform für Datenmanagement und -publikation
iBRAIN2	Analysesoftware von Mikroskopbildern
NFS	Nationaler Forschungsschwerpunkt
openBIS	Software zum Verwalten und Teilen biologischer Forschungsdaten
RTD-Projekte	Research, Technology and Development Projekte
sciCORE	Center for Scientific Computing, Universität Basel
SEB	Scientific Executive Board von SystemsX.ch
SIB	Swiss Institute of Bioinformatics
SIS	Scientific IT Services, ETH Zürich
SNF	Schweizerischer Nationalfonds
SPHN	Swiss Personalized Health Network
SWIR	Schweizerischer Wissenschafts- und Innovationsrat
SyBIT	SystemsX.ch Biology IT
SystemsX.ch	Swiss Systems Biology Initiative
S3IT	Service and Support for Science IT, Universität Zürich
Vital-IT	Competence Center in Bioinformatics and Computational Biology, affiliiert an der Universität Lausanne

1 Einleitung

1.1 Auftrag und Hintergrund

Dieser Bericht untersucht die Rolle der nationalen Forschungsinitiative „Swiss Systems Biology Initiative (SystemsX.ch)“ bei den Entwicklungen nachhaltiger Dateninfrastruktur im Bereich der schweizerischen Systembiologie-Forschung. Der Schweizerische Wissenschafts- und Innovationsrat (SWIR) hat das Projektteam um Prof. Dr. Fritz Sager vom Kompetenzzentrum für Public Management der Universität Bern beauftragt, den Zeitraum 2007 bis 2017 anhand je einer Momentaufnahme des Anfangs- und Endzeitpunkts sowie anhand einer vertieften Betrachtung der Strukturen, Akteure und Prozesse zu analysieren. Die folgenden Fragen sollen beantwortet werden:

(1) Was war der Ist-Zustand vor Beginn der Initiative bezüglich Dateninfrastruktur, was war der Bedarf der Institutionen, resp. der Forschenden (und wurde dieser erfüllt)?
(2) Wie sieht die heutige Situation im Bereich der Dateninfrastruktur für die Systembiologie aus?
(3) Wie (und warum) veränderten sich Strategien, Strukturen und Schnittstellen in ausgewählten Institutionen zwischen 2007 und 2017?
(4) Welche Rolle spielte dabei SystemsX.ch als nationale Initiative bei der Förderung der Dateninfrastruktur?
(5) Wie ist die Implementierung von Dateninfrastrukturen in den Institutionen und die Unterstützung durch SystemsX.ch dafür insgesamt zu beurteilen (insbesondere bezüglich Nachhaltigkeit und Transparenz)?
(6) Was sind die Gründe, dass sich nicht eine einzige nachhaltige Organisationsstruktur kristallisierte?
(7) Welche Lehren ziehen beteiligte Akteure daraus für künftige Vorhaben dieser Art?

Um die Lehren für zukünftige Projekte anhand eines konkreten Beispiels formulieren zu können, richten sich die Beantwortung der letzten Frage und die allgemeinen Schlussfolgerungen nach Projekten in der Grösse des *Swiss Personalized Health Network* (SPHN).

1.2 Vorgehen und Aufbau

Beim vorliegenden Bericht handelt es sich um keine klassische Evaluation. Vielmehr wird mittels der zwei Momentaufnahmen von 2007 und 2017 wie auch gezielten Einblicken in den dazwischen stattfindenden Prozess die Entwicklung auf nationaler und subnationaler Ebene erarbeitet. Zum vertieften Verständnis der heutigen Situation wurden nebst der Initiative an sich die drei lokalen Fälle Universität Zürich, Universität Bern und Universität Genf genauer untersucht.

Die Datenerhebung erfolgte mittels zweier Ansätze: Die durch den SWIR erhaltenen Dokumente wurden untersucht und falls notwendig um zusätzliche Unterlagen ergänzt. Es wurden zudem qualitative Interviews mit Schlüsselakteuren der nationalen Ebene (SystemsX.ch, dessen Biology IT-Abteilung SyBIT und der Schweizerische Nationalfonds SNF) sowie der drei lokalen Fälle durchgeführt. Eine Liste der Interviewpartner findet sich im Appendix.

Die Datenauswertung erfolgte nach qualitativen Kriterien, wobei die gewonnenen Informationen zusammengeführt und in ihrer Gesamtheit zur Beantwortung der oben festgelegten Fragestellungen berücksichtigt wurden. Nach einer chronologischen Darstellung der untersuchten Ereignisse erfolgt die

Präsentation der Resultate entlang der Fragestellungen. Die zentralen Erkenntnisse finden sich zu Beginn jedes Unterkapitels in einem Informationskasten. Der Bericht endet mit einem Fazit des Projektteams.

2 Chronologie der Ereignisse

Es folgt eine Darstellung des zeitlichen Ablaufs bezüglich SyBIT und der Entwicklung von Dateninfrastrukturen, wie er sich anhand der vom SWIR erhaltenen Unterlagen und der geführten Interviews mit verschiedenen Schlüsselakteuren präsentiert.

Oktober 2007	Die schweizerischen National- und Ständeräte bewilligen einen Kredit von 100 Mio. CHF, um die nationale Forschungsinitiative „SystemsX.ch“ zur Förderung der Zusammenarbeit im Bereich der Systembiologie zu unterstützen. Die Initiative stellt einen Verbund der sieben Partner ETH Zürich, EPF Lausanne sowie der Universitäten Basel, Bern, Genf, Lausanne und Zürich dar. Anders als die vom SNF lancierten und finanzierten Nationalen Forschungsschwerpunkte (NFS) erhält SystemsX.ch seine Ressourcen direkt vom Bund sowie von den oben erwähnten Partnern. Der SNF wird jedoch in die Organisationsstruktur der Forschungsinitiative einbezogen. Er soll mittels eines internationalen Expertenpanels die zu unterstützenden Forschungsprojekte auswählen und so die wissenschaftliche Qualität absichern.
Ende 2007 bis Mai 2008	Bei SystemsX.ch ist man sich einig, dass die Systembiologieforschung vor grossen Herausforderungen steht bezüglich der Datengenerierung, -verarbeitung und -wartung. Um dem zu begegnen, erarbeiten die beiden bestehenden Bioinformatik-Institutionen C-ISD (Center for Information Sciences and Databases, ETH Zürich) und Vital-IT (Competence Center in Bioinformatics and Computational Biology, Teil des Swiss Institute of Bioinformatics SIB) ein Konzept für das Projekt „SyBIT“. SyBIT soll eine IT-Unterstützungseinheit sein, welche für die RTD-Projekte (Research, Technology and Development) in SystemsX.ch arbeitet. Die Zusammenarbeit innerhalb von SyBIT stellen sich die Initianten so vor, dass C-ISD hauptsächlich Software-Lösungen für die Forschenden entwickeln soll, während die ETH Zürich im östlichen und Vital-IT im westlichen Teil der Schweiz die benötigten Datenspeicherungs- und Datenverarbeitungskapazitäten zur Verfügung stellen.
August 2008	Das für SystemsX.ch zuständige Expertenpanel des SNF lehnt den Vorschlag von C-ISD und Vital-IT ab. Nebst kleineren kritischen Anmerkungen wird hauptsächlich gefordert, dass die Organisationsstruktur von SyBIT zentraler angelegt sein sollte. Ein von den bestehenden Institutionen unabhängiges Management solle im Science Executive Board (SEB) von SystemsX.ch vertreten sein, um die Steuerung des Projekts zu erleichtern.
September bis Oktober 2008	Das SEB erstellt ein neues Konzept für SyBIT, unter Berücksichtigung der Kommentare des SNF. Das Konzept wird vom Board of Directors (BoD) von SystemsX.ch genehmigt und an den SNF geschickt.

