INTERNATIONAL SPACE STATION

- Utilization Statistics
  Expeditions 0 – 62
  December 1998 – April 2020

This is a product of the ISS Program Science Forum comprised of representatives from the ISS Partner Agencies: Canadian Space Agency (CSA), European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA), National Aeronautics and Space Administration (NASA) and the State Space Corporation ROSCOSMOS (ROSCOSMOS) and the ISS Participant Agency: Italian Space Agency (ASI).

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NUMBER OF INVESTIGATIONS PERFORMED ON THE INTERNATIONAL SPACE STATION

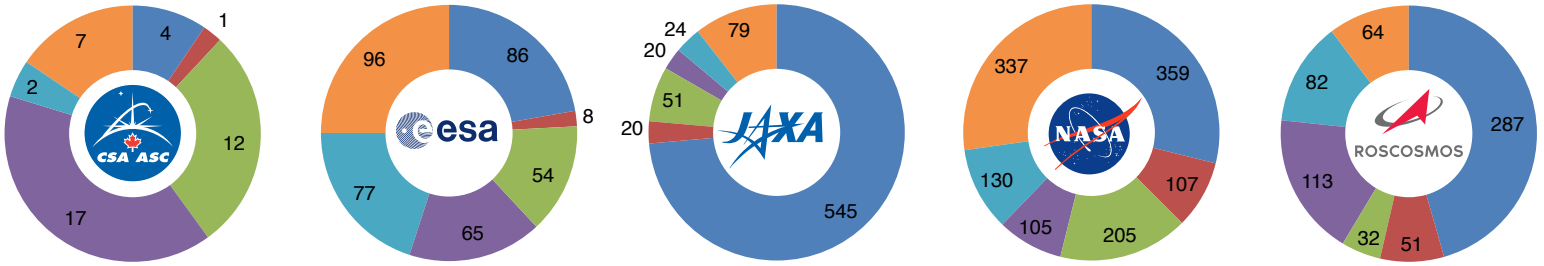
The information below provides an overview of ISS utilization up to the end of April 2020. An Expedition pair reflects the 6-month period used by the ISS Program for planning and execution of its activities. The utilization reflects activities of all of the ISS International Partners: CSA, ESA, JAXA, NASA, and ROSCOSMOS. An investigation is defined as a set of activities and measurements (observations) designed to test a scientific hypothesis, related set of hypotheses, or set of technology validation objectives. Investigators include the principal investigator(s) and co-investigator(s) that are working to achieve the objective of the investigation.

Research Investigations	ISS Expeditions 59/60 Mar 2019 — Oct 2019	ISS Expeditions 61/62 Oct 2019 — Apr 2020	ISS Expeditions 0-62 Dec 1998 — Apr 2020
Total Investigations	369	304	3040
New Investigations	168	94	-
Completed/Permanent Investigations	124	59	2349
Number of Investigators with Research on the ISS	991	900	4418
Countries/Areas with ISS Investigations	50	52	109
Research Resources	**ISS Expeditions 59/60 Mar 2019 — Oct 2019**	**ISS Expeditions 61/62 Oct 2019 — Apr 2020**	**ISS Expeditions 0-62 Dec 1998 — Apr 2020**
Upmass	5831kg	4421 kg	88766 kg
Downmass	3064 kg	1059 kg	27682 kg
Crew Time	2857 hrs	2589 hrs	48545 hrs

Number of Current Investigations on the International Space Station ‡	ISS Expedition 63 Apr 2020 — Oct 2020
Total Investigations	277
New Investigations	65
Number of Investigators with Research on the ISS	575
Countries/Areas with ISS Investigations	26

‡ The investigations statistics represented in the Current Investigations reflect research planned for Expedition 63. Future utilization projections are expected to increase as new integration process allows later manifesting of experiments. The numbers of investigations actually performed will be reported after completion of the expeditions.