November bis Dezember 2008	Die Stelle des Projektmanagers von SyBIT wird ausgeschrieben und mit Peter Kunszt besetzt.
Januar 2009	Der SNF bewilligt das revidierte Konzept für SyBIT.
April 2009	Peter Kunszt definiert eine „Datenstrategie“ für SyBIT. Er schlägt ein Mixmodell aus voller Integration auf RTD-Projektebene sowie externer Integration auf übergeordneter Ebene vor. - Volle Integration: Die Forschungsgruppen innerhalb eines RTDs sollen auf gemeinsame Infrastrukturen zurückgreifen und ihre Daten auf einheitliche Weise sowie zugänglich für alle Mitarbeitenden abspeichern. - Externe Integration: SyBIT soll eine Meta-Datenplattform erstellen und betreuen, auf welcher Informationen zu den einzelnen RTD-Projekten und den in ihnen verwendeten Daten abgespeichert sind. Die Meta-Datenplattform soll für alle Forschenden innerhalb von SystemsX.ch zugänglich sein und den gegenseitigen Austausch sowie Synergien ermöglichen.
Dezember 2009	SystemsX.ch präsentiert dem SNF die Strategieplanung für die zweite Phase des Projekts, 2012-2016. Bezüglich SyBIT wird erwähnt, dass das Ziel einer integrierten IT-Infrastruktur weiterverfolgt werden soll.
Mai 2010	Der SNF bezieht Stellung zur Strategieplanung von SystemsX.ch. Nebst anderen Punkten formuliert er die Empfehlung, SystemsX.ch solle sich in der zweiten Phase auf die Forschung konzentrieren und den Aufbau neuer Infrastrukturen auf das Nötigste beschränken.
2010 bis 2014	An den Universitäten Zürich und Basel werden neue IT-Unterstützungseinheiten (Service and Support for Science IT S3IT respektive Center for Scientific Computing sciCORE) gegründet. C-ISD wird geschlossen, die Mitarbeitenden werden in die neue Abteilung Science IT Services (SIS) der ETH Zürich transferiert. Die Universität Bern eröffnet die Interfaculty Bioinformatics Unit, die einen Vertrag mit Vital-IT abschliesst, jedoch nicht in Zusammenarbeit mit SystemsX.ch oder SyBIT auf- und ausgebaut wird.
Frühling 2014	FAIRDOM (Findable, Accessible, Interoperable and Reusable, Data, Operating Procedures and Models) wird lanciert, ein Datenmanagement-Projekt, das nebst SystemsX.ch finanziert wird durch den *Biotechnology and Biological Sciences Research Council* aus Grossbritannien, das *Bundesministerium für Bildung und Forschung* aus Deutschland und die *Netherlands Organisation for Scientific Research* aus den Niederlanden. Erkenntnisse aus SyBIT fliessen in dieses neue, europäische Projekt ein.
August 2015	Peter Kunszt kündet seine Stelle an der Universität Zürich und tritt somit auch als Manager von SyBIT zurück. Bernd Rinn, Leiter von SIS, übernimmt die Nachfolge im SyBIT-Management.
Dezember 2018	Projektende von SystemsX.ch (angekündigt).

3 Beantwortung der Forschungsfragen

3.1 Was war der Ist-Zustand vor Beginn der Initiative bezüglich Dateninfrastruktur, was war der Bedarf der Institutionen, resp. der Forschenden (und wurde dieser erfüllt)?

Der Bedarf und das diesbezügliche Bewusstsein waren 2007 über die Forschungsprojekte hinweg sehr heterogen. Die interviewten RTD-Projektleitenden äusserten sich positiv bezüglich der Bedarfserfüllung.

Die interviewten Personen sowohl aus der Deutschschweiz als auch aus der Romandie waren sich einig, dass der Bedarf der Forschenden bezüglich Dateninfrastruktur 2007 sehr heterogen war. Experten im Bereich Datenmanagement hätten vorausgesehen, dass die Systembiologieforschung vor grossen Herausforderungen stand und ihre Infrastrukturen entsprechend würde anpassen müssen. Einzelne Leitende von Forschungsprojekten waren sich dieser kommenden Entwicklung ebenfalls bewusst und zögerten deshalb nicht, konkrete Forderungen an SystemsX.ch zu stellen. Ein Grossteil der Forschenden sei allerdings stark in den klassischen Methoden der Labor-Biologieforschung verankert gewesen, sodass sie allfällige künftige Bedürfnisse nicht kannten und entsprechend keine Wünsche formulieren konnten. Bei diesen Projekten war es entscheidend, dass SyBIT proaktiv kommunizierte und die neuen Möglichkeiten aufzeigte.

Der allgemeine Eindruck widerspiegelte sich auch in den Interviews, die mit Forschungsprojektleitern verschiedener SystemsX.ch-Projekte geführt wurden. Sie alle hatten zu Beginn ihres Projektes – teilweise wesentlich später als 2007 – sehr spezifische Anforderungen im Bereich der Dateninfrastruktur zu bewältigen und waren froh, hierbei Unterstützung von SyBIT zu erhalten. Ihre Bedürfnisse wurden laut eigenen Angaben vollumfänglich durch SyBIT erfüllt. Es ist allerdings zu erwähnen, dass die untersuchte Stichprobe der Projektleitenden selektiv war und daher nicht als repräsentativ bezeichnet werden kann.

Ein Blick in die 2016 von SystemsX.ch durchgeführte Umfrage bei den Projektleitenden zeigt, dass ein Grossteil von ihnen ähnlicher Meinung war. Die Dienstleistungen wurden als „good“, „very good“ und „excellent“ bezeichnet. Es zeigt sich jedoch in einigen Rückmeldungen, dass die Unterstützung SyBITs teilweise aufgrund bestehender, lokaler IT-Supports obsolet war. Wenige Projektleitende gaben ausserdem zu Protokoll, dass sie keine Unterstützung von SyBIT erhalten hatten und den Sinn von SyBIT für ihr Projekt auch nicht erkennen konnten.

3.2 Wie sieht die heutige Situation im Bereich der Dateninfrastruktur für die Systembiologie aus?

Die zu verarbeitenden Datenmengen sowie die entsprechenden Infrastrukturen sind seit 2007 stark angestiegen. In der Deutschschweiz sind diese Infrastrukturen auf lokaler (universitärer) Ebene verankert, in der Romandie findet sich mit Vital-IT hingegen ein zentraler Ansprechpartner für alle universitären Hochschulen.

Die von Experten vorhergesagten Entwicklungen (vgl. Frage 3.1) sind grösstenteils eingetroffen. Forschende im Bereich der Systembiologie arbeiten mit massiv erhöhten Datenmengen, wozu entspre-

chende Analyse- und Wartungskenntnisse benötigt werden. Die Anforderungen bezüglich Zusammenarbeit, Transparenz und Publikation von Daten sind ebenfalls gestiegen. Dennoch existieren in der Schweiz keine zentralisierten Lösungen. Es wird stattdessen weiterhin mit lokalen Strukturen und Supportgruppen gearbeitet.

Die Universitäten in der Deutschschweiz können hierzu jeweils auf eigene IT-Unterstützungseinheiten zurückgreifen, namentlich sciCORE (Universität Basel), S3IT (ETH Zürich), SIS (Universität Zürich) und die Interfaculty Bioinformatics Unit (Universität Bern). In der Romandie stellt hingegen das an der Universität Lausanne angesiedelte Institut Vital-IT den zentralen Ansprechpartner für alle Forschenden in Lausanne und Genf dar. Vital-IT bestand im Unterschied zu den Einheiten der Deutschschweiz bereits vor Beginn von SystemsX.ch und diente den nachfolgenden Institutionen als Modell.

3.3 Wie (und warum) veränderten sich Strategien, Strukturen und Schnittstellen in ausgewählten Institutionen zwischen 2007 und 2017?

Es lassen sich drei elementare Wendepunkte erkennen:

(1) Die Etablierung von SyBIT als Einheit mit eigenem Projektmanagement (2008)
(2) Der Richtungsentscheid des SNF, stärker auf die Forschung als auf Infrastruktur zu fokussieren (2010)
(3) Die Initiierung von FAIRDOM mit internationalen Partnern (2014)

Diese Veränderungen sind Ausdruck des fortbestehenden Spannungsfelds zwischen lokaler Verankerung von Dateninfrastruktur und Datenmanagement beziehungsweise der Aggregation desselben auf übergeordnete Ebenen.

Die nachfolgenden Ausführungen beziehen sich nicht auf die Systembiologie-Forschung in der Schweiz generell, sondern auf die Entwicklungen im Umfeld von SystemsX.ch und SyBIT. In Bezug auf die Dateninfrastruktur und das Datenmanagement konnten drei elementare Wendepunkte identifiziert werden:

(1) *Die Etablierung von SyBIT als Einheit mit eigenem Projektmanagement (2008):* Bereits bei der Etablierung von SyBIT eröffnete sich in der Diskussion der verschiedenen Konzepte ein Spannungsfeld zwischen rein lokalem Support für einzelne Forschungsprojekte und dem Versuch, mit SyBIT eine übergeordnete Plattform für die ganze Schweiz zu schaffen. Während der Vorschlag von C-ISD und Vital-IT sich eher am Modell des lokalen Supports orientierte, versuchte der SNF mit seiner Ablehnung des Konzepts und den begleitenden Verbesserungsvorschlägen, einen zentralisierenderen Weg einzuschlagen. Das SEB entschied sich mit Genehmigung des BoD schliesslich für einen Mittelweg: SyBIT sollte zwar einen von den bestehenden Institutionen unabhängigen Projektmanager haben, der auch in den Entscheidungsgremien der nationalen Forschungsinitiative vertreten ist. Gleichzeitig sollten er und seine Mitarbeitenden ihre Arbeit jedoch gänzlich an den Bedürfnissen der RTDs ausrichten und jeweils lokal sowie für begrenzte Zeit Hilfestellungen bieten. Der neu eingestellte Projektmanager von SyBIT, Peter Kunszt, erarbeitete kurz nach seiner Anstellung eine hierzu passende Datenstrategie. Während die Daten innerhalb der RTDs völlig integriert und allen Mitarbeitenden zugänglich gemacht werden sollten, würde SyBIT zusätzlich eine nationale Meta-Datenplattform erstellen, die Informationen über alle RTDs innerhalb von SystemsX.ch bereithalten und den Forschenden den Austausch sowie die Erkennung allfälliger Synergien erleichtern sollte.

(2) *Der Richtungsentscheid des SNF, stärker auf die Forschung als auf Infrastruktur zu fokussieren (2010):* In der Antwort auf die von SystemsX.ch erstellte Strategieplanung für die zweite Phase der Forschungsinitiative formulierte der SNF die Empfehlung, dass SystemsX.ch seine Ressourcen künftig stärker auf die Förderung der Forschung und weniger auf den Aufbau neuer Infrastrukturen fokussieren soll. Während der Impuls zu dieser Richtungsänderung formell also vom SNF kam, ging aus den Interviews mit beteiligten Akteuren hervor, dass ihm ein iterativer Prozess zwischen den verschiedenen Entscheidungsebenen vorausgegangen war. Die Mitarbeitenden von SyBIT und SystemsX.ch hatten in ihrer Zusammenarbeit mit den Forschenden festgestellt, dass der Bedarf nach einer zentralisierteren Plattform fehlte. Beratungen über das weitere Vorgehen führten schliesslich zum besagten Strategiewechsel. Eine Folge dieses Entscheids war auch die verstärkte Fokussierung von SyBIT und SystemsX.ch auf die Förderung der lokalen Verankerung der entwickelten Softwareprodukte und Dateninfrastrukturen.

(3) *Die Initiierung von FAIRDOM mit internationalen Partnern (2014):* Mit dem Aufbau von FAIRDOM ist ein letzter, partieller Strategiewechsel von SyBIT und SystemsX.ch bezüglich des Datenmanagements erkennbar. Das von öffentlichen Institutionen in der Schweiz, Grossbritannien, Deutschland und den Niederlanden gestützte Projekt bietet Forschenden im Bereich der Systembiologie verschiedene Möglichkeiten an, um komplexe Forschungsprojekte mit unterschiedlichen Datensätzen, verschiedenen Methoden und mehreren involvierten Akteuren oder Institutionen handhabbarer und einfacher zugänglich zu machen. Zusätzlich wurde mit dem FAIRDOMhub ein online zugängliches Register kreiert, um Daten und Modelle abzuspeichern, zu teilen und zu publizieren. SystemsX.ch und SyBIT tragen damit zu einer Lösung auf internationaler Ebene bei, die auf nationaler Ebene zwar angepeilt, aber nicht realisiert wurde.

Auf die Gründe, weshalb mit SyBIT in der Schweiz nie eine zentrale Organisationsstruktur und eine zentrale Datenplattform entstanden sind, wird bei Frage 3.6 genauer eingegangen.

3.4 Welche Rolle spielte dabei SystemsX.ch als nationale Initiative bei der Förderung der Dateninfrastruktur?

SystemsX.ch und SyBIT waren entscheidend, um wissenschaftliche IT-Unterstützungseinheiten an Schweizer Universitäten zu etablieren. Die Forschenden sind grundsätzlich zufrieden mit den Leistungen von SyBIT. Der Output von SyBIT sei aber schwer zu messen.

SyBIT war wichtig, um die Bildung von wissenschaftlichen IT-Unterstützungseinheiten an Schweizer Universitäten voranzutreiben. Zusammen mit Partnern der ETHZ hat SyBIT die Gründung der Abteilung SIS an der ETHZ angestossen. Andere Beispiele von neuen wissenschaftlichen IT-Unterstützungseinheiten an Deutschschweizer Universitäten sind wie bereits erwähnt S3IT, Universität Zürich und sciCORE, Universität Basel. In der Romandie behält Vital-IT die Rolle der wissenschaftlichen IT-Unterstützung für alle in diesem Bereich arbeitenden Institutionen. Die Universität Bern baute eigenständig und in Kooperation mit Vital-IT, allerdings ohne direkte Zusammenarbeit mit SyBIT, eine IT-Unterstützungseinheit auf (Interfaculty Bioinformatics Unit).

Generell wurden die Arbeit von SyBIT und die der wissenschaftlichen IT-Unterstützungseinheiten von den Interviewpartnern geschätzt. Die damaligen Verantwortlichen von SyBIT sahen ihre Rolle einerseits als Koordinatoren, indem sie die Forschenden mit neuen technologischen Ideen stimulierten und die Zusammenarbeit zwischen den Forschenden initiierten. In der Selbstevaluation wird erwähnt, dass

SyBIT zu einem Kulturwandel sowie zu vermehrter Kollaboration zwischen systembiologischen Forschungsgruppen und wissenschaftlichen IT-Unterstützungseinheiten beigetragen hat. Andererseits agierte SyBIT als ein Beschleuniger („accelerator"), indem schnelle und unkomplizierte Zugänge zu Ressourcen ermöglicht wurden. Ein interviewter Projektleiter hält fest, dass eine solche projektbasierte und forschungsorientierte Ausrichtung die Bedürfnisse der Forschenden gut abdecke. SyBIT sei aktiv auf seine Forschungsgruppe zugegangen und habe sich nach deren Bedürfnissen erkundet. Darum sei SyBIT essentiell für den Erfolg seiner Forschungsprojekte geworden.

Die Selbstevaluation von SystemsX.ch zeigt, dass die SyBIT-Dienstleistungen nicht von allen SystemsX.ch-Forschungsprojekten in Anspruch genommen wurden, was vonseiten der Verantwortlichen von SystemsX.ch mit den unterschiedlichen Bedürfnissen der Forschenden und mit den zu geringen Kenntnissen der Dienstleistungen von SyBIT begründet wird. Ein Interviewpartner erwähnte, dass die heterogene Nutzung und Evaluation von SyBIT Ausdruck der unterschiedlichen Bedürfnisse der Forschenden sei, überhaupt Dienstleistungen von SyBIT wahrzunehmen.

Verschiedene Interviewpartner erwähnten, dass es schwierig sei, die Wirkung von SyBIT zu evaluieren, weil bezüglich der Arbeit von SyBIT keine Leistungsdaten erhoben wurden. So hatte SyBIT auch immer Probleme, seine Arbeit zu rechtfertigen: Dem Expertenpanel des SNF konnte zum Beispiel keine Liste mit Publikationen vorlegt werden, bei denen ersichtlich geworden wäre, dass SyBIT mitgewirkt hatte.