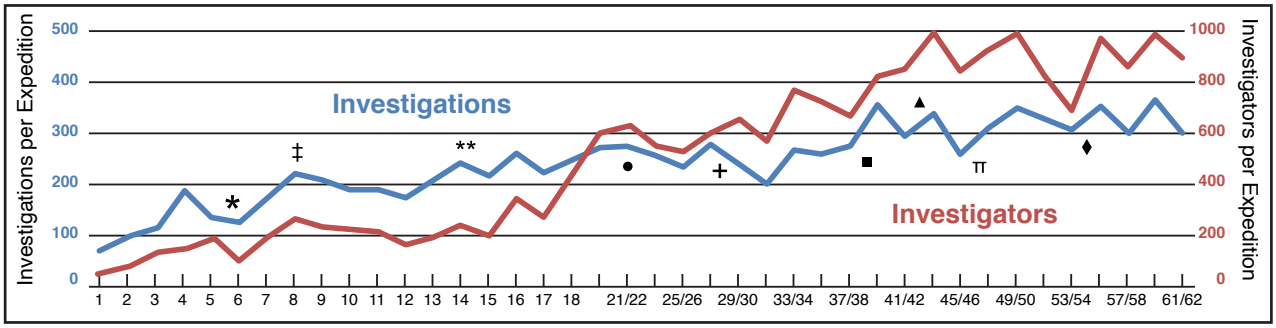
RESEARCH DISCIPLINES OF INTERNATIONAL SPACE STATION INVESTIGATIONS BY PARTNER AGENCIES



NASA utilization includes 69 investigations, ESA utilization includes 3 investigations, and ROSCOSMOS utilization includes 1 investigation by the Italian Space Agency (ASI), an ISS Participant Agency.

Biology & Biotechnology | Earth & Space Science | Educational & Cultural Activities | Human Research | Physical Science | Technology Development and Demonstration

Number of Investigations and Investigators with Research on the ISS per Expedition



* Post Columbia
‡ Japanese investigation surge in protein crystal growth
** Shuttle Return to Flight
• 6 Crew
\+ Final Shuttle Flight
■ Commercial resupply flights begin
▲ Loss of Orb-3
ᴨ Loss of 59P and SpX-7
♦ 4 USOS Crew and Extended Expedition

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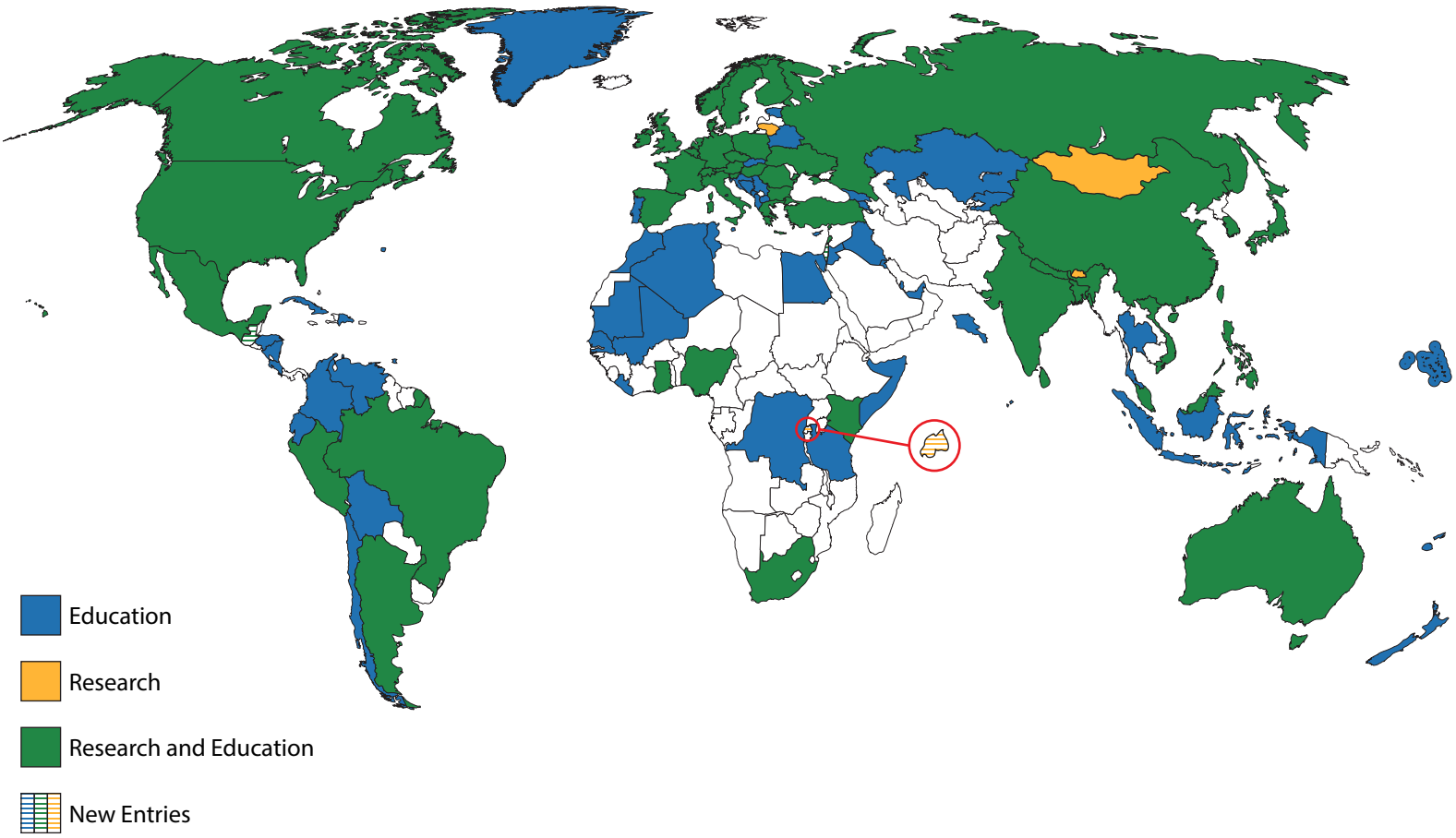
International Participation on ISS