3.5 Wie ist die Implementierung von Dateninfrastrukturen in den Institutionen und die Unterstützung durch SystemsX.ch dafür insgesamt zu beurteilen (insbesondere bezüglich Nachhaltigkeit und Transparenz)?

Es konnte sich weder eine zentrale SyBIT-Organisationsstruktur noch eine zentrale Plattform zur Datenaufbewahrung aus den SystemsX.ch-Forschungsprojekten etablieren. SyBIT war jedoch entscheidend in der Implementation von nachhaltigen Softwarelösungen und für die Etablierung von wissenschaftlichen IT-Unterstützungseinheiten an Schweizer Universitäten. SyBIT war auch wichtig, um die Aufbewahrung von erhobenen Daten zu sichern.

SyBIT hat nie eine zentrale Meta-Datenplattform erstellt, wie es in der Datenstrategie von Peter Kunszt 2009 definiert wurde (Gründe dafür werden im Unterkapitel 3.6 diskutiert). Die Nachhaltigkeit von SyBIT zeigt sich aber einerseits in Software-Lösungen, die immer noch verwendet und weiterentwickelt werden, und anderseits in den dezentralen wissenschaftlichen IT-Unterstützungseinheiten, die an Schweizer Universitäten angegliedert sind.

Die Relevanz von SyBIT für das Entstehen dieser dezentralen wissenschaftlichen IT-Unterstützungseinheiten wurde bereits in Unterkapitel 3.4 diskutiert. Es war eine bewusste Nachhaltigkeitsstrategie von SystemsX.ch und SyBIT, die Schaffung dieser IT- Unterstützungseinheiten an den Universitäten zu unterstützen. Als sich abzeichnete, dass keine zentrale Organisationsstruktur entstehen würde, wurden diese dezentralen Einheiten gefördert. Die Verantwortlichen von SystemsX.ch kontaktierten direkt die Universitätsleitungen, um diese zum Aufbau von wissenschaftlichen IT-Unterstützungseinheiten zu bewegen. So entstand zum Beispiel sciCORE an der Universität Basel. Diese wissenschaftlichen IT-Einheiten kooperieren heute über das Programm „P-5 Wissenschaftliche Information" von swissuniversities. Die Forschenden begrüssten, dass es weiterhin Strukturen gibt, die IT-Unterstützungsdienstleistungen anbieten. Ein Forschender schätzte die räumliche Nähe zu diesen wissenschaftlichen IT-Unterstützungseinheiten, um Probleme schnell und effizient zu lösen. Es wurde jedoch von einem Interviewpartner angefügt, dass eine Gefahr der Dezentralisierung sei, dass diese wissenschaftlichen IT-

Unterstützungseinheiten bei den IT-Universitätsdiensten angeschlossen werden. Die Arbeitsweise dieser zwei IT-Einheiten sei sehr verschieden: Während die wissenschaftlichen IT-Unterstützungseinheiten mit einer wissenschaftlichen Projektlogik funktionierten, würden die IT-Universitätsdienste eher mit einer routinehaften Arbeitsweise operieren.

SyBIT hat mitgeholfen, verschiedene Softwarepakete selbst zu entwickeln oder „open source"-Software weiterzuentwickeln. Grundsätzlich sind die meisten Softwareprodukte, die mit SyBIT-Geld erstellt wurden, öffentlich verfügbar (open source). 40-50% der Software seien aber nicht lange haltbar, weil diese nur für spezifische Forschungsprojekte entwickelt worden seien. Es komme selten vor, dass Software-Lösungen zu einem viel benutzten Standard werden. Vor allem das Open Biology Information System (openBIS)[1], aber auch iBRAIN2[2], wurden in den Interviews als Beispiele für nachhaltige Softwarelösungen erwähnt. Ein interviewter Forschender wird openBIS auch nach dem Projektende SyBITs weiternutzen. Zudem wird openBIS auch in der europäischen Forschungszusammenarbeit FAIRDOM genutzt. openBIS war des Weiteren die Grundlage für die Weiterentwicklung der Sofware iBRAIN zu iBRAIN2. In dieser Weiterentwicklung sei SyBIT sehr hilfreich gewesen. iBRAIN2 wird unterdessen auch an der ETH Zürich sowie an den Universitäten Zürich und Basel genutzt.

Die oben erwähnten Verankerungsversuche auf lokaler Ebene und die Verwendung von „open source" Software tragen auch wesentlich zur Transparenz dessen bei, was SyBIT in den vergangenen Jahren erarbeitet hat. Der aktiv ausgeübte Druck von SystemsX.ch und SyBIT, die Datenaufbewahrung nach Beendigung der Forschungsprojekte sicherzustellen, habe zudem laut Interviewpartnern die Wirkung gehabt, dass sich einige Forschende bewusst wurden, dass sie in die Langlebigkeit ihrer Daten investieren müssen (Life Cycle of Data). Der SNF verlangt neu einen Data Management Plan. SystemsX.ch verlangt dies bereits seit 8-10 Jahren. Es sei aber teuer, Daten langfristig aufzubewahren, da die Datenmengen exponentiell wachsen. Die Daten werden zwar dezentral aufbewahrt, aber zumindest sei die Datenaufbewahrung langfristig gesichert, weil die Universitäten die Datenaufbewahrung zahlen würden.

3.6 Was sind die Gründe, dass sich nicht eine einzige nachhaltige Organisationsstruktur kristallisierte?

Der Aufbau einer zentralen Organisationsstruktur und einer zentralen Datenplattform war zu Beginn von SyBIT angedacht, wurde aber aus den folgenden vier Gründen nie umgesetzt:

(1) Es gab keine Nachfrage der Forschenden bezüglich einer zentralisierten Organisationsstruktur. Die Forschenden wünschten sich eine projektbasierte Unterstützung.
(2) Die unterschiedlichen Datenformate machten es schwierig, Daten zentral abzulegen und diese auszuwerten.
(3) Es gab keine Steuerungsentscheide, an der geplanten zentralen Organisationsstruktur festzuhalten.
(4) „Politische Gründe" erschwerten die Zusammenarbeit. Darunter fallen die schwierige Zusammenarbeit zwischen Deutschschweizer und Westschweizer Organisationen, Verantwortungsstreitigkeiten und persönliche Meinungsverschiedenheiten zwischen Schlüsselpersonen.

[1] openBIS ermöglicht das Verwalten und Teilen biologischer Forschungsdaten.
[2] iBRAIN2 ist eine Analysesoftware von Mikroskopbildern, die über Rechnerverbunde (Computercluster) funktioniert.

Obwohl sich keine zentrale nachhaltige Struktur von SyBIT ergab, war SyBIT nachhaltig in Bezug auf Softwarelösungen und auf die dezentralen wissenschaftlichen IT-Unterstützungseinheiten. SyBIT konnte auch helfen, erhobene Daten öffentlich zu machen.

Aus den geführten Interviews ergaben sich vier Gründe, warum sich keine zentrale Organisationsstruktur und keine zentrale Dateninfrastruktur gebildet haben.

(1) Es gab keine bis wenig Nachfrage der Forschenden, ihre Daten auf einer zentralen Datenplattform abzulegen. Sie präferierten stattdessen dezentrale IT-Unterstützungseinheiten, die räumlich näher sind und sie deshalb gezielter unterstützen können. Ein Interviewpartner beurteilte den Strategiewechsel von SyBIT (von einem Mixmodell zu vollkommen dezentral) „als eine Anpassung an die Realität. Der Strategiewechsel wurde von den Forschenden angestossen. Wir haben in Workshops gemerkt, dass alle anders arbeiten". In ähnlicher Weise beschrieb ein Forscher, dass man schrittweise realisierte, dass eine Datenintegration in eine zentrale Plattform zu kompliziert sei (siehe Punkt 2). Zudem gab es keine Nachfrage von Forschenden, Daten auszuwerten, die andere Forschungsgruppen erhoben hatten. Verschiedene Interviewpartner erwähnten, dass sich eine zentrale Organisationsstruktur nach aussen vielversprechend anhöre und somit auch geeignet sei, um an Forschungsgelder zu gelangen, dass es aber nicht wirklich sinnvoll sei, um Forschung zu betreiben. Ein Interviewpartner meinte, dass es für Forschende nicht wirklich interessant sei, Energie und Ressourcen für das Teilen von Daten aufzuwenden, wenn sie eigentlich forschen und publizieren sollten. Es sei auch unklar, wie man als Forschender Anerkennung für seine erhobenen Daten bekommen würde. Es müsse erst einmal Vertrauen entstehen, dass es einen Mehrwert geben kann, die erhobenen Daten zu teilen. Ein anderer Forscher sah nicht viele Vorteile für seine eigenen Projekte, wenn die Daten geteilt würden. Es sei jedoch nicht so, dass Forschende per se ihre Daten nicht teilen wollten. Mit der Einrichtung von Sperrfristen etwa würden prinzipiell Lösungen existieren, die es den Forschenden ermöglichen, ihre eigenen Daten für sich „auszuschlachten", bevor sie sie der restlichen Forschergemeinschaft zur Verfügung stellen. Ein Interviewpartner fasste zusammen, dass SyBIT auch etabliert worden sei, damit die Universitäten Geld für wissenschaftlichen IT-Support erhalten. Den Mehrwert für eine übergeordnete Plattform hätten die Forschenden nicht gesehen, auch weil dies ein zusätzlicher Aufwand für sie gewesen wäre.

(2) Während der erste Grund vor allem den zusätzlichen Aufwand für die Forschenden sowie das fehlende Bedürfnis von ihrer Seite betont, fokussiert der zweite Grund auf die technischen Schwierigkeiten beim Teilen der Daten. Verschiedene Interviewpartner betonten, dass die Daten in den Life Sciences fragmentiert seien und dass sehr diverse Datenformate gebraucht würden. Es gibt verschiedenste Methoden und Techniken, um biologische Daten zu erheben. Als Beispiele wurden Unterschiede in den Datenformaten zwischen sequentiellen DNA-Daten und Mikroskop-Bildern genannt. Diese erhobenen Daten müssten zuerst standardisiert werden, damit sie analysiert werden könnten. Dazu wiederum bräuchte es zuerst Grundlagenforschung um zu eruieren, wie eine solche Standardisierung vonstattengehen könnte.

(3) Kein Steuerungsorgan, weder SEB noch SNF, habe auf einer zentralen Organisationsstruktur und einer zentralen Datenplattform bestanden. Schon zu Beginn von SyBIT verlangte das SEB von SyBIT einen Fokus auf Forschungsunterstützung. SyBIT sollte sich hauptsächlich um Forschungsgruppen kümmern, die nicht so versiert waren bezüglich IT-Lösungen. Der Aufbau einer Datenplattform war höchstens ein sekundäres Ziel. Der Entscheid, dass keine zentrale Lösung für die Datenaufbewahrung angestrebt werden soll, ging wie unter 3.3 erwähnt von den Forschenden aus. In einem iterativen Prozess konnten sie ihre Bedürfnisse in die Steuerungsorgane speisen. Somit war es für das SEB und für den SNF klar, dass eine dezentrale Organisationsstruktur und eine dezentrale Datenaufbewahrung geschaffen werden muss. Das SEB hat

daraufhin SyBIT konkret angewiesen, mehr Forschungsunterstützung zu leisten und mitzuhelfen, dass sich dezentrale wissenschaftliche IT-Unterstützungseinheiten ausbreiten können (siehe auch Antwort 3.4). Auch der SNF wies SyBIT an, sich nicht mehr auf die Schaffung einer zentralen Datenplattform zu konzentrieren, sondern sich im Angesicht der beschränkten Projektdauer von SyBIT auf die Stärkung der lokalen Infrastrukturen an den Universitäten zu konzentrieren.

(4) Verschiedene zusätzliche Gründe, die in den Interviews genannt wurden, können unter dem Stichwort „politische Gründe" zusammengefasst werden. Erstens wurde mehrmals erwähnt, dass es unterschiedliche Arbeitsweisen zwischen Forschungsgruppen in der Deutschschweiz und der Romandie gab. So war in der Romandie nur ein Institut (Vital-IT) für SystemsX.ch verantwortlich, während in der Deutschschweiz dezentraler gearbeitet wurde. Diese Unterschiede hätten bereits vor SystemsX.ch bestanden. Es wurde betont, dass SyBIT durchaus half, die Zusammenarbeit zwischen den zwei Sprachregionen zu verbessern. Dies zeigt sich auch an den vielen Projekten, die über die Sprachgrenze hinweg realisiert wurden. Zweitens gab es zwischen den SystemsX.ch-Partnern vor allem vor dem Projektbeginn SyBITs Meinungsverschiedenheiten bezüglich der Verantwortung über dieses IT-Projekt. Der grösste Streitpunkt war die Kontrolle über die zentrale Organisationsstruktur respektive die Frage, wer über die Geldverteilung bestimmen kann. Ein Interviewpartner meinte: „Eine top-down Organisation und eine zentrale Dateninfrastruktur hätten vielleicht die Arbeit erleichtert, aber es war einfach nicht durchsetzbar. Es gab mal die Idee, eine zentrale Dateninfrastruktur im „neutralen" Wallis zu erstellen, aber dies kam auch nicht zu Stande." Mehrere Interviewpartner betonten auch, dass die Universitäten im föderalen System der Schweiz relativ autonom agieren könnten, was Zentralisierungsversuche erschweren würde. Drittens gab es persönliche Schwierigkeiten zwischen verschiedenen Schlüsselpersonen innerhalb von SyBIT. Diese Konflikte waren hauptsächlich zu Anfangszeiten von SyBIT vorhanden und wurden danach ausgeräumt. Verschiedene Interviewpartner meinten aber, dass diese persönlichen Probleme nicht ausschlaggebend gewesen seien in Bezug auf die fehlende Ausbildung einer zentralen Organisationsstruktur.

3.7 Welche Lehren ziehen beteiligte Akteure daraus für künftige Vorhaben dieser Art?

Die Interviewpartner sind sich bezüglich Lehren aus dem Fall SystemsX.ch respektive SyBIT nicht einig. Die Mehrheit rät bei künftigen Projekten zu einer dezentralisierten Organisationstruktur und Dateninfrastruktur, vor allem wenn die Akteure und Daten sehr divers sind, wie etwa im Fall des SPHN. Andere Interviewpartner sehen hingegen Synergiepotential in einer zentralisierten Organisationsstruktur und Datenplattform, weil Spitäler eine solche Infrastruktur ihrer Meinung nach nicht selber aufbauen und betreiben könnten.

Die Meinungen bezüglich zukünftiger Organisationsstrukturen von grossen Forschungsinitiativen gehen auseinander. Die Mehrheit der Interviewpartner rät, auf eine dezentralisierte Netzwerkstruktur zu setzen, um die Bedürfnisse der Forschenden besser erkennen zu können und die Forschenden effektiver zu unterstützen. Gerade in heterogenen und interdisziplinären Forschungsinitiativen sei es wichtig, auf Netzwerkstrukturen zu setzen. Die wissenschaftlichen IT-Unterstützungseinheiten sollen sich auf die Bedürfnisse der Forschenden konzentrieren. Ein Interviewpartner betonte die Wichtigkeit der „embeddedness" der wissenschaftlichen IT-Unterstützungseinheiten. Er machte den Vorschlag, dass es dezentrale IT-Unterstützungseinheiten und eine Kern-Unterstützungseinheit geben solle. Die Mitarbeitenden der dezentralen Einheiten sollten einmal in der Woche in der Kerneinheit arbeiten, um

Interaktion und Informationsfluss sicherzustellen. Ein anderer Interviewpartner hob die Relevanz von zentralen Koordinationsorganen hervor, die schon über Expertise verfügen, gerade zu Beginn von solchen Forschungsinitiativen. Dadurch könne bereits am Anfang von Forschungsinitiativen eine gewisse Produktivität garantiert werden. Ein weiterer Akteur meinte, dass grosse Forschungsinitiativen grundsätzlich sehr schwierig zu steuern seien. Deshalb sollte man auf kleinere und besser steuerbare Forschungsprojekte setzen, die eine externe Qualitätssicherung aufweisen. Zudem sollten klare Vertragssituationen geschaffen werden mit einer Universität als Vertragspartner (ähnlich der NFS-Struktur).