109 highlighted countries and areas have participated in ISS Research and Education Activities

International Collaboration on ISS

ISS Benefits Increased Through International Collaboration

Partner Agency*	Agency Only	Collaboration (Hosting)	Investigations Implemented	Collaboration (Participating)	Total Agency Impact	% Increase Through Collaboration
CSA	32	11	43	36	79	84%
ESA	291	95	386	348	734	90%
JAXA	492	247	739	181	920	24%
NASA	1007	236	1243	122	1365	10%
ROSCOSMOS	337	292	629	281	910	45%
		Totals	3040	968	4008	32%

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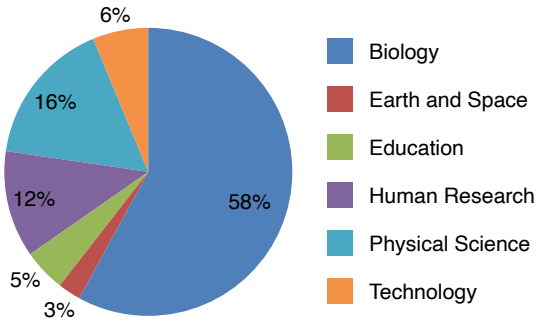
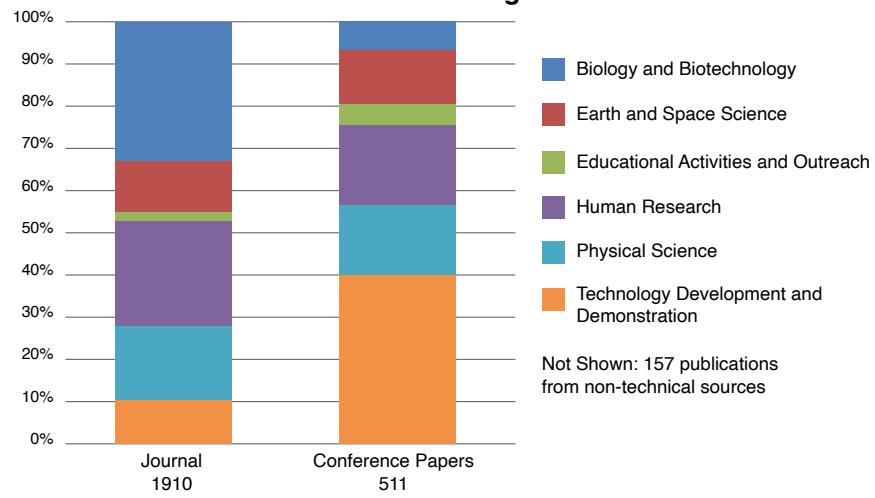
International Collaboration Percentage by Investigation Categories