Bezüglich der Dateninfrastruktur ergeben die Interviews ein ähnliches Bild. Die einen Interviewpartner betonen mögliche Synergieeffekte einer zentralen Dateninfrastruktur. Kooperation sei effizienter, als wenn alle Forschenden oder jede Universität sich selbstständig um das Aufbewahren der Daten kümmern müsse. Insbesondere auf internationaler Ebene könnte eine derartige Plattform fruchtbar sein. Andere Interviewpartner raten, auf eine zentralisierte Datenplattform zu verzichten. Es sei unrealistisch, dass Forschende Daten, die sie nicht selber erhoben haben, auswerten würden und können. Es sei schon genug kompliziert, die eigenen Daten auszuwerten. Bevor es eine zentrale Datenplattform geben würde, bräuchte es zudem zuerst die unter 3.6 erwähnte Grundlagenforschung zu Datenstandardisierung. Eine weitere wichtige Lehre aus SyBIT sei, dass es für einen nachhaltigeren Umgang mit Daten entscheidend sei, wenn bereits in den Projektanträgen Angaben zum Datenmanagement enthalten sein müssen. SyBIT kontaktierte jeweils die Verantwortlichen der verschiedenen Projektanträge und besprach mit ihnen vor Projekteingabe, was in die Projektanträge bezüglich Datenmanagement aufgenommen werden könnte.

Die Mehrheit der Interviewpartner ist skeptisch, ob eine zentralisierte Organisationsstruktur und Dateninfrastruktur in einer so grossen Forschungsinitiative wie etwa dem SPHN funktionieren könnte. Ein Interviewpartner wies auf die Datenformate hin, die im SPHN noch viel heterogener seien als bei SystemsX.ch – bereits innerhalb von SystemsX.ch habe die Datenstandardisierung ja schon nicht funktioniert. Verschiedene Interviewpartner betonten, dass die Heterogenität der Akteure ein Problem werden könne. Die Spitäler seien nochmals diverser, als es die verschiedenen Akteure in SystemsX.ch waren. Die Spitäler würden auch über verschiedene Datensysteme verfügen. Zudem würden mit den Pharmafirmen noch Stakeholder aus der Privatwirtschaft im SPHN mitwirken, was Steuerungsversuche weiter erschweren würde. Auch würde im Bereich der Medizin mehr Geld vorhanden sein als in der Biologie, weswegen es schwieriger würde, diese heterogenen Akteure zu einer Kooperation anzuregen. Ein Interviewpartner denkt jedoch, dass eine zentralisierte Dateninfrastruktur Vorteile bringen könnte. Dateninfrastruktur sei keine Kernkompetenz von Spitälern. Sie sollte so aufgebaut sein, dass sich die Forschenden auf die Datenanalyse konzentrieren können. Es sollte egal sein, wo die Rechenleistung produziert wird.

4 Fazit

Zuerst soll an dieser Stelle hervorgehoben werden, dass das Projektteam vielerlei positive Rückmeldungen zu der Arbeit von SystemsX.ch und insbesondere von SyBIT erhalten hat. Die projektbezogene Unterstützung wurde von den Forschenden sehr geschätzt.

Nachdem unter Kapitel 3.7 die Lehren der Interviewpartner dargestellt wurden, sollen hier nun noch die Schlussfolgerungen erläutert werden, die das Projektteam aus dem Fall SystemsX.ch für künftige Projekte ähnlicher Grösse – wie etwa das SPHN – zieht. Dabei soll vorangestellt werden, dass diese Empfehlungen weder auf Basis von quantitativen Analysen mit grossen Datensätzen noch aufgrund von akribisch durchgeführten qualitativen Untersuchungen im Stile etwa des *Causal Process Tracings* erfolgen. Auch wenn das Projektteam mit der Triangulation unterschiedlicher Dokumentquellen und verschiedener Interviewpartner versucht hat, eine möglichst umfassende Sichtweise zu erlangen, war das Mandat doch zu klein, um den Schritt hin zu einer kausalen Generalisierung zu wagen. Die im Folgenden angeführten Punkte sind deshalb als tentativ zu betrachten.

Ist es das Ziel eines zukünftigen Projekts, eine nationale Plattform für die Datenlagerung, -analyse und den Datenaustausch unter verschiedenen Akteure zu kreieren, so sollte Folgendes beachtet werden:

(1) *Fixe Vorgaben von oben:* Ein wesentlicher Punkt, der sich bei der fehlenden Etablierung einer nationalen Plattform für SystemsX.ch herauskristallisiert, ist die fehlende Verbindlichkeit des Projekts. Die Verantwortlichen von SystemsX.ch, SyBIT und dem SNF sprachen sich zu Beginn von SystemsX.ch zwar alle für die Schaffung einer zentralisierten Plattform aus, es wurde aber nie vertraglich geregelt. Ohne derartige Festlegungen ist es interessierten Akteuren nicht möglich, bei allfälligen Verfehlungen die Erfüllung des Zieles einzufordern. Dementsprechend sollten sich künftige Projektverantwortliche und weitere Beteiligte von Beginn weg darüber im Klaren sein, welches die zu erreichenden Ziele sind, und sie verbindlich fixieren.

(2) *Leistungsbereitschaft von unten:* Ein weiterer Stolperstein für die Schaffung einer nationalen Organisationsstruktur bei SystemsX.ch war das fehlende Interesse vonseiten der Forschenden, für welche die geplante Dienstleistung eigentlich gedacht war und die mit dem Einspeisen ihrer Daten auch aktiv zu ihrem Erfolg hätten beitragen müssen. Die Initianten für ein neues Projekt sollten also grundlegende Abklärungen bei den Involvierten vornehmen, bevor sie mit der Etablierung beginnen. Sobald das Grundgerüst steht, ist es zudem unerlässlich, dieselben Involvierten über die Vorteile des Projekts zu informieren und zu einer konstruktiven Mitarbeit zu motivieren.

(3) *Finanzierungssicherheit:* Ein Projekt braucht zum Erfolg die entsprechenden Ressourcen. SyBIT wurde von Beginn weg angewiesen, seine Gelder in die Unterstützung der RTD-Projekte zu investieren. Für die Fokussierung auf die Zusatzaufgabe einer nationalen Plattform wären separate Mittel ein wesentlicher, treibender Faktor.

(4) *Planungssicherheit:* Einhergehend mit den Punkten (1) und (3) ist es wichtig, einem Projekt ein stabiles Umfeld zu gewähren, damit es sich entfalten kann. Dies war bei SystemsX.ch nicht genügend gegeben: Die 2010 ausgestellte Empfehlung des SNF an die Verantwortlichen von SystemsX.ch stellte einen Strategiewechsel dar, der allfällige Bemühungen zur Erschaffung einer nationalen Plattform unterband.

Appendix: Liste der Interviewpartner

Bruggmann, Rémy: Leiter der Interfaculty Bioinformatics Unit an der Universität Bern (Kurzinterview).

Christ, Urs: Ehemals Verantwortlicher für SystemsX.ch beim SNF.

Kuhlemeyer, Cris: Leiter des SystemsX.ch-Projekts *PlantGrowth2* an der Universität Bern.

Kunszt, Peter: Projektmanager von SyBIT 2009-2015.

Pelkmans, Lucas: Ehemaliger SystemsX.ch-Projektleiter an der Universität Zürich, seit 2013 Vorsitzender des SEB von SystemsX.ch.

Rinn, Bernd: Leiter des SIS an der ETH Zürich, seit 2015 Projektmanager von SyBIT.

Soldati, Thierry: Leiter des SystemsX.ch-Projekts *HostPathX* an der Universität Genf.

Vonder Mühll, Daniel: Geschäftsleiter SystemsX.ch.

Xenarios, Ioannis: Direktor von Vital-IT.

Anhang E

SystemsX: related grants awarded by the SNSF

SNF, 19. April 2017

SWISS NATIONAL SCIENCE FOUNDATION

SNSF Data Team
dateteam@snf.ch - ajo

19 April, 2017

SystemsX: related grants awarded by the SNSF

The impact of the SystemsX program is currently being evaluated by the SWIR. To support this evaluation, the SNSF in this document provides data on its funding in the research areas of the SystemsX program. To identify the relevant research areas we choose a simple approach: we assume that all applicants for SystemsX applications are active in the relevant field. We therefore identify all involved responsible applicants and co-applicants in the program and list all other SNSF grants that these researchers have been awarded (after the earliest submission date to SystemsX until the present date). We include both researchers whose SystemsX applications were approved as well as those whose were rejected, as both groups can safely be assumed to consist of active researchers in the relevant research area. The following tables provide information about their non-SystemsX SNSF grants[1].

The first application to SystemsX was submitted on 2009-01-06, and has since involved:

Total Applications	Total People (primary and co-applicants)
383	645

These researchers were also funded by the following SNSF grants, not related to SystemsX:

Awarded projects with same people	Funding to same people (MCHF)	Publications from same people
1259	708.6	3575

These funded SNSF projects can be broken down into funding categories, which were awarded the following funding, representing the following percentages of total SNSF funding in each category (since the first submission to SystemsX until the present date).

SNSF Funding Category	# grants	MCHF	% total funding
Project funding	799	391.0	13.7
Programmes	218	225.0	24.8
Infrastructure	116	39.2	13.6
Careers	80	52.0	4.6
Science communication	46	1.4	3.3

[1]We include projects in all funding schemes of the SNSF except for NCCRs, where - for technical reasons - we do not have fine-grained information on involved researchers on a project or sub-project level. The numbers we report are therefore probably lower than the effective total SNSF funding.

Anhang F

Gespräche SWR

Diskussionen mit Vertretern des SystemsX.ch-Konsortiums und des SNF, „Site Visit“, 14./15. Juni 2017

Liste der weiteren Gesprächspartnerinnen und Gesprächspartner (Einzelinterviews)

Gesprächsleitfäden

SWR, Dezember 2016–Juni 2017

Diskussionen mit Vertretern des SystemsX.ch-Konsortiums und des SNF, „Site Visit“, 14./15. Juni 2017

Teilnehmende

- **SWIR**: Prof. Dr. Hans-Joachim Böhm (Vorsitz), Prof. Dr. Gerd Folkers (Unterstützung der Geschäftsstelle: Dr. Claudia Acklin (Donnerstag), Eva Herrmann, Dr. Frédéric Joye-Cagnard)
- **Experten:** Prof. Dr. Luis Serrano, Prof. Dr. Martin Vingron
- **SystemsX.ch-Konsortium**: Prof. Dr. Ruedi Aebersold (Mittwoch), Dr. Eavan Dorcey, Prof. Dr. Ralph Eichler, Prof. Dr. Detlef Günther, Prof. Dr. Lucas Pelkmans, Dr. Daniel Vonder Mühll
- **SNF-Fachleute:** Prof. Dr. Dieter Imboden, Prof. Dr. Angelika Kalt

Schedule June 14, 2017

Time	What	Who	Where
02.00–06.00 p.m.	Meeting „Site visit“ (details see below)	SSIC Expert panel SystemsX.ch	ETH Hauptgebäude, „Pallmann Zimmer“, HG E 42

Structure of the meeting

02.00–02.15	Opening
02.15–03.15	Part I: Excellence in Science - 5’ Introduction by SystemsX.ch, Ruedi Aebersold - Discussion
03.15–4.00	Part II: Structural impacts - 5’ Introduction by SystemsX.ch, Detlef Günther - Discussion
04.00–04.15	Coffee break
04.15–05.15	Part III: Networking and partnership - 5’ Introduction by SystemsX.ch, Ralph Eichler - Discussion
05.15–06.00	Part IV: Promoting young talents - 5’ Introduction b SystemsX.ch, Lucas Pelkmans - Discussion
06.00–06.05	Closing remarks

Schedule June 15, 2017

Time	What	Who	Where
09.45–11.15 a.m.	Meeting with SNSF	SSIC Expert panel SNSF experts	Hotel Continental, Stampfenbachstrasse 60, Zürich, meeting room
11.15–11.30 a.m.	Coffee break Arrival of SystemsX.ch Consortium	SSIC Expert panel SystemsX.ch SNSF experts	Hotel Continental, Zürich, Stampfenbachstrasse 60, meeting room
11.30–12.45 a.m.	Meeting „Final round“	SSIC Expert panel SystemsX.ch	Hotel Continental, meeting room

Liste der weiteren Gesprächspartnerinnen und Gesprächspartner (Einzelinterviews)

Im Rahmen der Wirkungsprüfung führte der SWR (vertreten durch die Ratsarbeitsgruppe und die SWR-Geschäftsstelle) zwischen Dezember 2016 und Juni 2017 sowohl Analyse- wie auch Recherchegespräche (zur Entstehung von SystemsX.ch) mit zentralen Akteuren durch. Gemäss den Vereinbarungen mit den Interviewten sind die Gesprächsinhalte vertraulich. Nachfolgend sind die Gesprächspartnerinnen und Gesprächspartner aufgeführt.[1]

Die Analysegespräche:

Prof. Dr. Ruedi Aebersold	Institute of Molecular Systems Biology ETHZ, Chairman des Scientific Executive Board von SystemsX.ch 2006-2012
Prof. Dr. Ron Appel	Direktor der SystemsX.ch-Partnerinstitution SIB und von Beginn weg Mitglied im Board of Directors
Prof. Dr. Edwin Constable	Vizerektor der SystemsX.ch-Partnerinstitution UniBas, Constable vertrat die UniBas im Board of Directors (ab 2011)
Prof. Dr. Jean-Pierre Eckmann	UniGE, Mitglied SNSF Review Panel Systems Biology (ab Beginn)
Prof. Dr. Susan Gasser	Direktorin der SystemsX.ch-Partnerinstitution FMI und von Beginn weg Mitglied im Board of Directors
Prof. Dr. Gisou van der Goot	Vertreterin der SystemsX.ch-Partnerinstitution EPFL im Board of Directors (ab 2013)
Dr. Ulf Grawunder / Dr. Roger Beerli	CEO und Chief Science Officer NBE Therapeutics; NBE Therapeutics war als Industriepartner Co-applicant (Transfer project 2014)
Prof. Dr. Michael Hengartner	Rektor der SystemsX.ch-Partnerinstitution UniZH und somit Member des Board of Directors (ab 2014)
Prof. Dr. Nouria Hernandez	Rektorin der SystemsX.ch-Partnerinstitution UniL und somit Member des Board of Directors (ab 2016)
Prof. Dr. Denis Hochstrasser	Vizerektor der SystemsX.ch-Partnerinstitution UniGE, Hochstrasser vertrat die UniGE im Board of Directors (ab 2013)
Dr. René Imhof	Guest industry im Board of Directors (bis 2010), Industriepartner Roche
Prof. Dr. Felix Kessler	Vizerektor der SystemsX.ch-Partnerinstitution UniNE, Kessler vertrat die UniNE im Board of Directors (ab 2016)
Prof. Dr. Antonio Loprieno	Rektor der UniBas 2006-2015, 2008-2015 zudem Präsident der Schweizerischen Rektorenkonferenz (CRUS)
Prof. Dr. Isabelle Mansuy	UniZH, Chair SNSF Review Panel Systems Biology (ab 2015)

Die Recherchegespräche:

Dr. Paul Burkhard	Verantwortlich für Nano-Tera.ch in der Division II der SNF-Geschäftsstelle
Dr. Urs Christ	Verantwortlich für SystemsX.ch in der Division IV der SNF-Geschäftsstelle
Dr. Daniel Höchli	Direktor der Geschäftsstelle des SNF
Dr. Charles Kleiber	Staatssekretär für Forschung
Dr. Raymond Werlen	Stellvertretender Generalsekretär der SUK

In der gleichen Zeitspanne wurden zudem Recherchegespräche mit den beiden Geschäftsführern Dr. Daniel Vonder Mühll (SystemsX.ch) und Dr. Martin Rajman (Nano-Tera.ch) geführt. Einen schriftlichen Beitrag erhielt der SWR überdies vom Sekretariat des ETH-Rats. Ein informelles Gespräch fand zudem statt mit Alban Frei, Doktorand ETHZ, der in seinem Dissertationsprojekt *Sichtbare Netzwerke. Forschungspolitik und Life Sciences zwischen 1990 und 2016 in der Schweiz. Eine Fallstudie zu SystemsX.ch*, Dissertation, Zürich: ETHZ, die jüngsten Transformationen in der schweizerischen Forschungspolitik und in den postgenomischen Lebenswissenschaften am Beispiel von SystemsX.ch untersuchte.