International Space Station Publications Data

	Clarivate Analytics® Ranks	Source (Number of Publications)
ISS Publications in Top 20 Sources	1	PLOS ONE (44)
	2	Nature (3)
	3	Nature Communications (2)
	4	Science (4)
	5	Scientific Reports (45)
	6	PNAS (5)
	7	New England Journal of Medicine (1)
	9	Physical Review Letters (37)
	13	Advanced Materials (1)
	17	The Astrophysical Journal (17)
	19	RSC Advances (1)
ISS Publications in Top 100 Sources	23	Chemical Communications (1)
	25	Monthly Notices of the Royal Astronomical Society (4)
	28	Journal of Biological Chemistry (2)
	32	Journal of Neuroscience (1)
	33	Applied Physics Letters (1)
	42	Astronomy and Astrophysics (3)
	45	Geophysical Research Letters (6)
	49	Optics Express (2)
	51	Chemistry - A European Journal (1)
	73	The Journal of Chemical Physics (5)
	74	NeuroImage (1)
	76	Journal of Alloys and Compounds (1)
	88	Physical Review E (3)
	93	Frontiers in Microbiology (6)
	98	International Journal of Molecular Sciences (10)
	99	The Astrophysical Journal Letters (9)
	100	Science Advances (1)

ISS Results Publications through March 2020



Publications in Top 20 Global Journals from October 2019 - March 2020*

Extremophiles cultivated bacteria from wipe samples taken aboard the ISS suggest that the ISS has an established microbiome that remains unchanged regardless of crew. Furthermore, bacteria are not becoming more resistant to the extreme space environment or to antibiotics; instead, the best-adapted organisms are the ones surviving (Mora, *Nature Communications*, 2019).

JAXA PCG examined P. gingivalis which causes periodontitis via its PgDPP11 enzyme. Space-grown PgDPP11 crystals underwent crystallography to locate an active site to shut PgDPP11 down, and biochemical experiments discovered SH-5 as a potential inhibitor. Biological tests support the use of SH-5 inhibitor to deter the growth of P. gingivalis (Sakamoto, *Scientific Reports*, 2019).

Scientists for **Mao Eye** dissected mouse eyes for genetic analysis, following 35 days aboard ISS. Findings show expression for retinitis pigmentosa genes increased and the physical structure of the retina was altered. Oxidative stress, a process associated with aging, also increased. Overall, long-term spaceflight may cause visual impairment (Overbey, *Scientific Reports*, 2019).

For **Rodent Research – 4 (CASIS) investigation**, mice had either surgery or a sham surgery on the femur before being flown to the ISS. After four weeks, results showed significant reduction in trabecular volume in mice with actual fractures. Also, tibias, regardless of gravity, showed increases in marrow and periosteal growth. This study allows for better understanding of the healing process of fractured bones in space (Dadwal, *Scientific Reports*, 2019).

The **EML Batch 1 - Thermolab Experiment** tested the saturation of electrical resistivity in two metal alloys at specific temperatures in levitated microgravity. This work demonstrates that electrical transport can be used to determine the temperature of viscosity of metal alloys. Results are directly applicable to the improvement of processing metal alloys on Earth (van Hoesen, *Physical Review Letters*, 2019).

Top 5 Most Cited ISS Results Publications Overall

AMS-02 has collected and analyzed billions of cosmic ray events, and identified 9 million of these as electrons or positrons (antimatter), providing data that may lead to the solution of the origin of cosmic rays and antimatter, increasing the understanding of how our galaxy was formed. (AMS Collaboration, *Physical Review Letters*, 2013. Times Cited = 655)

Subregional Bone found that the greatest space-induced bone loss occurs in pelvis, hip, and leg bones, which should be the focus of countermeasures and surface activities designed for space explorers on future missions beyond low Earth orbit. (Lang TF, et al, *Journal of Bone and Mineral Research*, 2004. Times Cited = 457)

MAXI, in coordination with the gamma-ray burst satellite Swift (USA), observed the instant that a massive black hole swallowed a star located in the center of a galaxy 3.9 billion light years away. This behavior had only been theorized before, and this first-ever observation contributes to a better understanding of the current state and evolution of the universe. (Burrows DN, et al, *Nature*, 2011. Times Cited = 293)

Microbe implicated that the Hfq (RNA chaperone) protein acts as a major post-transcriptional regulator of Salmonella gene expression. (Sittka A, et al, *Molecular Microbiology*, 2007. Times Cited = 267)

Astrovaktsina showed that the localization of the V-antigen in Yersinia plays a crucial role in the translocation process and its efficacy as the main protective antigen against plague. (Mueller CA, et al, *Science*, 2005. Times Cited = 252)

**There were 8 papers with ISS Results published in the Top 20 Globally Ranked Journals from October 2019 – March 2020.*

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