[1] Der SWR hatte neben den hier erwähnten Personen weitere Akteure um ein Gespräch gebeten. Leider kamen jedoch nicht alle gewünschten Interviews zustande.

Gesprächsleitfäden SWR

Gesprächsleitfaden Analysegespräche:

Einstieg

- Wissenschaftlicher Output – Nachwuchs – Netzwerke und Partnerschaften – Strukturen (das sind die für das SBFI relevanten Dimensionen für die Wirkungsprüfung): In welchem dieser Bereiche orten Sie aus der Sicht Ihrer Institution die grössten Erfolge / die grössten Misserfolge von SystemsX.ch? Weshalb?

A: Structural impact	KEYWORDS: Neuorientierung (+Schwergewicht ETHZ) – (nachhaltig) geschaffene Strukturen – (nachhaltiges) Data management – wegen SystemsX.ch Aufgegebenes

A1 Inwiefern hat SystemsX.ch einen Strategie- und Strukturwandel in Ihrer Institution bewirkt/befördert und inwiefern entsprachen diese Änderungen den Bedürfnissen ihrer Institution?
A2 Personelles: Was bleibt nach Beendigung des Programms bestehen (siehe Tabelle unten)? Wäre die Akzentuierung der Systembiologie nicht ohnehin erfolgt?
A3 Daten-Infrastrukturen: Was wurde geschaffen, und wie wird es heute von wem benutzt?

B: Networking/Partnership	KEYWORDS: Interdisziplinäre Kooperation – interinstitutionelle Kooperation – neue Zusammenarbeitsformen mit der Privatwirtschaft – Spin-offs vs. big industry – Förderlinien (funding schemes) von SystemsX.ch

B1 Inwiefern wurde wegen SystemsX.ch in ihrer Institution die Interdisziplinarität gefördert? Was waren Erfolgselemente, was lief weniger gut?
B2 Haben wegen SystemsX.ch und seinen funding schemes mehr Forscher in einer anderen Arbeitsgruppe weitergearbeitet?
B3 Gab es echte interdisziplinäre Kooperationen oder arbeiteten primär bio(-medizinische) Projekte verstärkt mit technischen Fachleuten zusammen? Erklärung?
B4 Wird wegen SystemsX.ch und seinen funding schemes mehr Infrastruktur gemeinsam genutzt?
B5 Warum gab es nicht mehr Industriekooperationen? Was waren die Hemmnisse? Wie bewerten Sie diesbezüglich die verschiedenen funding schemes von SystemsX.ch?

C: Excellence in science	KEYWORDS: Qualität des wissenschaftlichen Output – neue interdisziplinäre Forschungsansätze und -perspektiven (vs. Forschungsmainstream)

C1 Inwiefern entwickelten sich dank SystemsX.ch neue Forschungsperspektiven? Wie äusserte sich das in Ihrer Institution?
C2 Welchen Einfluss hatte die Art der SystemsX.ch-Förderung zur Erreichung des Globalzieles (internationale Spitzenposition)?
C3 *Und allgemein*: Hat die SystemsX.ch-Förderung die Forschungslandschaft Schweiz verändert? Was sind positive, was negative Auswirkungen?

D: Young talents	KEYWORDS: Interdisziplinäre PhD – Transition Postdoc Fellowships – Werdegang der Absolventen – in Curricula embedded – Weiterbildungsangebote – Community building

D1 Wie bewerten Sie die Entwicklung, dass SystemsX.ch weniger Mittel als geplant in die Nachwuchsförderung investierte, mehr in Forschungsprojekte?
D2 Wie bewerten Sie die SystemsX.ch-funding schemes der interdisziplinären PhD und der Postdocs (fitness to purpose)? Lessons learned?
D3 Inwiefern beeinflusste SystemsX.ch die Curricula Ihrer Institution?
D4 Welche Bedeutung hatten die verschiedenen Weiterbildungsangebote für die Schaffung einer systembiologischen Community, gibt es dabei auch negative Aspekte?
D5 *Und allgemein:* Was haben die Institutionen getan, um die interdisziplinären Werdegänge wertzuschätzen? Hat die SystemsX.ch-Förderung den Blick auf die Bedeutung von interdisziplinären Kenntnissen bei der Bewertung von jungen Forschenden verändert?

E: Governance (SystemsX.ch und SNF)	KEYWORDS: Governance des Programms – Bewertung der verschiedenen Förderlinien (funding schemes) von SystemsX.ch (vgl. SNF / NCCR)

E1 Wie bewerten Sie die Struktur von SystemsX.ch und ihren Einfluss zur Erreichung des Globalzieles (internationale Spitzenposition)?
E2 Was waren die Auswirkungen der starken Rolle des Scientific Executive Board (SEB)?
E3 SystemsX.ch verfügte seit 2012 nicht mehr über ein Scientific Advisory Board – genügten die checks and balances?
E4 Wie bewerten Sie die Rolle des SNF im ganzen Prozess?
E5 Ist das Programm komplementär zu den SNF-Förderungen? / Was ist der Mehrwert des Programms und seinen funding schemes (im Vgl. insbes. zu den NCCR)
E6 *Und allgemein*: Nach der Erfahrung von SystemsX.ch, wie sollen generell Fördermittel investiert werden – bottom-up-SNF-Projektförderung / neuer Impuls, neues Schwerpunktthema / Weiterentwicklung in Personalized Health?

F: Übergeordnete Sicht, alles in allem

F1 Was war der Mehrwert, was hat die gezielte, thematische Förderung (neben den bestehenden Förderstrukturen) gebracht, das sonst nicht entstanden wäre?
F2 Gibt es zum Besprochenen weitere lessons learned?

G: Organisationales

G1 Kontaktperson – wen können wir für allfällige Nachfragen kontaktieren?

Gesprächsleitfaden Recherchegespräche:

1. Positionnement de l'institution resp. de la personne

- Comment avez-vous pris connaissance du lancement de l'Initiative NTCH / SXCH?

2. Origine de NTCH / SXCH + Contexte général

- Quelle était l'analyse de fond qui a motivé son lancement? Quelles étaient les principales motivations de cette initiative?
- Comment caractériser le contexte d'alors sur le plan de l'encouragement de la recherche? Quels enjeux? quel positionnement des acteurs?

3. Appréciation de l'initiative (au niveau interne à NTCH / SXCH)

- Quels sont les principaux résultats de NTCH / SXCH?
- Les succès? Les échecs? „More of the same"? Les problèmes?
- Quelle est la valeur ajoutée de NTCH / SXCH en général et par rapport à un PRN?

4. Appréciation de l'initiative (niveau système FRI)

- Est-ce que NTCH / SXCH peut être considéré comme un instrument resp. un programme d'encouragement de la recherche, au même sens que les PRN ou que les SCCER, ou bien est-ce qu'il s'agit d'une initiative ad hoc, unique „One shot programme"? Y avait-il une volonté d'influer sur le paysage de l'encouragement de la recherche?
- Comment faut-il comprendre les demandes faites par différents acteurs lors de la révision de la LERI en 2011 de placer SXCH et NTCH dans la LERI et non plus dans la LAU (Contributions liées à des projets / Projektgebundene Beiträge)?
- Y a-t-il eu des conséquences particulières de NTCH / SXCH sur les formes d'encouragement de la recherche en Suisse? p. ex. est-ce que BRIDGE est une conséquence? et les SCCER? Autres (i.e. SPHNI) ?
- Le contexte d'encouragement a passablement changé depuis 2008. Serait-il aujourd'hui encore possible / justifié / nécessaire de lancer une initiative de ce type? avec ce mode d'organisation?